STIR
Internet-Draft
Intended status: Standards Track
Expires: September 9, 2020

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March 8, 2020

Registry for Country-Specific Secure Telephone Identity (STIR) Trust Anchors
draft-burger-stir-iana-cert-01

Abstract

National policy defines telephone numbering governance. One area of such governance are the policies applied to the Secure Telephone Identity Credentials defined in RFC 8226. Nations have policies for the acceptable trust anchors for these credentials. This document defines an IANA registry that enables a SIP call recipient in one country to validate the signature, as defined in RFC 8224, that originates in another country useing an appropriate trust anchor for the signer's certification path, per the origination country's trust anchor policy.

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 September 9, 2020.

1. Introduction

One problem that plagues some communications applications is a caller deliberately misrepresenting their identity with the intent to defraud, cause harm, or wrongfully obtain anything of value. The IETF Secure Telephone Identity Revisited (STIR) work group has developed a series of RFCs specifying the mechanisms for cryptographically signing the asserted identity and other elements in Session Initiation Protocol (SIP) [RFC3261] messages. One kind of identity used in SIP is an E.164 [E.164] telephone number. A telephone number is a string of digits, where the first one to three digits indicate a country code. The International Telecommunications Union - Telecommunications Sector (ITU-T) defines country codes and delegates the authority for numbers under a country code to the respective national communications authority for that country, as listed in E.164 Annex D [E.164D]. Note the country code does not itself necessarily uniquely identify a country. For example, in country codes +1 and +7, multiple countries share the country code. In the cases of +1 and +7, further digits in the E.164 number, known as national significant digits (also known as area codes in +1) further identify the country. As well, there are non-geographic services with country codes assigned to them.

Section 7 of Authenticated Identity Management in the Session Initiation Protocol [RFC8224] describes the process for signing identity tokens. Correspondingly, the STIR Certificates document [RFC8226] describes the format of the signing certificate. The protocol and formats are independent of and can have uses beyond that of signing originating telephone numbers. As well, given that for the most part governments are responsible for managing the numbering resources within their country code, governmental policy may impact who is authorized to issue signing certificates and what constitutes a valid certification path. As such, the base STIR documents defer certificate and validation policy to other documents. This document describes a registry for finding a STIR trust anchor for a given country code for signed telephone numbers. This document only enables policies for E.164 number identity assertions. Moreover, while this document describes the STIR trust anchor registry for various national STIR trust anchors, it does not mandate any particular policy regime.

Recalling the STIR problem statement [RFC7340], the goal is to provide authenticated identity for the caller. When a SIP endpoint receives a message with a signed STIR token, that endpoint needs to know whether the signing certificate is, in fact, allowed to make assertions for that identity. It does us no good for a caller with ill intent to have a signed assertion that has a valid certification path to an unauthorized trust anchor. Likewise, it does us no good to use self-signed certificates to sign a SIP message, as even with some limited verification, if there is the slightest chance of an entity with nefarious intent to succeed in either spoofing or taking over the identify of a caller, experience has shown they will do so.

As mentioned above, the ITU-T assigns telephone numbers, specifically the responsibility to assign numbers beneath a country's country code, to national communications authorities. A national regulator can inform service providers under its authority which trust anchors are authoritative for numbers under its control. This is straightforward within a country. However, this does not work for the global, interconnected communications network. When someone in a first country calls someone in a second country, how is the service provider or end user in the second country to know who is authoritative for signing certificates in the first country?

To solve this problem, this document establishes an IANA registry of STIR trust anchors, indexed by country codes.

2. Terminology

This document uses the terms "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" as RFC 2119 [RFC2119] defines them.

As noted above, a country code may not sufficiently identify a particular country. Likewise, national policy may assign different STIR trust anchors for different sets of national significant numbers (e.g., area codes). For example, while +7 generally identifies the Russian Federation, +76 and +77 identify Kazakhstan. Likewise, +1 generally identifies the North American Numbering Plan (NANP), which identifies countries by area code (the following three digits after the country code). For example, +1869 identifies Saint Kitts and Nevis while +1649 identifies Turks and Caicos. The term "country code" appearing from this point forward in this document refers to the country code and, if necessary, the subsequent digits that identify a country or region. With the exception of ITU-T country code +1, the ITU-T country code is the "country code" for the purposes of this registry. In the NANP (+1) case, this means the "country code" can be four digits long. Specifically, to identify a

specific country in the NANP, what this document terms the "country code" will be the leading +1 and the following three-digit area code.

3. STIR Trust Anchor Registry

This registry maps E.164 country codes to STIR trust anchors. There can be one or more STIR trust anchors per country code.

3.1. Numeric Country Code

E.164 [E.164] defines the country code as a one- to three-digit string. However, there are some country codes that have different country delegations beyond the country code. In these cases, we use additional digits in the number to unambituously identify a country. For example, footnote b of E.164 Annex D [E.164D] shows 25 countries under country code +1 and two countries under country code +7. As well, country code +881, for satellite services, and codes +882 and +883, for international networks, are under the jurisdiction of various national authorities.

To distinguish the various national authorities under a given country code, the country code entry can contain these identity codes. Currently, the longest entry can be seven digits, but this could change in the future. As noted above, distinguishing the appropriate certificate to use can be a matter of local policy. We suggest longest match, but be aware that local policy may dictate another policy within that jurisdiction.

3.2. STIR Trust Anchor

Each country can have zero or more STIR trust anchors. The trust anchor is a self-signed certificate [RFC5280]. The STIR trust anchor is the trust anchor for STIR (SIP) PKI in the given jurisdiction. In the common Web browser situation, a Web server operator can purchase a certificate issued by one of hundreds of certificate authorities from anywhere in the world. The expectation is the authority for signing the identity of a caller will be more strict than the authority for signing the identity of, for example, a Web site. To ensure interoperability, browser and operating system manufacturers need to include the STIR trust anchors from those certificate authorities so when a user in one part of the world accesses a Web server in another part of the world that has a certificate issued by a certificate authority in yet a different part of the world, the site will validate. In the telephone number identity situation, for the most part the individual national numbering authorities will choose a very limited set of STIR trust anchors who they will allow to issue signing certificates for numbers assigned to that country.

Within a single country, it would be a relatively easy matter for the national communications regulator to impose and inform their domestic service providers who is the designated certificate authority within that country. However, given the large amount of international telephone traffic (as an example, there were over 100,000,000,000 minutes of traffic between the U.S. and other countries in 2014, including VoIP [FCC_intl]), there is a need for service providers and users in different countries to validate that one of the proper certificate authorities for that country has issued the signing certificate.

The entry for each national STIR trust anchor is a text certificate [RFC7468] that contains the public key of the STIR trust anchor, matching the private key the STIR trust anchor uses to sign signing keys used by its delegates, such as telecommunications service providers.

4. IANA Considerations

Refer to [RFC8126] for a description of IANA Considerations terms and their meanings.

4.1. Registry Policy: First Come First Served

This registry is First Come First Served, understanding there can be multiple trust anchors registered for a given Country Code prefix. The integrity of an originating nation's numbering system is generally the purview of the respective national government. Moreover, the integrity of a terminating network, including the accuracy of received signaling, is generally the purview of the government with jurisdiction over the terminating network. We do not anticipate IANA to intervene in disputes of who has the authority for entering and changing STIR trust anchors. In general, IANA SHOULD validate the request originates from an entity authorized by the recognized national authority for the country as specified in [ITU-D.Agencies], unless it is not clear who the national authority is. However, because it is likely the regulatory authorities in the terminating country will determine the validity of the STIR trust anchor found in the IANA registry, irrespective of the depth of vetting IANA could perform, if IANA believes the registration is not fraudulent, it SHOULD accept the registration even if it cannot positively identify or contact the appropriate national authority.

4.2. Registry Elements

The STIR Trust Anchor registry consists of one or more entities indicating the public keys of STIR trust anchors for a given country code. With around 200 countries, each of which might have one to

four STIR trust anchors, results in a registry with a total participation of about one thousand entries. The expectation is there would be substantially fewer entries in practice.

4.2.1. Numeric Country Code

The numeric country code is a one- to eight-digit string indicating the numeric country code and optional identity digits. Identity digits are often known as an area code or city code. [E.164D] lists country codes and the identity digits when there are overlapping country codes (+1, +7, and some international codes).

IANA MUST verify the requested mapping includes a valid numeric country code as specified in E.164 Annex D.

NOTE: The conventional leading + to indicate the string identifies a country code is NOT part of the Country Code element in the registry.

4.2.2. STIR Trust Anchor

The STIR trust anchor is an RFC7468 [RFC7468] text file that contains the public key of the authorized STIR trust anchor that signs the certificates authorized to sign STIR signaling in the given country. There can be one or more entries in the registry for a given ISO country code to allow for multiple STIR trust anchors for a given country.

IANA MUST verify the certificate is valid by using the provided public key in the certificate to validate the signature in the certificate.

IANA SHOULD remove a STIR trust anchor from the registry if the certificate expires.

4.2.3. Domain of Authority

For traceback and reputation purposes, IANA MUST record the validated domain of the entity that made the request to enter, delete, or modify an entry in the STIR Trust Anchor Registry. The mechanism for validating the domain is a matter of IANA policy. Mechanisms include ensuring an emailed request uses DKIM [RFC6376] with secure cryptographic algorithms [RFC8301], web requests have validated client certificates identifying the domain of the requestor, or out of band methods. Note that an unauthenticated inbound phone call is not likely to be an acceptable mechanism of identifying the domain.

4.3. Other IANA Considerations

There is the potential for a malicious actor attempting to load a trust anchor that could enable them to sign spoofed signaling. As such, IANA SHOULD note who is making the request, to sufficient detail to locate that party for referral to the relevant national authorities. For most countries, it will be the national authority itself or a clear delegate that will be making the registration. For example, in the United States, the Federal Communications Commission has delegated the governance of the STIR trust anchor to the U.S. STI-GA, administered by ATIS, which is an identifiable, incorporated entity with a fixed, physical address.

5. Security Considerations

The choice of having the STIR trust anchor stored by IANA means that users accessing the certificates MUST use a source-authenticated retrieval mechanism, such as HTTPS [RFC7231]. It almost goes without saying implementers should be using the most up-to-date TLS implementation (or its successor) when retrieving registry elements from IANA. Likewise, the application resolving the URI MUST verify the domain in the certificate matches the IANA domain. The application resolving the URI MUST use DNSSEC [RFC4035] if it is available to the client. Finally, during TLS negotiation the application MUST verify the authority signing IANA's certificate matches the application's understanding of who should sign IANA's certificate. At the time of this writing, that trust anchor would be the DigiCert High Assurance EV Root CA.

Because IANA takes no responsibility for the accuracy of any given country's STIR trust anchor entry, this document presumes the terminating provider or local authority will use local policy to determine the trustworthiness of any given entry. ATIS [ATIS-Intl] describes an example of such a local policy.

6. Acknowledgements

Russ Housley, Jim McEachern, and Sean Turner gave invaluable insight. Ken Carlberg and Padma Krishnaswamy of the United States Federal Communications Commission provided useful feedback in an incredibly short time period. Finally, a huge thank-you to Michelle Cotton and Kim Davies for helping normalize the registries and the procedures for populating them.

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Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: January 14, 2021

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July 13, 2020

STIR Certificate Delegation
draft-ietf-stir-cert-delegation-03

Abstract

The Secure Telephone Identity Revisited (STIR) certificate profile provides a way to attest authority over telephone numbers and related identifiers for the purpose of preventing telephone number spoofing. This specification details how that authority can be delegated from a parent certificate to a subordinate certificate. This supports a number of use cases, including those where service providers grant credentials to enterprises or other customers capable of signing calls with STIR.

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This Internet-Draft will expire on January 14, 2021.

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1. Introduction

The STIR problem statement [RFC7340] reviews the difficulties facing the telephone network that are enabled by impersonation, including various forms of robocalling, voicemail hacking, and swatting. One of the most important components of a system to prevent impersonation is the implementation of credentials which identify the parties who control telephone numbers. The STIR certificates [RFC8226] specification describes a credential system based on [X.509] version 3 certificates in accordance with [RFC5280] for that purpose. Those credentials can then be used by STIR authentication services [RFC8224] to sign PASSporT objects [RFC8225] carried in SIP [RFC3261] requests.

[RFC8226] specifies an extension to X.509 that defines a Telephony Number (TN) Authorization List that may be included by certification authorities (CAs) in certificates. This extension provides additional information that relying parties can use when validating transactions with the certificate. When a SIP request, for example, arrives at a terminating administrative domain, the calling number

attested by the SIP request can be compared to the TN Authorization List of the certificate that signed the PASSporT to determine if the caller is authorized to use that calling number.

Initial deployment of [RFC8226] has focused on the use of Service Provider Codes (SPCs) to attest the scope of authority of a certificate. Typically, these codes are internal telephone network identifiers such as the Operating Company Numbers (OCNs) assigned to carriers in the United States. However, these network identifiers are effectively unavailable to non-carrier entities, and this has raised questions about how such entities might best participate in STIR, when needed. Additionally, a carrier may sometimes operate numbers that are formally assigned to another carrier. [RFC8226] gave an overview of a certificate enrollment model based on "delegation," whereby the holder of certificate might allocate a subset of that certificate's authority to another party. This specification details how delegation of authority works for STIR certificates.

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. Motivation

The most pressing need for delegation in STIR arises in a set of use cases where callers want to use a particular calling number, but for whatever reason, their outbound calls will not pass through the authentication service of the service provider that controls that numbering resource.

One example would be an enterprise that places outbound calls through a set of service providers, for each call choosing a provider based on a least-cost routing algorithm or similar local policy. The enterprise was assigned a calling number by a particular service provider, but some calls originating from that number will go out through other service providers.

A user might also roam from their usual service provider to a different network or administrative domain, for various reasons. Most "legitimate spoofing" examples are of this form: where a user wants to be able to use the main call-back number for their business as a calling party number, even when the user is away from the business.

These sorts of use cases could be addressed if the carrier who controls the numbering resource were able to delegate a credential that could be used to sign calls regardless of which network or administrative domain handles the outbound routing for the call. In the absence of something like a delegation mechanism, outbound carriers may be forced to sign calls with credentials that do not cover the originating number in question. Unfortunately, that practice would be difficult to distinguish from malicious spoofing, and if it becomes widespread, it could erode trust in STIR overall.

4. Delegation of STIR Certificates

STIR delegate certificates are certificates containing a TNAuthList object that have been signed with the private key of a parent certificate that itself contains a TNAuthList object. The parent certificate needs contain a basic constraints extension with the cA boolean set to "true", indicating that the subject can sign certificates. Every STIR delegate certificate identifies its parent certificate with a standard [RFC5280] Authority Key Identifier extension.

The authority bestowed on the holder of the delegate certificate by the parent certificate is recorded in the delegate certificate's TNAuthList. Because STIR certificates use the TNAuthList object rather than the Subject Name for indicating the scope of their authority, traditional [RFC5280] name constraints are not directly applicable to STIR. In a manner similar to the RPKI [RFC6480] "encompassing" semantics, each delegate certificate must have a TNAuthList scope that is equal to or a subset of its parent certificate's scope: it must be "encompassed." For example, a parent certificate with a TNAuthList that attested authority for the numbering range +1-212-555-1000 through 1999 could issue a certificate to one delegate attesting authority for the range +1-212-555-1500 through 1599, and to another delegate a certificate for the individual number +1-212-555-1824.

Delegate certificates may also contain a basic constraints extension with the cA boolean set to "true", indicating that they can sign subordinate certificates for further delegates. In the STIR ecosystem, CA certificates may be used to sign PASSporTs; this removes the need for creating a redundant end-entity certificate with an identical TNAuthList to its parent, though if for operational or security reasons certificate holders wish to do so, they may.

4.1. Scope of Delegation

STIR certificates may have a TNAuthList containing one or more SPCs, one or more telephone number ranges, or both. When delegating from a STIR certificate, a child certificate may inherit from its parent either of the above. Depending on the sort of numbering resources that a delegate has been assigned, various syntaxes can be used to capture the delegated resource.

Some non-carrier entities may be assigned large and complex allocations of telephone numbers, which may be only partially contiguous or entirely disparate. Allocations may also change frequently, in minor or significant ways. These resources may be so complex, dynamic, or extensive that listing them in a certificate is prohibitively difficult. Section 10.1 of [RFC8226] describes one potential way to address this, including the TNAuthList (specified in [RFC8226]) in the certificate by-reference rather than by value, where a URL in the certificate points to a secure, dynamically-updated list of the telephone numbers in the scope of authority of a certificate. For entities that are carriers in all but name, another alternative is the allocation of an SPC; this yields much the same property, as the SPC is effectively a pointer to an external database which dynamically tracks the numbers associated with the SPC. Either of these approaches may make sense for a given deployment.

Other non-carrier entities may have straightforward telephone number assignments, such as enterprises receiving a set of thousand blocks from a carrier that may be kept for years or decades. Particular freephone numbers may also have a long-term association with an enterprise and its brand. For these sorts of assignments, assigning an SPC may seem like overkill, and using the TN ranges of the TNAuthList (by-value) is sufficient.

Whichever approach is taken to representing the delegated resource, there are fundamental trade-offs regarding when and where in the architecture a delegation is validated: that is, when the delegated TNAuthList is checked to be "encompassed" by the TNAuthList of its parent. This might be performed at the time the delegate certificate is issued, or at the time that a verification service receives an inbound call, or potentially both. It is generally desirable to offload as much of this as possible to the certification process, as verification occurs during call setup and thus additional network dips could lead to perceptible delay, whereas certification happens outside of call processing as a largely administrative function. Ideally, if a delegate certificate can supply a by-value TN range, then a verification service could ascertain that an attested calling party number is within the scope of the provided certificate without requiring any additional network dip. In practice, verification

services may already incorporate network queries into their processing (for example, to deference the "x5u" field of a PASSporT) that could piggyback any additional information needed by the verification service.

Note that the permission semantics of the [RFC8226] TNAuthList are additive: that is, the scope of a certificate is the superset of all of the SPCs and telephone number ranges enumerated in the TNAuthList. As SPCs themselves are effectively pointers to a set of telephone number ranges, and a telephone number may belong to more than one SPC, this may introduce some redundancy to the set of telephone numbers specified as the scope of a certificate. The presence of one or more SPCs and one or more sets of telephone number ranges should similarly be treated additively, even if the telephone number ranges turn out to be redundant to the scope of an SPC.

5. Authentication Services Signing with Delegate Certificates

Authentication service behavior for delegate certificates is little changed from [RFC8224] STIR behavior. The same checks are performed by the authentication service, comparing the calling party number attested in call signaling with the scope of the authority of the signing certificate. Authentication services SHOULD NOT use a delegate certificate without validating that its scope of authority is encompassed by that of its parent certificate, and if that certificate has a own parent, the entire certification path SHOULD be validated.

This delegation architecture does not require that a non-carrier entity act as its own authentication service. That function may be performed by any authentication service that holds the private key corresponding to the delegate certificate, including one run by an outbound service provider, a third party in an enterprise’s outbound call path, or in the SIP User Agent itself.

Note that authentication services creating a PASSporT for a call signed with a delegate certificate MUST provide an "x5u" link corresponding to the entire certification path, rather than just the delegate certificate used to sign the call, as described in Section 7.

6. Verification Service Behavior for Delegate Certificate Signatures

The responsibility of a verification service validating PASSporTs signed with delegate certificates, while largely following baseline [RFC8224] and [RFC8225], requires some additional procedures. When the verification service dereferences the "x5u" parameter, it will acquire a certificate list rather than a single certificate. It MUST

then validate all of the credentials in the list, identifying the parent certificate for each delegate through its Authority Key Identifier extension.

While ordinarily, relying parties have significant latitude in certification path construction when validating a certification path, STIR assumes a more rigid hierarchical subordination model, rather than one where relying parties may want to derive their own certification path to particular trust anchors. If the certificates acquired from the "x5u" element of a PASSporT do not lead to an anchor that the verification service trusts, it treats the validation no differently than it would when a non-delegated certificate was issued by an untrusted root; in SIP, it MAY return a 437 "Unsupported Credential" response if the call should be failed for lack of a valid Identity header.

7. Acquiring Multiple Certificates in STIR

PASSporT [RFC8225] uses the "x5u" element to convey the URL where verification services can acquire the certificate used to sign a PASSporT. This value is mirrored by the "info" parameter of the Identity header when a PASSporT is conveyed via SIP. Commonly, this is an HTTPS URI.

When a STIR delegate certificate is used to sign a PASSporT, the "x5u" element in the PASSporT will contain a URI indicating where a certificate list is available. While baseline JWS also supports an "x5c" element specifically for certificate chains, in operational practice, certification path are already being delivered in the STIR environment via the "x5u" element, so this specification recommends continuing to use "x5u". That list will be a concatenation of PEM-encoded certificates of the type "application/pem-certificate-chain" defined in [RFC8555]. The certificate path [RFC5280] ordering MUST be organized from the trust anchor towards the signer. The list begins with the certificate used to sign the PASSporT, followed by its parent, and then any subsequent grandparents, great-grandparents, and so on. The key identifier in the Authority Key Identifier extension in the first certificate MUST appear in the Subject Key Identifier extension in the second certificate. The key identifier pairing MUST match in this way throughout the entire chain of certificates. Note that ACME [RFC8555] requires the first element in a pem-certificate-chain to be an end-entity certificate; however, STIR relaxes this requirement, because CA certificates are permitted to sign PASSporTs, so for STIR, the first element in a pem-certificate-chain used for STIR MAY be a CA certificate.

8. Certification Authorities and Service Providers

Once a telephone service provider has received a CA certificate attesting their numbering resources, they may delegate resources from it as they see fit. Note that the allocation to a service provider of a certificate with a basic constraints extension with the cA boolean set to "true" does not require that a service provider act as a certification authority itself; serving as a certification authority is a function requiring specialized expertise and infrastructure. A third-party certification authority, including the same one that issued the service provider its parent certificate, could act as the CA that issues delegate certificates for the service provider, if the necessary business relationships permit it. A service provider might in this case act as a Token Authority (see Section 8.1) granting its customers permissions to receive certificates from the CA.

Note that if the same CA that issued the parent certificate is also issuing a delegate certificate, it may be possible to shorten the certification path, which reduces the work required of verification services. The trade-off here is that if the CA simply issued a non-delegate certificate (whose parent is the CA's trust anchor) with the proper TNAuthList value, relying parties might not be able to ascertain which service provider owned those telephone numbers, information which might be used to make an authorization decision on the terminating side. However, some additional object in the certificate outside of the TNAuthList could preserve that information; this is a potential area for future work.

All CAs must detail in their practices and policies a requirement to validate that the "encompassing" of a delegate certificate by its parent. Note that this requires that CAs have access to the necessary industry databases to ascertain whether, for example, a particular telephone number is encompassed by an SPC. Alternatively, a CA may acquire an Authority Token that affirms that a delegation is in the proper scope. Exactly what operational practices this entails may vary in different national telephone administrations, and are thus left to the CP/CPS [RFC3647].

8.1. ACME and Delegation

STIR deployments commonly use ACME [RFC8555] for certificate acquisition, and it is anticipated that delegate certificates as well will be acquired through an ACME interface. An entity can acquire a certificate from a particular CA by requesting an Authority Token [I-D.ietf-acme-authority-token] from the parent with the desired TNAuthList [I-D.ietf-acme-authority-token-tnauthlist] object. Note

that if the client intends to do further subdelegation of its own, it should request a token with the "ca" Authority Token flag set.

The entity then presents that Authority Token to a CA to acquire a STIR delegate certificate. ACME returns an "application/pem-certificate-chain" object with suitable for publishing as an HTTPS resource for retrieval with the PASSporT "x5u" mechanism as discussed in Section 7. If the CSR presented to the ACME server is for a certificate with the cA boolean set to "true", then the ACME server makes a policy decision to determine whether or not it is appropriate to issue that certificate to the requesting entity. That policy decision will be reflected by the "ca" flag in the Authority Token.

Service providers that want the capability to rapidly revoke delegated certificates can rely on the ACME STAR [I-D.ietf-acme-star] mechanism to automate the process of short-term certificate expiry.

8.2. Handling Multiple Certificates

In some deployments, non-carrier entities may receive telephone numbers from several different carriers. This could lead to enterprises needing to maintain a sort of STIR keyring, with different certificates delegated to them from different providers, potentially issued by different CAs, which they choose between when signing a call. This could be the case regardless of which syntax is used in the TNAuthList to represent the scope of the delegation (see Section 4.1).

For a small number of certificates, this is probably not a significant burden. For cases where it becomes burdensome, a few potential approaches exist. A delegate certificate could be cross-certified with another delegate certificate via an Authority Information Access field containing the URL of a Certificate Authority Issuer, so that a signer would only need to sign with a single certificate to inherit the privileges of the other certificate(s) it has cross-certified with. In very complex delegation cases, it might make more sense to establish a bridge CA that cross-certifies with all of the certificates held by the enterprise, rather than requiring a mesh of cross-certification between a large number of certificates. Again, this bridge CA function would likely be performed by some existing CA in the STIR ecosystem.

9. Alternative Solutions

At the time this specification was written, STIR was only starting to see deployment. In some future environments, the policies that govern CAs may not permit them to issue intermediate certificates

with a TNAuthList object and a cA boolean set to "true" in the basic constraints certificate extension [RFC5280]. Similar problems in the web PKI space motivated the development of TLS subcerts [I-D.ietf-tls-subcerts], which substitutes a signed "delegated credential" token for a certificate for such environments. A comparable mechanism could be developed for the STIR space, allowing STIR certificates to sign a data object which contains effectively the same data as the delegate certificate specified here, including a public key that could sign PASSporTs. The TLS subcerts system has furthermore developed ways for the issuer of a delegated credential to revoke it, as well as exploring the potential interaction with ACME to issue short-lived certificates for temporary delegation. Specification of a mechanism similar to TLS subcerts for STIR is future work, and will be undertaken only if the market require it.

10. IANA Considerations

This document contains no actions for the IANA.

11. Privacy Considerations

Any STIR certificate that identifies a narrow range of telephone numbers potentially exposes information about the entities that are placing calls. As this information is necessarily a superset of the calling party number that is openly signaled during call setup, the privacy risks associated with this mechanism are not substantially greater than baseline STIR. See [RFC8224] for guidance on the use of anonymization mechanisms in STIR.

12. Security Considerations

This document is entirely about security. For further information on certificate security and practices, see [RFC5280], in particular its Security Considerations. Also see the Security Considerations of [RFC8226] for general guidance on the implications of the use of certificates in STIR.

13. Acknowledgments

We would like to thank Richard Barnes, Chris Wendt, Dave Hancock, Russ Housley, and Sean Turner for key input to the discussions leading to this document.

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Network Working Group
Internet-Draft
Intended status: Informational
Expires: September 10, 2020

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March 9, 2020

STIR Out-of-Band Architecture and Use Cases
draft-ietf-stir-oob-07

Abstract

The PASSporT format defines a token that can be carried by signaling protocols, including SIP, to cryptographically attest the identify of callers. Not all telephone calls use Internet signaling protocols, however, and some calls use them for only part of their signaling path, or cannot reliably deliver SIP header fields end-to-end. This document describes use cases that require the delivery of PASSporT objects outside of the signaling path, and defines architectures and semantics to provide this functionality.

Status of This Memo

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This Internet-Draft will expire on September 10, 2020.

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Table of Contents

1. Introduction

The STIR problem statement [RFC7340] describes widespread problems enabled by impersonation in the telephone network, including illegal robocalling, voicemail hacking, and swatting. As telephone services are increasingly migrating onto the Internet, and using Voice over IP (VoIP) protocols such as SIP [RFC3261], it is necessary for these

protocols to support stronger identity mechanisms to prevent impersonation. For example, [RFC8224] defines a SIP Identity header field capable of carrying PASSporT [RFC8225] objects in SIP as a means to cryptographically attest that the originator of a telephone call is authorized to use the calling party number (or, for native SIP cases, SIP URI) associated with the originator of the call.

Not all telephone calls use SIP today, however, and even those that do use SIP do not always carry SIP signaling end-to-end. Calls from telephone numbers still routinely traverse the Public Switched Telephone Network (PSTN) at some point. Broadly, calls fall into one of three categories:

1. One or both of the endpoints is actually a PSTN endpoint.

2. Both of the endpoints are non-PSTN (SIP, Jingle, ...) but the call transits the PSTN at some point.

3. Non-PSTN calls which do not transit the PSTN at all (such as native SIP end-to-end calls).

The first two categories represent the majority of telephone calls associated with problems like illegal robocalling: many robocalls today originate on the Internet but terminate at PSTN endpoints. However, the core network elements that operate the PSTN are legacy devices that are unlikely to be upgradable at this point to support an in-band authentication system. As such, those devices largely cannot be modified to pass signatures originating on the Internet--or indeed any inband signaling data--intact. Even if fields for tunneling arbitrary data can be found in traditional PSTN signaling, in some cases legacy elements would strip the signatures from those fields; in others, they might damage them to the point where they cannot be verified. For those first two categories above, any in-band authentication scheme does not seem practical in the current environment.

While the core network of the PSTN remains fixed, the endpoints of the telephone network are becoming increasingly programmable and sophisticated. Landline "plain old telephone service" deployments, especially in the developed world, are shrinking, and increasingly being replaced by three classes of intelligent devices: smart phones, IP PBXs, and terminal adapters. All three are general purpose computers, and typically all three have Internet access as well as access to the PSTN; they may be used for residential, mobile, or enterprise telephone services. Additionally, various kinds of gateways increasingly front for deployments of legacy PBX and PSTN switches. All of this provides a potential avenue for building an

authentication system that implements stronger identity while leaving PSTN systems intact.

This capability also provides an ideal transitional technology while in-band STIR adoption is ramping up. It permits early adopters to use the technology even when intervening network elements are not yet STIR-aware, and through various kinds of gateways, it may allow providers with a significant PSTN investment to still secure their calls with STIR.

The techniques described in this document therefore build on the PASSporT [RFC8225] mechanism and the work of [RFC8224] to describe a way that a PASSporT object created in the originating network of a call can reach the terminating network even when it cannot be carried end-to-end in-band in the call signaling. This relies on a new service defined in this document called a Call Placement Service (CPS) that permits the PASSporT object to be stored during call processing and retrieved for verification purposes.

Potential implementors should note that this document merely defines the operating environments in which this out-of-band STIR mechanism is intended to operate. It provides use cases, gives a broad description of the components and a potential solution architecture. Various environments may have their own security requirements: a public deployment of out-of-band STIR faces far greater challenges than a constrained intranetwork deployment. To flesh out the storage and retrieval of PASSporTs in the CPS within this context, this document includes a strawman protocol suitable for that purpose. Deploying this framework in any given environment would require additional specification outside the scope of the current document.

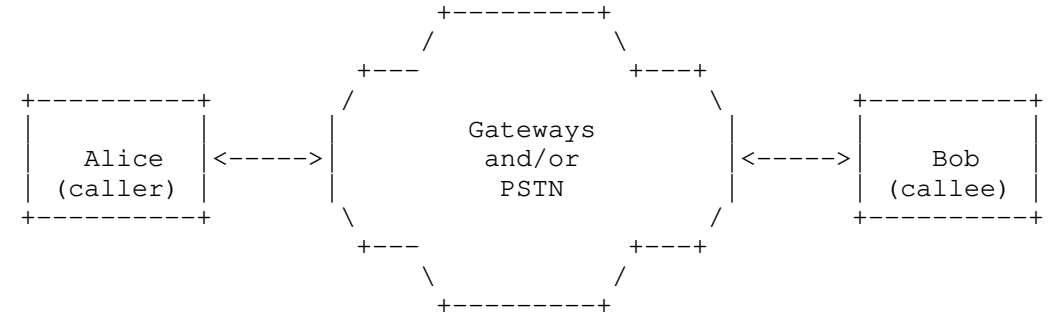
2. Terminology

TThe 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.

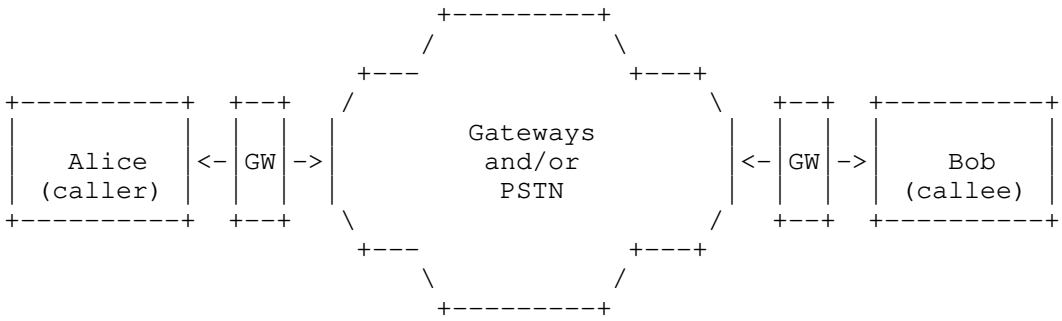
3. Operating Environments

This section describes the environments in which the proposed out-of-band STIR mechanism is intended to operate. In the simplest setting, Alice is calling Bob, and her call is routed through some set of gateways and/or the PSTN which do not support end-to-end delivery of STIR. Both Alice and Bob have smart devices which can access the Internet (perhaps enterprise devices, or even end user ones), but they do not have a clear telephone signaling connection between them:

Alice cannot inject any data into signaling which Bob can read, with the exception of the asserted destination and origination E.164 numbers. The calling party number might originate from her own device or from the network. These numbers are effectively the only data that can be used for coordination between the endpoints.



In a more complicated setting, Alice and/or Bob may not have a smart or programmable device, but instead just a traditional telephone. However, one or both of them are behind a STIR-aware gateway that can participate in out-of-band coordination, as shown below:



In such a case, Alice might have an analog (e.g., PSTN) connection to her gateway/ switch which is responsible for her identity. Similarly, the gateway would verify Alice's identity, generate the right calling party number information and provide that number to Bob using ordinary Plain Ol' Telephone Service (POTS) mechanisms.

4. Dataflows

Because in these operating environments endpoints cannot pass cryptographic information to one another directly through signaling, any solution must involve some rendezvous mechanism to allow endpoints to communicate. We call this rendezvous service a "call placement service" (CPS), a service where a record of call placement,

in this case a PASSporT, can be stored for future retrieval. In principle this service could communicate any information, but minimally we expect it to include a full-form PASSporT that attests the caller, callee, and the time of the call. The callee can use the existence of a PASSporT for a given incoming call as rough validation of the asserted origin of that call. (See Section 11 for limitations of this design.)

This architecture does not mandate that any particular sort of entity operate a CPS, or mandate any means to discover a CPS. A CPS could be run internally within a network, or made publicly available. One or more CPSes could be run by a carrier, as repositories for PASSporTs for calls sent to its customers, or a CPS could be built-in to an enterprise PBX, or even a smartphone. To the degree possible, it is specified here generically, as an idea that may have applicability to a variety of STIR deployments.

There are roughly two plausible dataflow architectures for the CPS:

1. The callee registers with the CPS. When the caller wishes to place a call to the callee, it sends the PASSporT to the CPS, which immediately forwards it to the callee, or,

2. The caller stores the PASSporT with the CPS at the time of call placement. When the callee receives the call, it contacts the CPS and retrieves the PASSporT.

While the first architecture is roughly isomorphic to current VoIP protocols, it shares their drawbacks. Specifically, the callee must maintain a full-time connection to the CPS to serve as a notification channel. This comes with the usual networking costs to the callee and is especially problematic for mobile endpoints. Indeed, if the endpoints had the capabilities to implement such an architecture, they could surely just use SIP or some other protocol to set up a secure session; even if the media were going through the traditional PSTN, a "shadow" SIP session could convey the PASSporT. Thus, we focus on the second architecture in which the PSTN incoming call serves as the notification channel and the callee can then contact the CPS to retrieve the PASSporT. In specialized environments, for example a call center that receives a large volume of incoming calls that originated in the PSTN, the notification channel approach might be viable.

5. Use Cases

The following are the motivating use cases for this mechanism. Bear in mind that just as in [RFC8224] there may be multiple Identity headers in a single SIP INVITE, so there may be multiple PASSporTs in

this out-of-band mechanism associated with a single call. For example, a SIP user agent might create a PASSporT for a call with an end user credential, and as the call exits the originating administrative domain the network authentication service might create its own PASSporT for the same call. As such, these use cases may overlap in the processing of a single call.

5.1. Case 1: VoIP to PSTN Call

A call originates in a SIP environment in a STIR-aware administrative domain. The local authentication service for that administrative domain creates a PASSporT which is carried in band in the call per [RFC8224]. The call is routed out of the originating administrative domain and reaches a gateway to the PSTN. Eventually, the call will terminate on a mobile smartphone that supports this out-of-band mechanism.

In this use case, the originating authentication service can store the PASSporT with the appropriate CPS (per the practices of Section 10) for the target telephone number as a fallback in case SIP signaling will not reach end-to-end. When the destination mobile smartphone receives the call over the PSTN, it consults the CPS and discovers a PASSporT from the originating telephone number waiting for it. It uses this PASSporT to verify the calling party number.

5.2. Case 2: Two Smart PSTN endpoints

A call originates with an enterprise PBX that has both Internet access and a built-in gateway to the PSTN, which communicates through traditional telephone signaling protocols. The PBX immediately routes the call to the PSTN, but before it does, it provisions a PASSporT on the CPS associated with the target telephone number.

After normal PSTN routing, the call lands on a smart mobile handset that supports the STIR out-of-band mechanism. It queries the appropriate CPS over the Internet to determine if a call has been placed to it by a STIR-aware device. It finds the PASSporT provisioned by the enterprise PBX and uses it to verify the calling party number.

5.3. Case 3: PSTN to VoIP Call

A call originates with an enterprise PBX that has both Internet access and a built-in gateway to the PSTN. It will immediately route the call to the PSTN, but before it does, it provisions a PASSporT with the CPS associated with the target telephone number. However, it turns out that the call will eventually route through the PSTN to an Internet gateway, which will translate this into a SIP call and

deliver it to an administrative domain with a STIR verification service.

In this case, there are two subcases for how the PASSporT might be retrieved. In subcase 1, the Internet gateway that receives the call from the PSTN could query the appropriate CPS to determine if the original caller created and provisioned a PASSporT for this call. If so, it can retrieve the PASSporT and, when it creates a SIP INVITE for this call, add a corresponding Identity header field per [RFC8224]. When the SIP INVITE reaches the destination administrative domain, it will be able to verify the PASSporT normally. Note that to avoid discrepancies with the Date header field value, only full-form PASSporT should be used for this purpose. In subcase 2, the gateway does not retrieve the PASSporT itself, but instead the verification service at the destination administrative domain does so. Subcase 1 would perhaps be valuable for deployments where the destination administrative domain supports in-band STIR but not out-of-band STIR.

5.4. Case 4: Gateway Out-of-band

A call originates in the SIP world in a STIR-aware administrative domain. The local authentication service for that administrative domain creates a PASSporT which is carried in band in the call per [RFC8224]. The call is routed out of the originating administrative domain and eventually reaches a gateway to the PSTN.

In this case, the originating authentication service does not support the out-of-band mechanism, so instead the gateway to the PSTN extracts the PASSporT from the SIP request and provisions it to the CPS. (When the call reaches the gateway to the PSTN, the gateway might first check the CPS to see if a PASSporT object had already been provisioned for this call, and only provision a PASSporT if none is present).

Ultimately, the call may terminate on the PSTN, or be routed back to a SIP environment. In the former case, perhaps the destination endpoint queries the CPS to retrieve the PASSporT provisioned by the first gateway. Or if the call ultimately returns to a SIP environment, it might be the gateway from the PSTN back to the Internet that retrieves the PASSporT from the CPS and attaches it to the new SIP INVITE it creates, or it might be the terminating administrative domain's verification service that checks the CPS when an INVITE arrives with no Identity header field. Either way the PASSporT can survive the gap in SIP coverage caused by the PSTN leg of the call.

5.5. Case 5: Enterprise Call Center

A call originates from a mobile user, and a STIR authentication service operated by their carrier creates a PASSporT for the call. As the carrier forwards the call via SIP, it attaches the PASSporT to the SIP call with an Identity header field. As a fallback in case the call will not go end-to-end over SIP, the carrier also stores the PASSporT in a CPS.

The call is then routed over SIP for a time, before it transitions to the PSTN and ultimately is handled by a legacy PBX at a high-volume call center. The call center supports the out-of-band service, and has a high-volume interface to a CPS to retrieve PASSporTs for incoming calls; agents at the call center use a general purpose computer to manage inbound calls and can receive STIR notifications through it. When the PASSporT arrives at the CPS, it is sent through a subscription/notification interface to a system that can correlate incoming calls with valid PASSporTs. The call center agent sees that a valid call from the originating number has arrived.

6. Storing and Retrieving PASSporTs

The use cases show a variety of entities accessing the CPS to store and retrieve PASSporTs. The question of how the CPS authorizes the storage and retrieval of PASSporT is thus a key design decision in the architecture. The STIR architecture assumes that service providers and in some cases end user devices will have credentials suitable for attesting authority over telephone numbers per [RFC8226]. These credentials provide the most obvious way that a CPS can authorize the storage and retrieval of PASSporTs. However, as use cases 3, 4 and 5 in Section 5 show, it may sometimes make sense for the entity storing or retrieving PASSporTs to be an intermediary rather than a device associated with either the originating or terminating side of a call, and those intermediaries often would not have access to STIR credentials covering the telephone numbers in question. Requiring authorization based on a credential to store PASSporTs is therefore undesirable, though potentially acceptable if sufficient steps are taken to mitigate any privacy risk of leaking data.

It is an explicit design goal of this mechanism to minimize the potential privacy exposure of using a CPS. Ideally, the out-of-band mechanism should not result in a worse privacy situation than in-band [RFC8224] STIR: for in-band, we might say that a SIP entity is authorized to receive a PASSporT if it is an intermediate or final target of the routing of a SIP request. As the originator of a call cannot necessarily predict the routing path a call will follow, an

out-of-band mechanism could conceivably even improve on the privacy story.

Broadly, the architecture recommended here thus is one focused on permitting any entity to store encrypted PASSporTs at the CPS, indexed under the called number. PASSporTs will be encrypted with a public key associated with the called number, so these PASSporTs may safely be retrieved by any entity, as only holders of the corresponding private key will be able to decrypt the PASSporT. This also prevents the CPS itself from learning the contents of PASSporTs, and thus metadata about calls in progress, which makes the CPS a less attractive target for pervasive monitoring (see [RFC7258]). As a first step, transport-level security can provide confidentiality from eavesdroppers for both the storing and retrieval of PASSporTs. To bolster the privacy story, prevent denial-of-service flooding of the CPS, and to complicate traffic analysis, a few additional mechanisms are also recommended below.

6.1. Storage

There are a few dimensions to authorizing the storage of PASSporTs. Encrypting PASSporTs prior to storage entails that a CPS has no way to tell if a PASSporT is valid; it simply conveys encrypted blocks that it cannot access itself, and can make no authorization decision based on the PASSporT contents. There is certainly no prospect for the CPS to verify the PASSporTs itself.

Note that this architecture requires clients that store PASSporTs to have access to an encryption key associated with the intended called party to be used to encrypt the PASSporT. Discovering this key requires the existence of a key lookup service (see Section 11); depending on how the CPS is architected, however, some kind of key store or repository could be implemented adjacent to it, and perhaps even incorporated into its operation. Key discovery is made more complicated by the fact that there can potentially be multiple entities that have authority over a telephone number: a carrier, a reseller, an enterprise, and an end user might all have credentials permitting them to attest that they are allowed to originate calls from a number, say. PASSporTs for out-of-band use therefore might need to be encrypted with multiple keys in the hopes that one will be decipherable by the relying party.

Again, the most obvious way to authorize storage is to require the originator to authenticate themselves to the CPS with their STIR credential. However, since the call is indexed at the CPS under the called number, this can weaken the privacy story of the architecture, as it reveals to the CPS both the identity of the caller and the callee. Moreover, it does not work for the gateway use cases

described above; to support those use cases, we must effectively allow any entity to store PASSporTs at a CPS. This does not degrade the anti-impersonation security of STIR, because entities who do not possess the necessary credentials to sign the PASSporT will not be able to create PASSporTs that will be treated as valid by verifiers. In this architecture, it does not matter whether the CPS received a PASSporT from the authentication service that created it or from an intermediary gateway downstream in the routing path as in case 4 above. However, if literally anyone can store PASSporTs in the CPS, an attacker could easily flood the CPS with millions of bogus PASSporTs indexed under a calling number, and thereby prevent the called party from finding a valid PASSporT for an incoming call buried in a haystack of fake entries.

The solution architecture must therefore include some sort of traffic control system to prevent flooding. Preferably, this should not require authenticating the source, as this will reveal to the CPS both the source and destination of traffic. A potential solution is discussed below in Section 7.5.

6.2. Retrieval

For retrieval of PASSporTs, this architecture assumes that clients will contact the CPS through some sort of polling or notification interface to receive all current PASSporTs for calls destined to a particular telephone number, or block of numbers.

As PASSporTs stored at the CPS are encrypted with a key belonging to the intended destination, the CPS can safely allow anyone to download PASSporTs for a called number without much fear of compromising private information about calls in progress - provided that the CPS always returns at least one encrypted blob in response to a request, even if there was no call in progress. Otherwise, entities could poll the CPS constantly, or eavesdrop on traffic, to learn whether or not calls were in progress. The CPS MUST generate at least one unique and plausible encrypted response to all retrieval requests, and these dummy encrypted PASSporTs MUST NOT be repeated for later calls. An encryption scheme needs to be carefully chosen to make messages look indistinguishable from random when encrypted, so that information about called party is not discoverable from legitimate encrypted PASSporTs.

Because the entity placing a call may discover multiple keys associated with the called party number, multiple valid PASSporTs may be stored in the CPS. A particular called party who retrieves PASSporTs from the CPS may have access to only one of those keys. Thus, the presence of one or more PASSporTs that the called party cannot decrypt - which would be indistinguishable from the "dummy"

PASSporTS created by the CPS when no calls are in progress - does not entail that there is no call in progress. A retriever likely will need to decrypt all PASSporTs retrieved from the CPS, and may find only one that is valid.

In order to prevent the CPS from learning the numbers that a callee controls, callees might also request PASSporTs for numbers that they do not own, that they have no hope of decrypting. Implementations could even allow a callee to request PASSporTs for a range or prefix of numbers: a trade-off where that callee is willing to sift through bulk quantities of undecryptable PASSporTs for the sake of hiding from the CPS what numbers it controls.

Note that in out-of-band call forwarding cases, special behavior is required to manage the relationship between PASSporTs using the diversion extension [I-D.ietf-stir-passport-divert]. The originating authentication service would encrypt the initial PASSporT with the public encryption key of the intended destination, but once a call is forwarded, it may go to a destination that does not possess the corresponding private key and thus could not decrypt the original PASSporT. This requires the retargeting entity to generate encrypted PASSporTs that show a secure chain of diversion: a retargeting storer SHOULD use the "div-o" PASSporT type, with its "opt" extension, as specified in [I-D.ietf-stir-passport-divert] in order to nest the original PASSporT within the encrypted diversion PASSporT.

7. Solution Architecture

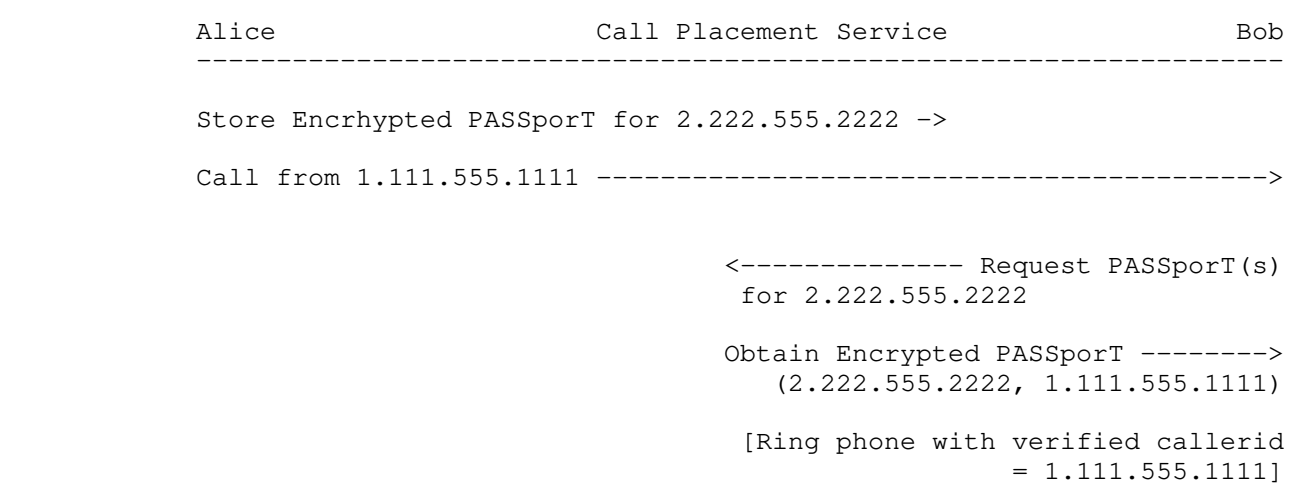
In this section, we discuss a high-level architecture for providing the service described in the previous sections. This discussion is deliberately sketchy, focusing on broad concepts and skipping over details. The intent here is merely to provide an overall architecture, not an implementable specification. A more concrete example of how this might be specified is given in Section 9.

7.1. Credentials and Phone Numbers

We start from the premise of the STIR problem statement [RFC7340] that phone numbers can be associated with credentials which can be used to attest ownership of numbers. For purposes of exposition, we will assume that ownership is associated with the endpoint (e.g., a smartphone) but it might well be associated with a provider or gateway acting for the endpoint instead. It might be the case that multiple entities are able to act for a given number, provided that they have the appropriate authority. [RFC8226] describes a credential system suitable for this purpose; the question of how an entity is determined to have control of a given number is out of scope for the current document.

7.2. Call Flow

An overview of the basic calling and verification process is shown below. In this diagram, we assume that Alice has the number +1.111.555.1111 and Bob has the number +2.222.555.2222.



When Alice wishes to make a call to Bob, she contacts the CPS and stores an encrypted PASSporT on the CPS indexed under Bob's number. The CPS then awaits retrievals for that number.

When Alice places the call, Bob's phone would usually ring and display Alice's number (+1.111.555.1111), which is informed by the existing PSTN mechanisms for relaying a calling party number (e.g., the CIN field of the IAM). Instead, Bob's phone transparently contacts the CPS and requests any current PASSporTs for calls to his number. The CPS responds with any such PASSporTs (or dummy PASSporTs if no relevant ones are currently stored). If such a PASSporT exists, and the verification service in Bob's phone decrypts it using his private key, validates it, then Bob's phone can present the calling party number information as valid. Otherwise, the call is unverifiable. Note that this does not necessarily mean that the call is bogus; because we expect incremental deployment, many legitimate calls will be unverifiable.

7.3. Security Analysis

The primary attack we seek to prevent is an attacker convincing the callee that a given call is from some other caller C. There are two scenarios to be concerned with:

1. The attacker wishes to impersonate a target when no call from that target is in progress.

2. The attacker wishes to substitute himself for an existing call setup.

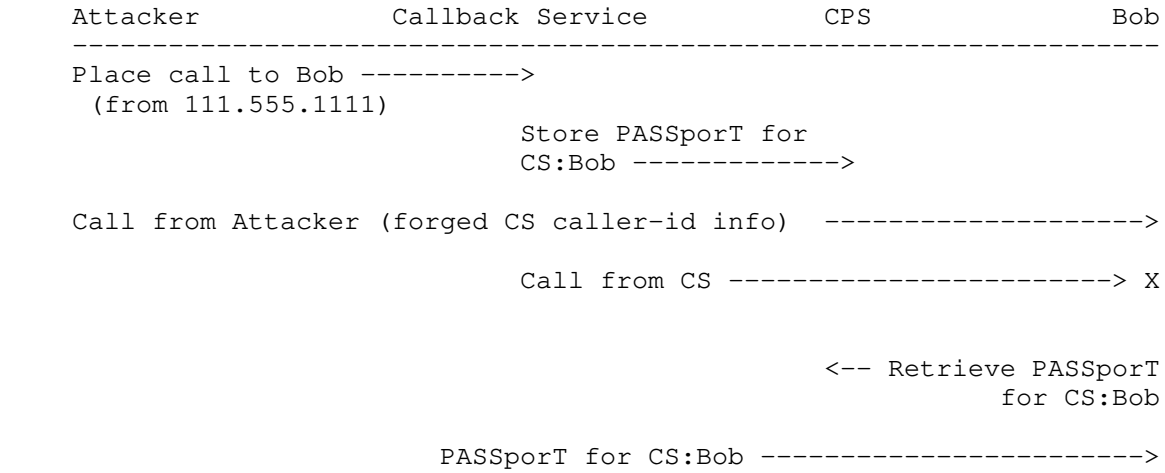
If an attacker can inject fake PASSporTs into the CPS or in the communication from the CPS to the callee, he can mount either attack. As PASSporTs should be digitally signed by an appropriate authority for the number and verified by the callee (see Section 7.1), this should not arise in ordinary operations. Any attacker who is aware of calls in progress can attempt to mount a race to subtitute themselves as described in Section 7.4. For privacy and robustness reasons, using TLS [RFC8446] on the originating side when storing the PASSporT at the CPS is RECOMMENDED.

The entire system depends on the security of the credential infrastructure. If the authentication credentials for a given number are compromised, then an attacker can impersonate calls from that number. However, that is no different from in-band [RFC8224] STIR.

A secondary attack we must also prevent is denial-of-service against the CPS, which requires some form of rate control solution that will not degrade the privacy properties of the architecture.

7.4. Substitution Attacks

All the receipt of the PASSporT from the CPS proves to the called party is that Alice is trying to call Bob (or at least was as of very recently) - it does not prove that any particular incoming call is from Alice. Consider the scenario in which we have a service which provides an automatic callback to a user-provided number. In that case, the attacker can try to arrange for a false caller-id value, as shown below:



In order to mount this attack, the attacker contacts the Callback Service (CS) and provides it with Bob's number. This causes the CS to initiate a call to Bob. As before, the CS contacts the CPS to insert an appropriate PASSporT and then initiates a call to Bob. Because it is a valid CS injecting the PASSporT, none of the security checks mentioned above help. However, the attacker simultaneously initiates a call to Bob using forged caller-id information corresponding to the CS. If he wins the race with the CS, then Bob's phone will attempt to verify the attacker's call (and succeed since they are indistinguishable) and the CS's call will go to busy/voice mail/call waiting.

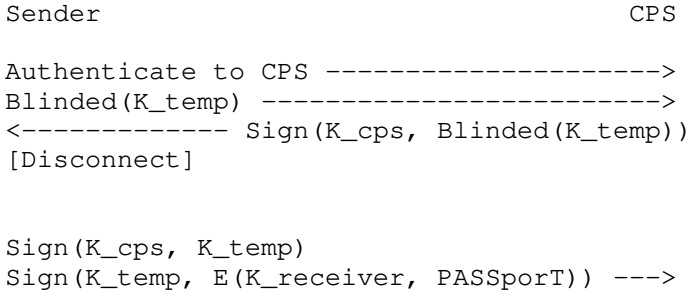
In order to prevent a passive attacker from using traffic analysis or similar means to learn precisely when a call is placed, it is essential that the connection between the caller and the CPS be encrypted as recommended above. Authentication services could store dummy PASSporTs at the CPS at random intervals in order to make it more difficult for an eavesdropper to use traffic analysis to determine that a call was about to be placed.

Note that in a SIP environment, the callee might notice that there were multiple INVITEs and thus detect this attack, but in some PSTN interworking scenarios, or highly intermediated networks, only one call setup attempt will reach the target. Also note that the success of this substitution attack depends on the attacker landing their call within the narrow window that the PASSporT is retained in the CPS, so shortening that window will reduce the opportunity for the attack. Finally, smart endpoints could implement some sort of state

coordination to ensure that both sides believe the call is in progress, though methods of supporting that are outside the scope of this document.

7.5. Rate Control for CPS Storage

In order to prevent the flooding of a CPS with bogus PASSporTs, we propose the use of "blind signatures" (see [RFC5636]). A sender will initially authenticate to the CPS using its STIR credentials, and acquire a signed token from the CPS that will be presented later when storing a PASSporT. The flow looks as follows:



At an initial time when no call is yet in progress, a potential client connects to the CPS, authenticates, and sends a blinded version of a freshly generated public key. The CPS returns a signed version of that blinded key. The sender can then unblind the key and gets a signature on K_temp from the CPS.

Then later, when a client wants to store a PASSporT, it connects to the CPS anonymously (preferably over a network connection that cannot be correlated with the token acquisition) and sends both the signed K_temp and its own signature over the encrypted PASSporT. The CPS verifies both signatures and if they verify, stores the encrypted passport (discarding the signatures).

This design lets the CPS rate limit how many PASSporTs a given sender can store just by counting how many times K_temp appears; perhaps CPS policy might reject storage attempts and require acquisition of a new K_temp after storing more than a certain number of PASSporTs indexed under the same destination number in a short interval. This does not of course allow the CPS to tell when bogus data is being provisioned by an attacker, simply the rate at which data is being provisioned. Potentially, feedback mechanisms could be developed that would allow the called parties to tell the CPS when they are receiving unusual or bogus PASSporTs.

This architecture also assumes that the CPS will age out PASSporTs. A CPS SHOULD NOT keep any stored PASSporT for no longer than a value that might be selected for the verification service policy for freshness of the "iat" value as described in [RFC8224] (i.e. sixty seconds). Any reduction in this window makes substitution attacks (see Section 7.4) harder to mount, but making the window too small might conceivably age PASSporTs out while a heavily redirected call is still alerting.

An alternative potential approach to blind signatures would be the use of oblivious pseudorandom functions (VOPRFs, per [I-D.privacy-pass]), which move prove faster.

8. Authentication and Verification Service Behavior for Out-of-Band

[RFC8224] defines an authentication service and a verification service as functions that act in the context of SIP requests and responses. This specification thus provides a more generic description of authentication service and verification service behavior that might or might not involve any SIP transactions, but depends only on placing a request for communications from an originating identity to one or more destination identities.

8.1. Authentication Service (AS)

Out-of-band authentication services perform steps similar to those defined in [RFC8224] with some exceptions:

Step 1: The authentication service MUST determine whether it is authoritative for the identity of the originator of the request, that is, the identity it will populate in the "orig" claim of the PASSporT. It can do so only if it possesses the private key of one or more credentials that can be used to sign for that identity, be it a domain or a telephone number or some other identifier. For example, the authentication service could hold the private key associated with a STIR certificate [RFC8225].

Step 2: The authentication service MUST determine that the originator of communications can claim the originating identity. This is a policy decision made by the authentication service that depends on its relationship to the originator. For an out-of-band application built-in to the calling device, for example, this is the same check performed in Step 1: does the calling device hold a private key, one corresponding to a STIR certificate, that can sign for the originating identity?

Step 3: The authentication service MUST acquire the public encryption key of the destination, which will be used to encrypt the PASSporT

(see Section 11). It MUST also discover (see Section 10) the CPS associated with the destination. The authentication service may already have the encryption key and destination CPS cached, or may need to query a service to acquire the key. Note that per Section 7.5 the authentication service may also need to acquire a token for PASSporT storage from the CPS upon CPS discovery. It is anticipated that the discovery mechanism (see Section 10) used to find the appropriate CPS will also find the proper key server for the public key of the destination. In some cases, a destination may have multiple public encryption keys associated with it. In that case, the authentication service MUST collect all of those keys.

Step 4: The authentication service MUST create the PASSporT object. This includes acquiring the system time to populate the "iat" claim, and populating the "orig" and "dest" claims as described in [RFC8225]. The authentication service MUST then encrypt the PASSporT. If in Step 3 the authentication service discovered multiple public keys for the destination, it MUST create one encrypted copy for each public key it discovered.

Finally, the authentication service stores the encrypted PASSporT(s) at the CPS discovered in Step 3. Only after that is completed should any call be initiated. Note that a call might be initiated over SIP, and the authentication service would place the same PASSporT in the Identity header field value of the SIP request - though SIP would carry a cleartext version rather than an encrypted version sent to the CPS. In that case, out-of-band would serve as a fallback mechanism in case the request was not conveyed over SIP end-to-end. Also, note that the authentication service MAY use a compact form of the PASSporT for a SIP request, whereas the version stored at the CPS MUST always be a full form PASSporT.

8.2. Verification Service (VS)

When a call arrives, an out-of-band verification service performs steps similar to those defined in [RFC8224] with some exceptions:

Step 1: The verification service contacts the CPS and requests all current PASSporTs for its destination number; or alternatively it may receive PASSporTs through a push interface from the CPS in some deployments. The verification service MUST then decrypt all PASSporTs using its private key. Some PASSporTs may not be decryptable for any number of reasons: they may be intended for a different verification service, or they may be "dummy" values inserted by the CPS for privacy purposes. The next few steps will narrow down the set of PASSporTs that the verification service will examine from that initial decryptable set.

Step 2: The verification service MUST determine if any "ppt" extensions in the PASSporTs are unsupported. It takes only the set of supported PASSporTs and applies the next step to them.

Step 3: The verification service MUST determine if there is an overlap between the calling party number presented in call signaling and the "orig" field of any decrypted PASSporTs. It takes the set of matching PASSporTs and applies the next step to them.

Step 4: The verification service MUST determine if the credentials that signed each PASSporT are valid, and if the verification service trusts the CA that issued the credentials. It takes the set of trusted PASSporTs to the next step.

Step 5: The verification service MUST check the freshness of the "iat" claim of each PASSporT. The exact interval of time that determines freshness is left to local policy. It takes the set of fresh PASSporTs to the next step.

Step 6: The verification service MUST check the validity of the signature over each PASSporT, as described in [RFC8225].

Finally, the verification service will end up with one or more valid PASSporTs corresponding to the call it has received. In keeping with baseline STIR, this document does not dictate any particular treatment of calls that have valid PASSporTs associated with them; the handling of the call after the verification process depends on how the verification service is implemented and on local policy. However, 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 UA implementations.

8.3. Gateway Placement Services

The STIR out-of-band mechanism also supports the presence of gateway placement services, which do not create PASSporTs themselves, but instead take PASSporTs out of signaling protocols and store them at a CPS before gatewaying to a protocol that cannot carry PASSporTs itself. For example, a SIP gateway that sends calls to the PSTN could receive a call with an Identity header field, extract a PASSporT from the Identity header field, and store that PASSporT at a CPS.

To place a PASSporT at a CPS, a gateway MUST perform Step 3 of Section 8.1 above: that is, it must discover the CPS and public key associated with the destination of the call, and may need to acquire a PASSporT storage token (see Section 6.1). Per Step 3 of

Section 8.1 this may entail discovering several keys. The gateway then collects the in-band PASSporT(s) from the in-band signaling, encrypts the PASSporT(s), and stores them at the CPS.

A similar service could be performed by a gateway that retrieves PASSporTs from a CPS and inserts them into signaling protocols that support carrying PASSporTS in-band. This behavior may be defined by future specifications.

9. Example HTTPS Interface to the CPS

As a rough example, we show a Call Placement Service implementation here which uses a REST API to store and retrieve objects at the CPS. The calling party stores the PASSporT at the CPS prior to initiating the call; the PASSporT is stored at a location at the CPS that corresponds to the called number. Note that it is possible for multiple parties to be calling a number at the same time, and that for called numbers such as large call centers, many PASSporTs could legitimately be stored simultaneously, and it might prove difficult to correlate these with incoming calls.

Assume that an authentication service has created the following PASSporT for a call to the telephone number 2.222.555.2222 (note that these are dummy values):

eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9
jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJkZXN0Ijp7InRuIjpbI
jIyMjI1NTUyMjIyIl19LCJpYXQiOiIxNTgzMjUxODEwIiwib3JpZyI6eyJ0biI6
IjExMTE1NTUxMTExIn19.pnij4IlLHoR4vxID0u3CT1e9Hq4xLngZUTv45Vbxmd
3IVyZug4KOSa378yfP4x6twY0KTdiDypsereS438ZHaQ

Through some discovery mechanism (see Section 10), the authentication service discovers the network location of a web service that acts as the CPS for 2.222.555.2222. Through the same mechanism, we will say that it has also discovered one public encryption key for that destination. It uses that encryption key to encrypt the PASSporT, resulting in the encrypted PASSporT:

rlWuoTpvBvWSHmV1AvVfVaE5pPV6VaOup3Ajo3W0VvjvrQI1VwbvnUE0pUZ6Yl9w
MKW0YzI4LJ1joTHho3WaY3Oup3Ajo3W0YzAypvW9rlWxMKA0Vwc7VaIlnFV6JlWm
nKN6LJkcL2INMKuuoKOfMF5wo20vKK0fVzyuqPV6VwR0AQZlZQtmAQHvYPWipzyaV
wc7VaEhVwbvZGVkAGH1AGRlZGVvsK0ed3cwG1ubEjnxRTwUPaJFjHafuq0-mW6S1
IBtSJFwUOe8Dwcwyx-pcSLcSLfbwAPcGmB3DsCBypxTnF6uRpx7j

Having concluded the numbered steps in Section 8.1, including acquiring any token (per Section 6.1) needed to store the PASSporT at the CPS, the authentication service then stores the encrypted PASSporT:

```
POST /cps/2.222.555.2222/ppts HTTP/1.1
Host: cps.example.com
Content-Type: application/passport

rlWuoTpvBvWSHmV1AvVfVaE5pPV6VaOup3Ajo3W0VvjvrQI1VwbvnUE0pUZ6Yl9w
MKW0YzI4LJ1joTHho3WaY3Oup3Ajo3W0YzAypvW9rlWxMKA0Vwc7VaIlnFV6JlWm
nKN6LJkcL2INMKuuoKOfMF5wo20vKK0fVzyuqPV6VwR0AQZlZQtmAQHvYPWipzyaV
wc7VaEhVwbvZGVkAGH1AGRlZGVvsK0ed3cwG1ubEjnxRTwUPaJFjHafuq0-mW6S1
IBtSJFwUOe8Dwcwyx-pcSLcSLfbwAPcGmB3DsCBypxTnF6uRpx7j
```

The web service assigns a new location for this encrypted PASSporT in the collection, returning a 201 OK with the location of /cps/2.222.222.2222/ppts/ppt1. Now the authentication service can place the call, which may be signaled by various protocols. Once the call arrives at the terminating side, a verification service contacts its CPS to ask for the set of incoming calls for its telephone number (2.222.222.2222).

```
GET /cps/2.222.555.2222/ppts
Host: cps.example.com
```

This returns to the verification service a list of the PASSporTs currently in the collection, which currently consists of only /cps/2.222.222.2222/ppts/ppt1. The verification service then sends a new GET for /cps/2.222.555.2222/ppts/ppt1/ which yields:

```
HTTP/1.1 200 OK
Content-Type: application/passport
Link: <https://cps.example.com/cps/2.222.555.2222/ppts>

rlWuoTpvBvWSHmV1AvVfVaE5pPV6VaOup3Ajo3W0VvjvrQI1VwbvnUE0pUZ6Yl9w
MKW0YzI4LJ1joTHho3WaY3Oup3Ajo3W0YzAypvW9rlWxMKA0Vwc7VaIlnFV6JlWm
nKN6LJkcL2INMKuuoKOfMF5wo20vKK0fVzyuqPV6VwR0AQZlZQtmAQHvYPWipzyaV
wc7VaEhVwbvZGVkAGH1AGRlZGVvsK0ed3cwG1ubEjnxRTwUPaJFjHafuq0-mW6S1
IBtSJFwUOe8Dwcwyx-pcSLcSLfbwAPcGmB3DsCBypxTnF6uRpx7j
```

That concludes Step 1 of Section 8.2; the verification service then goes on to the next step, processing that PASSporT through its various checks. A complete protocol description for CPS interactions is left to future work.

10. CPS Discovery

In order for the two ends of the out-of-band dataflow to coordinate, they must agree on a way to discover a CPS and retrieve PASSporT objects from it based solely on the rendezvous information available: the calling party number and the called number. Because the storage of PASSporTs in this architecture is indexed by the called party

number, it makes sense to discover a CPS based on the called party number as well. There are a number of potential service discovery mechanisms that could be used for this purpose. The means of service discovery may vary by use case.

Although the discussion above is written largely in terms of a single CPS, having a significant fraction of all telephone calls result in storing and retrieving PASSporTs at a single monolithic CPS has obvious scaling problems, and would as well allow the CPS to gather metadata about a very wide set of callers and callees. These issues can be alleviated by operational models with a federated CPS; any service discovery mechanism for out-of-band STIR should enable federation of the CPS function. Likely models include ones where a carrier operates one or more CPS instances on behalf of its customers, enterprises run a CPS instance on behalf of their PBX users, or where third-party service providers offer a CPS as a cloud service.

Some service discovery possibilities under consideration include the following:

For some deployments in closed (e.g. intranetwork) environments, the CPS location can simply be provisioned in implementations, obviating the need for a discovery protocol.

If a credential lookup service is already available (see Section 11), the CPS location can also be recorded in the callee's credentials; an extension to [RFC8226] could for example provide a link to the location of the CPS where PASSporTs should be stored for a destination.

There exist a number of common directory systems that might be used to translate telephone numbers into the URIs of a CPS. ENUM [RFC6116] is commonly implemented, though no "golden root" central ENUM administration exists that could be easily reused today to help the endpoints discover a common CPS. Other protocols associated with queries for telephone numbers, such as the TeRI [I-D.ietf-modern-teri] protocol, could also serve for this application.

Another possibility is to use a single distributed service for this function. VIPR [I-D.jennings-vipr-overview] proposed a RELOAD [RFC6940] usage for telephone numbers to help direct calls to enterprises on the Internet. It would be possible to describe a similar RELOAD usage to identify the CPS where calls for a particular telephone number should be stored. One advantage that the STIR architecture has over VIPR is that it assumes a credential system that proves authority over telephone numbers;

those credentials could be used to determine whether or not a CPS could legitimately claim to be the proper store for a given telephone number.

This document does not prescribe any single way to do service discovery for a CPS; it is envisioned that initial deployments will provision the location of the CPS at the Authentication Service and Verification Service.

11. Encryption Key Lookup

In order to encrypt a PASSporT (see Section 6.1), the caller needs access to the callee's public encryption key. Note that because STIR uses ECDSA for signing PASSporTs, the public key used to verify PASSporTs is not suitable for this function, and thus the encryption key must be discovered separately. This requires some sort of directory/lookup system.

Some initial STIR deployments have fielded certificate repositories so that verification services can acquire the signing credentials for PASSporTs, which are linked through a URI in the "x5u" element of the PASSporT. These certificate repositories could clearly be repurposed for allowing authentication services to download the public encryption key for the called party - provided they can be discovered by calling parties. This document does not specify any particular discovery scheme, but instead offers some general guidance about potential approaches.

It is a desirable property that the public encryption key for a given party be linked to their STIR credential. An ECDH [RFC7748] public-private key pair might be generated for a subcert [I-D.ietf-tls-subcerts] of the STIR credential. That subcert could be looked up along with the STIR credential of the called party. Further details of this subcert, and the exact lookup mechanism involved, are deferred for future protocol work.

Obviously, if there is a single central database that the caller and callee each access in real time to download the other's keys, then this represents a real privacy risk, as the central key database learns about each call. A number of mechanisms are potentially available to mitigate this:

Have endpoints pre-fetch keys for potential counterparties (e.g., their address book or the entire database).

Have caching servers in the user's network that proxy their fetches and thus conceal the relationship between the user and the keys they are fetching.

Clearly, there is a privacy/timeliness tradeoff in that getting up-to-date knowledge about credential validity requires contacting the credential directory in real-time (e.g., via OCSP [RFC2560]). This is somewhat mitigated for the caller's credentials in that he can get short-term credentials right before placing a call which only reveals his calling rate, but not who he is calling. Alternately, the CPS can verify the caller's credentials via OCSP, though of course this requires the callee to trust the CPS's verification. This approach does not work as well for the callee's credentials, but the risk there is more modest since an attacker would need to both have the callee's credentials and regularly poll the database for every potential caller.

We consider the exact best point in the tradeoff space to be an open issue.

12. Acknowledgments

The ideas in this document come out of discussions with Richard Barnes and Cullen Jennings. We'd also like to thank Russ Housley, Chris Wendt, Eric Burger, Mary Barnes, Ben Campbell, Ted Huang, Jonathan Rosenberg and Robert Sparks for helpful suggestions.

13. IANA Considerations

This memo includes no request to IANA.

14. Privacy Considerations

Delivering PASSporTs out-of-band offers a different set of privacy properties than traditional in-band STIR. In-band operations convey PASSporTs as headers in SIP messages in cleartext, which any forwarding intermediaries can potentially inspect. By contrast, out-of-band STIR stores these PASSporTs at a service after encrypting them as described in Section 6, effectively creating a path between the authentication and verification service in which the CPS is the sole intermediary, but the CPS cannot read the PASSporTs. Potentially, out-of-band PASSporT delivery could thus improve on the privacy story of STIR.

The principle actors in the operation of out-of-band are the AS, VS, and CPS. The AS and VS functions differ from baseline [RFC8224] behavior, in that they interact with an CPS over a non-SIP interface, of which the REST interface in Section 9 serves as an example. Some out-of-band deployments may also require a discovery service for the CPS itself (Section 10) and/or encryption keys (Section 11). Even with encrypted PASSporTs, the network interactions by which the AS and VS interact with the CPS, and to a lesser extent any discovery

services, thus create potential opportunities for data leakage about calling and called parties.

The process of storing and retrieving PASSporTs at a CPS can itself reveal information about calls being placed. The mechanism takes care not to require that the AS authenticate itself to the CPS, relying instead on a blind signature mechanism for flood control prevention. Section 7.4 discusses the practice of storing "dummy" PASSporTs at random intervals to thwart traffic analysis, and as Section 8.2 notes, a CPS is required to return a dummy PASSporT even if there is no PASSporT indexed for that calling number, which similarly enables the retrieval side to randomly request PASSporTs when there are no calls in progress. These measures can help to mitigiate information disclosure in the system. In implementations that require service discovery (see Section 10), perhaps through key discovery (Section 11), similar measures could be used to make sure that service discovery does not itself disclose information about calls.

Ultimately, this document only provides a framework for future implementation of out-of-band systems, and the privacy properties of a given implementation will depend on architectural assumptions made in those environments. More closed systems for intranet operations may adopt a weaker security posture but otherwise mitigate the risks of information disclosure, where more open environment will require careful implementation of the practices described here.

For general privacy risks associated with the operations of STIR, also see the Privacy Considerations of [RFC8224].

15. Security Considerations

This entire document is about security, but the detailed security properties will vary depending on how the framework is applied and deployed. General guidance for dealing with the most obvious security challenges posed by this framework is given in Section 7.3 and Section 7.4, along proposed solutions for problems like denial-of-service attacks or traffic analysis against the CPS.

Although there are considerable security challenges associated with widespread deployment of a public CPS, those must be weighed against the potential usefulness of a service that delivers a STIR assurance without requiring the passage of end-to-end SIP. Ultimately, the security properties of this mechanism are at least comparable to in-band STIR: the substitution attack documented in Section 7.4 could be implemented by any in-band SIP intermediary or eavesdropper who happened to see the PASSporT in transit, say, and launch its own call

with a copy of that PASSporT to race against the original to the destination.

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Network Working Group
Internet-Draft
Updates: RFC8224 (if approved)
Intended status: Standards Track
Expires: January 14, 2021

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July 13, 2020

PASSporT Extension for Diverted Calls
draft-ietf-stir-passport-divert-09

Abstract

PASSporT is specified in RFC 8225 to convey cryptographically-signed information about the people involved in personal communications. This document extends PASSporT to include an indication that a call has been diverted from its original destination to a new one. This information can greatly improve the decisions made by verification services in call forwarding scenarios. Also specified here is an encapsulation mechanism for nesting a PASSporT within another PASSporT that assists relying parties in some diversion scenarios.

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 January 14, 2021.

Table of Contents

1. Introduction

A Personal Assertion Token (PASSporT [RFC8225]) is a token format based on the JSON Web Token (JWT [RFC7519]) for conveying cryptographically-signed information about the people involved in personal communications; it is used by the Secure Telephone Identity Revisited (STIR [RFC8224]) protocol to convey a signed assertion of the identity of the participants in real-time communications established via a protocol like SIP. This specification extends PASSporT to include an indication that a call has been diverted from its original destination to a new one.

Although the STIR problem statement [RFC7340] is focused on preventing the impersonation of the caller's identity, which is a common enabler for threats such as robocalling and voicemail hacking on the telephone network today, it also provides a signature over the

called number at the time that the authentication service sees it. As [RFC8224] Section 12.1 describes, this protection over the contents of the To header field is intended to prevent a class of cut-and-paste attacks. If Alice calls Bob, for example, Bob might attempt to cut-and-paste the Identity header field in Alice's INVITE into a new INVITE that Bob sends to Carol, and thus be able to fool Carol into thinking the call came from Alice and not Bob. With the signature over the To header field value, the INVITE Carol sees will clearly have been destined originally for Bob, and thus Carol can view the INVITE as suspect.

However, as [RFC8224] Section 12.1.1 points out, it is difficult for Carol to confirm or reject these suspicions based on the information she receives from the baseline PASSporT object. The common "call forwarding" service serves as a good example of the reality that the original called party number is not always the number to which a call is delivered. There are a number of potential ways for intermediaries to indicate that such a forwarding operating has taken place. The address in the To header field value of SIP requests is not supposed to change, according to baseline SIP behavior [RFC3261]; instead, it is the Request-URI that is supposed to be updated when a call is retargeted. Practically speaking, however, many operational environments do alter the To header field. The History-Info header field [RFC7044] was created to store the Request-URIs that are discarded by a call in transit. The SIP Diversion header field [RFC5806], though historic, is still used for this purpose by some operators today. Neither of these header fields provide any cryptographic assurance of secure redirection, and they both record entries for minor syntactical changes in URIs that do not reflect a change to the actual target of a call.

This specification therefore extends PASSporT with an explicit indication that the original called number in PASSporT no longer reflects the destination to which a call is intended to be delivered. For this purpose, it specifies a Divert PASSporT type ("div") for use in common SIP retargeting cases; it is expected that in this case, SIP INVITE requests will carry multiple Identity header fields, each containing its own PASSporT. Throughout this document, PASSporTs that contain a "div" element will be referred to as "div" PASSporTs. Verification services and the relying parties who make authorization decisions about communications may use this diversion indication to confirm that a legitimate retargeting of the call has taken place, rather than a cut-and-paste attack. For out-of-band [I-D.ietf-stir-oob] use cases, and other non-SIP applications of PASSporT, a separate "div-o" PASSporT type is also specified, which defines an "opt" PASSporT element for carrying nested PASSporTs within a PASSporT. These shall in turn be referred to in this document as "div-o" PASSporTs.

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. The 'div' PASSporT Type and Claim

This specification defines a PASSporT [RFC8225] type called "div" that may be employed by authentication services located at retargeting entities. All "div" PASSporTs MUST contain a new JSON Web Token "div" claim, also specified in this document, which indicates a previous destination for a call during its routing process. When a retargeting entity receives a call signed with a PASSporT, it may act as an authentication service and create a new PASSporT containing the "div" claim to attach to the call.

Note that a new PASSporT is only necessary when the canonical form of the "dest" identifier (per the canonicalization procedures in [RFC8224] Section 8.3) changes due to this retargeting. If the canonical form of the "dest" identifier is not changed during retargeting, then a new PASSporT with a "div" claim MUST NOT be produced.

The headers of the new PASSporTs generated by retargeting entities MUST include the "div" PASSporT type, and an "x5u" field pointing to a credential that the retargeting entity controls. "div" PASSporTs MUST use full form instead of compact form. The new PASSporT header will look as follows:

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

A "div" PASSporT claims set is populated with elements drawn from the PASSporT(s) received for a call by the retargeting entity: at a high level, the original identifier for the called party in the "dest" object will become the "div" claim in the new PASSporT. If the "dest" object of the original PASSporT contains multiple identifiers, because it contains one or more name/value pairs with an array as its value, the retargeting entity MUST select only one identifier from the value(s) of the "dest" object to occupy the value of the "div" field in the new PASSporT. Moreover, it MUST select an identifier that is within the scope of the credential that the retargeting

entity will specify in the "x5u" of the PASSporT header (as described below).

The new target for the call selected by the retargeting entity becomes the value of the "dest" object of the new PASSporT. The "orig" object MUST be copied into the new PASSporT from the original PASSporT received by the retargeting entity. The retargeting entity SHOULD retain the "iat" object from the original PASSporT, though if in the underlying signaling protocol (e.g. SIP) the retargeting entity changes the date and time information in the retargeted request, the new PASSporT should instead reflect that date and time. No other claims or extensions are to be copied from the original PASSporT to the "div" PASSporT.

So, for an original PASSporT claims set of the form:

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

If the retargeting entity is changing the target from 12155551213 to 12155551214, the claims set of a "div" PASSpoRT generated by the retargeting entity would look as follows:

```
{ "dest":{"tn":["12155551214"]},
  "div":{"tn":"121555551213"},
  "iat":1443208345,
  "orig":{"tn":"12155551212"} }
```

The combined full form PASSporT (with a signature covered by the ES256 keys given in Appendix A) would look as follows:

```
 eyJhbGciOiJFUzI1NiIsInBwdCI6ImRpdiIsInR5cCI6InBhc3Nwb3J0IiwieDV1Ij \
 oiaHR0cHM6Ly93d3cuZXhhbXBsZS5jb20vY2VydC5jZXIifQ.eyJkZXN0Ijp7InRuI \
 jpbIjEyMTU1NTUxMjE0Il19LCJkaXYiOnsidG4iOiIxMjE1NTU1NTEyMTMifSwiaWF \
 0IjoxNDQzMjA4MzQ1LCJvcmlnIjp7InRuIjoiMTIxNTU1NTEyMTIifX0.xBHWipDEE \
 J8a6TsdX6xUXAnblsFiGUiAxwLiv0HLC9IICj6eG9jQd6WzeSSjHRBwxmChHhVIiMT \
 SqIlk3yCNkg
```

The same "div" PASSporT would result if the "dest" object of the original PASSporT contained an array value, such as {"tn":["12155551213","19995551234"]}, and the retargeting entity chose to retarget from the first telephone number in the array. Every "div" PASSporT is diverting from only one identifier.

Note that the "div" element may contain other name/value pairs than just a destination, including a History-Info indicator (see Section 8). After the PASSporT header and claims have been

constructed, their signature is generated per the guidance in [RFC8225] - except for the credential required to sign it. While in the ordinary construction of a PASSporT, the credential used to sign will have authority over the identity in the "orig" claim (for example, a certificate with authority over the telephone number in "orig" per [RFC8226]), for all PASSporTs using the "div" type the signature MUST be created with a credential with authority over the identity present in the "div" claim. So for the example above, where the original "dest" is "12155551213", the signer of the new PASSporT object MUST have authority over that telephone number, and need not have any authority over the telephone number present in the "orig" claim.

Note that Identity header fields are not ordered in a SIP request, and in a case where there is a multiplicity of Identity header fields in a request, some sorting may be required to match "div" PASSporTs to their originals.

PASSporTs of type "div" MUST NOT contain an "opt" (see Section 6) element in their payload.

4. Using 'div' in SIP

This section specifies SIP-specific usage for the "div" PASSporT type and its handling in the SIP Identity header field "ppt" parameter value. Other protocols using PASSporT may define behavior specific to their use of the "div" claim.

4.1. Authentication Service Behavior

An authentication service only adds an Identity header field value containing the "div" PASSporT type to a SIP request that already contains at least one Identity header field value; it MUST NOT add a "div" PASSporT to an INVITE that contains no Identity header field. The retargeting entity SHOULD act as a verification service and validate the existing Identity header field value(s) in the request before proceeding; in some high-volume environments, it may instead put that burden of validating the chain entirely on the terminating verification service. As the authentication service will be adding a new PASSporT that refers to an original, it MUST NOT remove the original request's Identity header field value before forwarding.

As was stated in Section 3, the authentication service MUST sign any "div" PASSporT with a credential that has a scope of authority covering the identity it populates in the "div" element value. Note that this is a significant departure from baseline STIR authentication service behavior, in which the PASSporT is signed by a credential with authority over the "orig" field. The "div" value

reflects the URI that caused the call to be routed to the retargeting entity, so in ordinary operations, it would already be the STIR entity holding the appropriate private keying material for calls originating from that identity.

A SIP authentication service typically will derive the "dest" element value of a "div" PASSporT from a new Request-URI that is set for the SIP request before it is forwarded. Older values of the Request-URI may appear in header fields like Diversion or History-Info; this document specifies an optional interaction with History-Info below in Section 8. Note as well that because PASSporT operates on canonicalized telephone numbers and normalized URIs, many smaller changes to the syntax of identifiers that might be captured by other mechanisms that record retargeting (like History-Info) will likely not require a "div" PASSporT.

When adding an Identity header field with a PASSporT claims set containing a "div" claim, SIP authentication services MUST also add a "ppt" parameter to that Identity header with a value of "div". For the example PASSporT given in Section 3, the new Identity header added after retargeting might look as follows:

```
Identity:eyJhbGciOiJFUzI1NiIsInBwdCI6ImRpdiIsInR5cCI6InBhc3Nwb3J0I \
iwieDV1IjoiaHR0cHM6Ly93d3cuZXhhbXBsZS5jb20vY2VydC5jZXIifQ.eyJkZXN0 \
Ijp7InRuIjpbIjEyMTU1NTUxMjE0Il19LCJkaXYiOnsidG4iOiIxMjE1NTU1NTEyMT \
MifSwiaWF0IjoxNDQzMjA4MzQ1LCJvcmlnIjp7InRuIjoiMTIxNTU1NTEyMTIifX0. \
xBHWipDEEJ8a6TsdX6xUXAnblsFiGUiAxwLiv0HLC9IICj6eG9jQd6WzeSSjHRBwxm \
ChHhVIiMTSqIlk3yCNkg; \
info=<https://www.example.com/cert.cer>;ppt="div"
```

Note that in some deployments, an authentication service will need to generate "div" PASSporTs for a request that contains multiple non-"div" Identity header field values. For example, a request arriving at a retargeting entity might contain in different Identity header fields a baseline [RFC8224] PASSporT and a PASSporT of type "rph" [RFC8443] signed by a separate authority. Provided that these PASSporTs share the same "orig" and "dest" values, the retargeting entity's authentication service SHOULD generate only one "div" PASSporT. If the "orig" or "dest" of these PASSporTs differ, however, one "div" PASSporT SHOULD be generated for each non-"div" PASSporT. Note that this effectively creates multiple chains of "div" PASSporTs in a single request, which complicates the procedures that need to be performed at verification services.

Furthermore, a request may also be retargeted a second time, at which point the subsequent retargeting entity SHOULD generate one "div"

PASSporT for each previous "div" PASSporT in the request which contains a "dest" object with the value of the current target - but not for "div" PASSporTs with earlier targets. Ordinarily, the current target will be readily identifiable, as it will be in the last "div" PASSporT in each chain, and in SIP cases it will correspond to the Request-URI received by the retargeting entity. Moreover, the current target will be an identifier that the retargeting entity possesses a credential to sign for, which may not be true for earlier targets. Ultimately, on each retargeting, the number of PASSporTs added to a request will be equal to the number of non-"div" PASSporTs that do not share the same "orig" and "dest" object values.

4.2. Verification Service Behavior

[RFC8224] Section 6.2 Step 5 requires that specifications defining "ppt" values describe any additional or alternative verifier behavior. The job of a SIP verification service handling one or more "div" PASSporTs is very different from that of a traditional verification service. At a high level, the immediate responsibility of the verification service is to extract all PASSporTs from the two or more Identity header fields in a request, identify which are "div" PASSporTs and which are not, and then order and link the "div" PASSporTs to the original PASSporT(s) in order to build one or more chains of retargeting.

In order to validate a SIP request using the "div" PASSporT type, a verification service needs to inspect all of the valid Identity header field values associated with a request, as an Identity header field value containing "div" necessarily refers to an earlier PASSporT already in the message. For each "div" PASSporT, the verification service MUST find an earlier PASSporT that contains a "dest" claim with a value equivalent to the "div" claim in each "div" PASSporT. It is possible that this earlier PASSporT will also contain a "div", and that it will in turn chain to a still earlier PASSporT stored in a different Identity header field value. If a complete chain cannot be constructed, the verification service cannot complete "div" validation; it MAY still validate any non-"div" PASSporTs in the request per normal [RFC8224] procedures. If a chain has been successfully constructed, the verification service extracts from the outermost (that is, the most recent) PASSporT in the chain a "dest" field; this will be a "div" PASSporT that no other "div" PASSporT in the SIP request refers to. Its "dest" element value will be referred to in the procedures that follow as the value of the "outermost "dest" field."

Ultimately, by looking at this chain of transformations and validating the associated signatures, the verification service will

be able to ascertain that the appropriate parties were responsible for the retargeting of the call to its current destination. This can help the verification service to determine that the original PASSporT in the call was not simply used in a cut-and-paste attack and inform any associated authorization decisions in terms of how the call will be treated - though, per [RFC8224] Section 6.2.1, that decision is a matter of local policy and is thus outside the scope of this specification.

A verification service parses a chain of PASSporTs as follows:

First, the verification service MUST compare the value in the outermost "dest" field to the target of the call. As it is anticipated that SIP authentication services that create "div" PASSporTs will populate the "dest" header from the retargeted Request-URI (see Section 4.1), in ordinary SIP operations, the Request-URI is where verification services will find the latest call target. Note however that after a "div" PASSporT has been added to a SIP request, the Request-URI may have been updated during normal call processing to an identifier that no longer contains the logical destination of a call; in this case, the verification service MAY compare the "dest" field to a provisioned telephone number for the recipient.

Second, the verification service MUST validate the signature over the outermost "div" PASSporT, and establish that the credential that signed the "div" PASSporT has the authority to attest for the identifier in the "div" element of the PASSporT (per [RFC8224] Section 6.2 Step 3).

Third, the verification service MUST validate that the "orig" field of the innermost PASSporT of the chain (the only PASSporT in the chain which will not be of PASSporT type "div") is equivalent to the "orig" field of the outermost "div" PASSporT; in other words, that the original calling identifier has not been altered by retargeting authentication services. If the "orig" value has changed, the verification service MUST treat the entire PASSporT chain as invalid. The verification service MUST also verify that all other "div" PASSporTs in the chain share the same "orig" value. Then the verification service validates the relationship of the "orig" field to the SIP-level call signaling per the guidance in [RFC8224] Section 6.2 Step 2.

Fourth, the verification service MUST check the date freshness in the outermost "div" PASSporT per [RFC8224] Section 6.2 Step 4. It is furthermore RECOMMENDED that the verification service check that the "iat" field of the innermost PASSporT is also within the date freshness interval; otherwise the verification service could

allow attackers to replay an old, stale PASSporT embedded in a fresh "div". However, note that in some use cases, including certain ways that call transfers are implemented, it is possible that an established call will be retargeted long after it has originally been placed, and verification services may want to allow a longer window for the freshness of the innermost PASSporT if the call is transferred from a trusted party (as an upper bound, a freshness window on the order of three hours might suffice).

Fifth, the verification service MUST inspect and validate the signatures on each and every PASSporT object in the chain between the outermost "div" PASSporT and the innermost PASSporT. Note that (per Section 4.1) a chain may terminate at more than one innermost PASSporT, in cases where a single "div" is used to retarget from multiple innermost PASSporTs. Also note that [RFC8224] Section 6.2 Step 1 applies to the chain validation process: if the innermost PASSporT contains an unsupported "ppt", its chain MUST be ignored.

Note that the To header field is not used in the first step above. Optionally, the verification service MAY verify that the To header field value of the received SIP signaling is equal to the "dest" value in the innermost PASSporT; however, as has been observed in some deployments, the original To header field value may be altered by intermediaries to reflect changes of target. Deployments that change the original To header field value to conceal the original destination of the call from the ultimate recipient should note that the original destination of a call may be preserved in the innermost PASSporT. Future work on "div" might explore methods to implement that sort of policy while retaining a secure chain of redirection.

5. The 'div-o' PASSporT Type

This specification defines a "div-o" PASSporT type that uses the "div" claim element in conjunction with the "opt" (Section 6) claim element. As is the case with "div" PASSporT type, a "div-o" PASSporT is created by an authentication service acting for a retargeting entity, but instead of generating a separate "div" PASSporT to be conveyed alongside an original PASSporT, the authentication service in this case embeds the original PASSporT inside the "opt" element of the "div-o" PASSporT. The "div-o" extension is designed for use in non-SIP or gatewayed SIP environments where the conveyance of PASSporTs in separate Identity header fields in impossible, such as out-of-band [I-D.ietf-stir-oob] STIR scenarios.

The syntax of "div-o" PASSporTs is very similar to "div". A "div-o" PASSporT header object might look as follows:

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

Whereas a "div" PASSporT claims set contains only the "orig", "dest", "iat", and "div" elements, the "div-o" additionally MUST contain an "opt" element (see Section 6), which encapsulates the full form of the previous PASSporT from which the call was retargeted, triggering the generation of this "div-o". The format of the "opt" element is identical to the encoded PASSporT format given in Appendix A of [RFC8225].

So, for an original PASSporT claims set of the form:

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

If the retargeting entity is changing the target from 12155551213 to 12155551214, the new PASSporT claims set for "div-o" would look as follows:

```
 { "orig":{"tn":"12155551212"},
   "dest":{"tn":["12155551214"]},
   "iat":1443208345,
   "div":{"tn":"121555551213"},
   "opt":"eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0c \
   HM6Ly93d3cuZXhhbXBsZS5jb20vY2VydC5jZXIifQ.eyJkZXN0Ijp7InRuIjpbIj \
   EyMTU1NTUxMjEzIl19LCJpYXQiOjE0NDMyMDgzNDUsIm9yaWciOnsidG4iOiIxMj \
   E1NTU1MTIxMiJ9fQ.1bEzkzcNbKvgz4QoMx0_DJ2T8qFMDC1sPqHPXl1WvbauzRJ \
   RvYlZqQ0qgGTlS8tJ_wXjVe07Z3wvDrdApHhhYw" }
```

While in ordinary operations, it is not expected that SIP would carry a "div-o" PASSporT, it might be possible in some gatewaying scenarios. The resulting full form Identity header field with a "div-o" PASSporT would look as follows:

```
Identity:eyJhbGciOiJFUzI1NiIsInBwdCI6ImRpdi1vIiwidHlwIjoicGFzc3Bvc \
nQiLCJ4NXUiOiJodHRwczovL3d3dy5leGFtcGxlLmNvbS9jZXJ0LmNlciJ9.eyJkZX \
N0Ijp7InRuIjoiMTIxNTU1NTEyMTQifSwiZGl2Ijp7InRuIjoiMTIxNTU1NTUxMjEz \
In0sImlhdCI6MTQ0MzIwODM0NSwib3B0IjoiZXlKaGJHY2lPaUpGVXpJMU5pSXNJbl \
I1Y0NJNkluQmhjM053YjNKMElpd2llRFYxSWpvaWFIUjBjSE02THk5M2QzY3VaWGho \
YlhCc1pTNWpiMjB2WTJWeWRDNWpaWElpZlEuZXlKa1pYTjBJanA3SW5SdUlqcGJJak \
V5TVRVMU5UVXhNakV6SWwxOUxDSnBZWFFpT2pFME5ETXlNRGd6TkRVc0ltOXlhV2Np \
T25zaWRHNGlPaUl4TWpFMU5UVTFNVEl4TWlKOWZRLjFiRXpremNOYkt2Z3o0UW9NeD \
BfREoyVDhxRk1EQzFzUHFIUFhsMVd2YmF1elJKUnZZbFpxUTBxZ0dUbFM4dEpfd1hq \
VmUwN1ozd3ZEcmRBcEhoaFl3Iiwib3JpZyI6eyJ0biI6IjEyMTU1NTUxMjEyIn19.C \
HeA9wRnthl7paMe6rP0TARpmFCXjmi_vF_HRz2O_oulB_R-G9xZNiLVvmvHv4gk6LI \
LaDV2y2VtHTLIEgmHig; \
info=<https://www.example.com/cert.cer>;ppt="div-o"
```

5.1. Processing 'div-o' PASSporTs

The authentication and verification service procedures required for "div-o" closely follow the guidance given in Section 4.1 and Section 4.2, with the major caveats being first, that they do store or retrieve PASSporTs via the Identity header field values of SIP requests, and second, that they process nested PASSporTs in the "opt" claim element. But transposing the rest of the behaviors described above to creating and validating "div-o" PASSporTs is straightforward.

For the "div-o" PASSporT type, retargeting authentication services that handle calls with one or more existing PASSporTs will create a corresponding "div-o" PASSporT for each received PASSporT. Each "div-o" PASSporT MUST contain an "opt" claim set element with the value of the original PASSporT from which the "div-o" was created; and as specified in Section 4.1, the authentication service MUST populate the "div" claim set element of the "div-o" PASSporT with the "dest" field fo the original PASSporT. Each received PASSporT may in turn contain its own "opt" claim set element, if the retargeting authentication service is not the first in its chain. Note that if the retargeting authentication service is handling a call with multiple PASSporTs, which in ordinary SIP operation would result in the construction of multiple "div" chains, it will in effect be generating one "div-o" PASSporT per chain.

The job of a verification service is in many ways easier for "div-o" than for "div", as the verification service has no need to correlate the PASSporTs it receives and assemble them into chains, as any chains in "div-o" will be nested through the "opt" element. Nonetheless, the verification services MUST perform the same chain validation described in Section 4.2 to validate that each nested PASSporT shares the same "orig" field as its enclosing PASSporT, and that the "dest" field of each nested PASSporT corresponds to the

"div" field of its enclosing PASSporT. The same checks MUST also be performed for freshness, signature validation, and so on. It is similarly OPTIONAL for the verification service to determine that the "dest" claims element of the outermost PASSporT corresponds to the called party indication of receive telephone signaling, where such indication would vary depending on the using protocol.

How authentication services or verification services receive or transport PASSporTs for "div-o" is outside the scope of this document, and dependent on the using protocol.

6. Definition of 'opt'

The presence of an "Original PASSporT" ("opt") claims set element signifies that a PASSporT encapsulates another entire PASSporT within it, typically a PASSporT that was transformed in some way to create the current PASSporT. Relying parties may need to consult the encapsulated PASSporT in order to validate the identity of a caller. "opt" as defined in this specification may be used by future PASSporT extensions as well as in conjunction with "div-o".

"opt" MUST contain a quoted full-form PASSporT as specified by [RFC8225] Appendix A; it MUST NOT contain a compact form PASSporT. For an example of a "div-o" PASSporT containing "opt," see Section 5.

7. 'div' and Redirection

The "div" mechanism exists primarily to prevent false negatives at verification services when an arriving SIP request, due to intermediary retargeting, does not appear to be intended for its eventual recipient, because the original PASSporT "dest" value designates a different destination.

Any intermediary that assigns a new target to a request can, instead of retargeting and forwarding the request, instead redirect with a 3xx response code. In ordinary operations, a redirection poses no difficulties for the operations of baseline STIR: when the user agent client (UAC) receives the 3xx response, it will initiate a new request to the new target (typically the target carried in the Contact header field value of the 3xx), and the "dest" of the PASSporT created for the new request will match that new target. As no impersonation attack can arise from this case, it creates no new requirements for STIR.

However, some UACs record the original target of a call with mechanisms like History-Info [RFC7044] or Diversion [RFC5806], and may want to leverage STIR to demonstrate to the ultimate recipient that the call has been redirected securely: that is, that the

original destination was the one that sent the redirection message that led to the recipient receiving the request. The semantics of the PASSporT necessary for that assertion are the same as those for the "div" retargeting cases above. The only wrinkle is that the PASSporT needs to be generated by the redirecting entity and sent back to the originating user agent client within the 3xx response.

This introduces more complexity than might immediately be apparent. In the first place, a 3xx response can convey multiple targets through the Contact header field value; to accommodate this, the "div" PASSporT MAY include one "dest" object array value per Contact, but if the retargeting entity wants to keep the Contact list private from targets, it may need to generate one PASSporT per Contact. Bear in mind as well that the original SIP request could have carried multiple Identity header field values that had been added by different authentication services in the request path, so a redirecting entity might need to generate one "div" PASSporT for each PASSporT in the original request. Often, this will mean just one "div" PASSporT, but for some deployment scenarios, it could require an impractical number of combinations. But in very complex call routing scenarios, attestation of source identity would only add limited value anyway.

STIR-aware SIP intermediaries that redirect requests MAY therefore convey one or more PASSporTs in the backwards direction within Identity header fields. These redirecting entities will act as authentication services for "div" as described in Section 4.1. This document consequently updates [RFC8224] to permit carrying Identity header fields in SIP 300-class responses. It is left to the originating user agent to determine which Identity header fields should be copied from the 3xx into any new requests resulting from the redirection, if any: use of these Identity header fields by entities receiving a 3xx response is OPTIONAL.

Finally, note that if an intermediary in the response path consumes the 3xx and explores new targets itself while performing sequential forking, it will effectively retarget the call on behalf of the redirecting server, and this will create the same need for "div" PASSporTs as any other retargeted call. These intermediaries MAY also copy PASSporTs from the 3xx response and insert them into sequential forking requests, if appropriate.

8. Extending ’div’ to work with Service Logic Tracking

It is anticipated that "div" may be used in concert with History-Info [RFC7044] in some deployments. It may not be clear from the "orig" and "dest" values which History-Info header a given PASSporT correlates to, especially because some of the target changes tracked

by History-Info will not be reflected in a "div" PASSporT (see Section 1). Therefore an "hi" element as defined here may appear in "div" corresponding to the History-Info header field index parameter value. So for a History-Info header field with an index value of "1.2.1", the claims set of the corresponding PASSporT with "div" might look like:

```
{ "orig":{"tn":"12155551212"},
  "dest":{"tn":["12155551214"]},
  "iat":1443208345,
  "div":{"tn":"121555551213",
         "hi":"1.2.1"} }
```

Past experience has shown that there may be additional information about the motivation for retargeting that relying parties might consider when making authorization decisions about a call, see for example the "reason" associated with the SIP Diversion header field [RFC5806]. Future extensions to this specification might incorporate reasons into "div".

9. Acknowledgments

We would like to thank Ning Zhang, Dave Hancock, Chris Wendt, Sean Turner, Russ Housley, Ben Campbell, Eric Burger, and Robert Sparks for contributions to this document.

10. IANA Considerations

This document contains actions for the IANA.

10.1. JSON Web Token Claims Registrations

This specification requests that the IANA add two new claims to the JSON Web Token Claims registry as defined in [RFC7519].

10.1.1. 'div' registration

Claim Name: "div"

Claim Description: Diverted Target of a Call

Change Controller: IESG

Specification Document(s): [RFCThis]

10.1.2. 'opt' registration

Claim Name: "opt"

Claim Description: Original PASSporT (in Full Form)

Change Controller: IESG

Specification Document(s): [RFCThis]

10.2. PASSporT Type Registrations

This specification defines two new PASSporT types for the PASSport Extensions Registry defined in [RFC8225], which resides at https://www.iana.org/assignments/passport/passport.xhtml#passport-extensions. They are:

"div" as defined in [RFCThis] Section 3.

"div-o" as defined in [RFCThis] Section 5.

11. Privacy Considerations

There is an inherent trade-off in any mechanism that tracks in SIP signaling how calls are routed through a network, as routing decisions may expose policies set by users for how calls are forwarded, potentially revealing relationships between different identifiers representing the same user. Note however that in ordinary operations, this information is revealed to the user agent service of the called party, not the calling party. It is usually the called party who establishes these forwarding relationships, and if indeed some other party is responsible for calls being forwarded to the called party, many times the called party should likely be entitled to information about why they are receiving these calls. Similarly, a redirecting entity who sends a 3xx in the backwards direction knowingly shares information about service logic with the caller's network. However, as there may be unforeseen circumstances where the revelation of service logic to the called party poses a privacy risk, implementers and users of this or similar diversion-tracking techniques should understand the trade-off.

Furthermore, it is a general privacy risk of identity mechanisms overall that they do not interface well with anonymization services; the interaction of STIR with anonymization services is detailed in [RFC8224] Section 11. Any forwarding service that acts as an anonymizing proxy may not be able to provide a secure chain of retargeting due to the obfuscation of the originating identity.

Also see [RFC8224] Section 11 for further considerations on the privacy of using PASSporTs in SIP.

12. Security Considerations

This specification describes a security feature, and is primarily concerned with increasing security when calls are forwarded. Including information about how calls were retargeted during the routing process can allow downstream entities to infer particulars of the policies used to route calls through the network. However, including this information about forwarding is at the discretion of the retargeting entity, so if there is a requirement to keep an intermediate called number confidential, no PASSporT should be created for that retargeting - the only consequence will be that downstream entities will be unable to correlate an incoming call with the original PASSporT without access to some prior knowledge of the policies that could have caused the retargeting.

Any extension that makes PASSporTs larger creates a potential amplification mechanism for SIP-based DDoS attacks. Since diversion PASSporTs are created as a part of normal forwarding activity, this risk arises at the discretion of the retargeting domain: simply using 3xx response redirections rather than retargeting (by supplying a "div" per Section 7) mitigates the potential impact. Under unusual traffic loads, even domains that might ordinarily retarget requests can switch to redirection.

SIP has an inherent capability to redirect requests, including forking them to multiple parties -- potentially a very large numbers of parties. The use of the "div" PASSporT type does not grant any additional powers to attackers who hope to place bulk calls; if present, the "div" PASSporT instead identifies the party responsible for the forwarding. As such, senders of bulk unsolicited traffic are unlikely to find the use of "div" attractive.

13. References

13.1. Normative References

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13.2. Informative References

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[RFC5806] Levy, S. and M. Mohali, Ed., "Diversion Indication in SIP", RFC 5806, DOI 10.17487/RFC5806, March 2010, <https://www.rfc-editor.org/info/rfc5806>.

[RFC7340] Peterson, J., Schulzrinne, H., and H. Tschofenig, "Secure Telephone Identity Problem Statement and Requirements", RFC 7340, DOI 10.17487/RFC7340, September 2014, <https://www.rfc-editor.org/info/rfc7340>.

[RFC8443] Singh, R., Dolly, M., Das, S., and A. Nguyen, "Personal Assertion Token (PASSporT) Extension for Resource Priority Authorization", RFC 8443, DOI 10.17487/RFC8443, August 2018, <https://www.rfc-editor.org/info/rfc8443>.

Appendix A. Appendix A: Keys for Examples

The following EC256 keys are used in the signing examples given in this document. WARNING: Do not use this key pair in production systems.

```
-----BEGIN PUBLIC KEY-----
MFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAEmzGM1VsO+3IqbMF54rQMaYKQftO4
hUYm9wv5wutLgEd9FsiTy3+4+Wa2O7pffOXPC0QzO+yD8hGEXGP/2mZo6w==
-----END PUBLIC KEY-----

-----BEGIN EC PRIVATE KEY-----
MHcCAQEEIFKCsFZ4Wsw3ZpBxgc4Z0sOjaXDdMk07Ny1fKg6OntAkoAoGCCqGSM49
AwEHoUQDQgAEmzGM1VsO+3IqbMF54rQMaYKQftO4hUYm9wv5wutLgEd9FsiTy3+4
+Wa2O7pffOXPC0QzO+yD8hGEXGP/2mZo6w==
-----END EC PRIVATE KEY-----
```

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Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: September 10, 2020

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March 09, 2020

PASSporT Extension for Rich Call Data
draft-ietf-stir-passport-rcd-06

Abstract

This document extends PASSporT, a token for conveying cryptographically-signed call information about personal communications, to include rich data that can be transmitted and subsequently rendered to users, extending identifying information beyond human-readable display name comparable to the "Caller ID" function common on the telephone network. The element defined for this purpose, Rich Call Data (RCD), is an extensible object defined to either be used as part of STIR or with SIP Call-Info to include related information about calls that helps people decide whether to pick up the phone. This signing of the RCD information is also enhanced with an integrity mechanism to optionally protect the handling of this information between authoritative and non-authoritative parties authoring and signing the Rich Call Data for support of different usage and content policies.

Table of Contents

1. Introduction

PASSporT [RFC8225] is a token format based on JWT [RFC7519] for conveying cryptographically-signed information about the people involved in personal communications; it is used to convey a signed assertion of the identity of the participants in real-time communications established via a protocol like SIP [RFC8224]. The STIR problem statement [RFC7340] declared securing the display name of callers outside of STIR's initial scope, so baseline STIR provides no features for caller name. This specification documents an optional mechanism for PASSporT and the associated STIR mechanisms which extends PASSporT to carry additional elements conveying richer information: information that is intended to be rendered to an end user to assist a called party in determining whether to accept or trust incoming communications. This includes the name of the person on one side of a communications session, the traditional "Caller ID" of the telephone network, along with related display information that would be rendered to the called party during alerting, or potentially used by an automaton to determine whether and how to alert a called party.

Traditional telephone network signaling protocols have long supported delivering a 'calling name' from the originating side, though in practice, the terminating side is often left to derive a name from the calling party number by consulting a local address book or an external database. SIP similarly can carry a 'display-name' in the From header field value from the originating to terminating side, though it is an unsecured field that is not commonly trusted. The same is true of information in the Call-Info header field.

The baseline use case for this document will be extending PASSporT to provide cryptographic protection for the "display-name" field of SIP requests as well as further "rich call data" (RCD) about the caller, which includes the contents of the Call-Info header field or other data structures that can be added to the PASSporT. This document furthermore specifies a third-party profile that would allow external authorities to convey rich information associated with a calling number via a new type of PASSporT. Finally, this document describes how to preserve the integrity of the RCD in scenarios where there may

be non-authoritative users that may be initiating and signing RCD and therefore a constraint on the RCD data that a PASSporT can attest via certificate-level controls.

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 [RFC2119] and [RFC6919].

3. Overview of the use of the Rich Call Data PASSporT extension

The main intended use of the signing of Rich Call Data (RCD) using STIR [RFC8224] and as a PASSporT extension [RFC8225] is from an entity that is associated with the originated with the call. Either the caller themselves if they are authoritative, or a service provider, or a third-party service may be authoritative over the rich call data on behalf of the caller or service provider representing the caller.

The RCD described in this document is of two main categories. The first data is a more traditional set of info about a caller associated with "display-name" in SIP [RFC3261] and typically is the calling name that is a textual description of the caller. The second data is a set of RCD that is defined as part of the jCard definitions or extensions to that data. [I-D.wendt-sipcore-callinfo-rcd] describes the use of jCard as RCD with the "jcard" Call-Info purpose token. Either or both of these two types of data can be incorporated into a "rcd" claim defined in this document.

Additionally, [I-D.wendt-sipcore-callinfo-rcd] also describes a "reason" parameter intended for description of the intent or reason for a particular call. A new claim "crn" for call reason can contain the string or object that describes the intent of the call. This claim is intentionally kept separate from the "rcd" claim because it is envisioned that reason will often change on a more frequent, per call, type of basis and would not fit the "rcdi" claim and other integrity methods tied to the certificate and identity of the caller.

In addition to the type of RCD that can be signed, there are three normative modes of use of the signing of Rich Call Data (RCD). The first and simplest mode is exclusively for when RCD content is directly included as part of the claims (i.e. no URIs are included in the content). In this mode the set of claims is signed via standard PASSporT [RFC8225] and SIP identity header [RFC8224] procedures. The second mode is an extension of the first where a "rcd" claim is included and the content MAY or MAY NOT include a URI identifying

external resources. In this mode, a "rcdi" integrity claim MUST be included. This integrity claim is defined in this document and provides a digest of the content so that, particularly for the case where there is URI references in the RCD, the content of that RCD can be comprehensively validated that it was received as intended by the signer of the PASSporT. The third mode is an extension to both the first and second modes and incorporates the ability to include the digest of the integrity claim as a required value in the certificate used to create the PASSporT digital signature. This mode allows for cases where there is a different authoritative entity responsible for the content of the RCD, separate from the signer of the PASSporT itself allowing the ability to have policy around the content and potential review or pre-determination of allowed RCD content.

4. Overview of Rich Call Data integrity

When incorporating call data that represents a user, even in traditional calling name services today, often there is policy and restrictions around what data is allowed to be used. Whether preventing offensive language or icons or enforcing uniqueness or whatever potential policy either via regulatory rules, a customer service agreements, or an enterprise brand consistency there may be the desire to pre-certify the specific use of rich data. This document defines a mechanism that allows for an indirect party that controls the policy to approve or certify the content, create a cryptographic digest that can be used to validate that data and applies a constraint in the certificate to allow the recipient and verifier to validate that the specific content of the RCD is as intended at its creation and approval or certification.

The integrity mechanism is a process of generating a sufficiently strong cryptographic digest for both the "rcd" claim contents (e.g. "nam" and "jcd") defined below and the resources defined by one or more globally unique HTTPS URLs referenced by the contents (e.g. an image file referenced by "jcd"). This mechanism is inspired and based on the W3C Subresource Integrity specification (http://www.w3.org/TR/SRI/). This mechanism additionally defines the ability to constrain the digest and RCD integrity mechanism to be mandatory without modification using JWT Constraints defined in [RFC8226].

5. PASSporT Claims

5.1. PASSporT "rcd" Claim

This specification defines a new JSON Web Token claim for "rcd", Rich Call Data, the value of which is a JSON object that can contain one

or more key value pairs. This document defines a default set of key values.

5.1.1. "nam" key

The "nam" key value is a display name, associated with the originator of personal communications, which may for example derive from the display-name component of the From header field value of a SIP request, or a similar field in other PASSporT using protocols. This key MUST be included once and MUST be included as part of the "rcd" claim value JSON object. If there is no string associated with a display name, the claim value SHOULD then be an empty string.

5.1.2. "jcd" key

The "jcd" key value is defined to contain a value of a jCard [RFC7095] JSON object. This jCard object is intended to represent and derives from the Call-Info header field value defined in [I-D.wendt-sipcore-callinfo-rcd] with a type of "jcard". As also defined in [I-D.wendt-sipcore-callinfo-rcd], format of the jCard and properties used should follow the normative usage and formatting rules and procedures. It is an extensible object where the calling party can provide both the standard types of information defined in jCard or can use the built-in extensibility of the jCard specification to add additional information. The "jcd" is optional. If included, this key MUST only be included once in the "rcd" JSON object and SHOULD NOT be included if there is a "jcl" key included. The "jcd" and "jcl" keys should be mutually exclusive.

5.1.3. "jcl" key

The "jcl" key value is defined to contain a HTTPS URL that refers the recipient to a jCard [RFC7095] JSON object hosted on a HTTPS enabled web server. This link may derive from the Call-Info header field value defined in [I-D.wendt-sipcore-callinfo-rcd] with a type of "jcard". As also defined in [I-D.wendt-sipcore-callinfo-rcd], format of the jCard and properties used should follow the normative usage and formatting rules and procedures. The "jcl" key is optional. If included, this key MUST only be included once in the "rcd" JSON object and SHOULD NOT be included if there is a "jcd" key included. The "jcd" and "jcl" keys should be mutually exclusive.

5.1.4. "rcdi" RCD integrity Claim

The "rcdi" claim is an optional claim that SHOULD be included if the application requires integrity to be applied to the content of the "rcd" claim and if included MUST be included only once with a

corresponding "rcd" claim. The value of the "rcdi" key pair should contain a string that is defined as follows.

The first part of the string should define the crypto algorithm used to generate the digest. For RCD, implementations MUST support the following hash algorithms, "SHA256", "SHA384", or "SHA512". The SHA-256, SHA-384, and SHA-512 are part of the SHA-2 set of cryptographic hash functions defined by the NIST. Implementations MAY support additional algorithms, but MUST NOT support known weak algorithms such as MD5 or SHA-1. In the future, the list of algorithms may re-evaluated based on security best practices. The algorithms MUST be represented in the text by "sha256", "sha384", or "sha512". The character following the algorithm string MUST be a minus character, "-". The subsequent characters MUST be the base64 encoded digest of a canonicalized and concatenated string based on the "rcd" claim and the URLs contained in the claim. The details of the creation of this string are defined in the next section.

Example:
"rcdi" : "sha256-H8BRh8j48O9oYatfu5AZzq6A9RINQZngK7T62em8MUt1FLm52t+eX6xO"

5.1.5. Creation of the "rcd" digest

In order to facilitate proper verification of the digest and whether the "rcd" content was modified, the input to the digest must be completely deterministic at three points in the process. First, at the certification point where the content is evaluated to conform to the application policy and the JWT Claim Constraints is applied to the certificate containing the digest. Second, when the call is signed at the Authentication Service, there may be a local policy to verify that the provided "rcd" claim corresponds to the digest. Third, when the "rcd" data is verified at the Verification Service, it MUST verify the digest by constructing the "rcd" input digest string.

The procedures for the creation of the "rcd" input digest string is as follows.

1. Arrange the keys in the "rcd" claim value to be in lexicographic order.

2. Serialize the resulting "rcd" claim value JSON object to remove all white space and line breaks. The procedures of this deterministic JSON serialization is defined in [RFC8225], Section 9.

3. Identify, in order of where they appear in the serialized string, all of the URLs referencing external resource files.

4. Construct the "rcd" input string by first inserting the serialized "rcd" claim value.

5. If there is at least one URL identified, insert a semicolon character at the end of the "rcd" serialized string.

6. Follow the semicolon with the Base64 encoded contents of resource file referenced by the first URL.

7. Repeat steps 5 and 6 for any additionally identified corresponding URLs including URLs contained in resources referenced by other URLs. When or if these nested URLs occur in the contents referred to by a parent URL, the insertion of the Base64 encoded contents should be included for all child URLs before moving to any subsequent parent URL.

Once the input serialized string has been created, use this string to create the base64 encoded digest output that can be inserted into the "rcdi" claim as discussed in the last section.

Example "rcd" claim with URL:
```
"rcd": { "nam" : "James Bond",
         "jcl" : "https://example.org/james_bond.json"
       }
```

Example "rcd" input digest string (with line breaks for readability):
```
{"nam":"James Bond","jcl":"https://example.org/james_bond.json"};
ONG##*NCCCDJK123...KLJASlkJlkjsadlf2e3
```

Example "rcdi" claim:
```
"rcdi":"sha256-u5AZzq6A9RINQZngK7T62em8M"
```

5.1.6. JWT Constraint for "rcdi" claim

Once both the contents of the "rcd" claim is certified and the construction of the "rcdi" claim is complete, the "rcdi" digest is linked to the STIR certificate associated with the signature in the PASSporT via JWT Claim Constraints as defined in [RFC8226] Section 8.

The certificate JWT Claims Constraint MUST include both of the following:

- a "mustInclude" for the "rcd" claim

- a "mustInclude" for the "rcdi" claim and a "permittedValues" equal to the created "rcdi" claim value string.

The "permitedValues" for the "rcdi" claim may contain multiple entries, to support the case where the certificate holder is authorized to use different sets of rich call data.

5.2. PASSporT "crn" claim - Call Reason

This specification defines a new JSON Web Token claim for "crn", Call Reason, the value of which is a single string or object that can contains information as defined in [I-D.wendt-sipcore-callinfo-rcd] corresponding to the "reason" parameter for the Call-Info header. This claim is optional.

Example "crn" claim with "rcd":

```
"rcd": { "nam" : "James Bond",
         "jcl" : "https://example.org/james_bond.json"
       },
"crn" : "For your ears only"
```

6. "rcd" and "crn" Claims Usage

Either the "rcd" or "crn" claim may appear in any PASSporT claims object as an optional element. The creator of a PASSporT MAY also add a "ppt" value of "rcd" to the header of a PASSporT as well, in which case the PASSporT claims MUST contain either a "rcd" or "crn" claim, and any entities verifying the PASSporT object will be required to understand the "ppt" extension in order to process the PASSporT in question. A PASSporT header with the "ppt" included will look as follows:

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

The PASSporT claims object will then contain the "rcd" key with its corresponding value. The value of "rcd" is an array of JSON objects, of which one, the "nam" object, is mandatory. The key syntax of "nam" follows the display-name ABNF given in [RFC3261].

After the header and claims PASSporT objects have been constructed, their signature is generated normally per the guidance in [RFC8225].

6.1. Example "rcd" PASSporTs

An example of a "nam" only PASSporT claims obejct is shown next (with line breaks for readability only).

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12025551001"},
   "iat":1443208345,
   "rcd":{"nam":"James Bond"} }
```

An example of a "nam" only PASSporT claims object with an "rcdi" claim is shown next (with line breaks for readability only).

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12025551001"},
   "iat":1443208345,
   "rcd":{"nam":"James Bond"}
   "rcdi":"sha256-H8BRh8j48O9oYatfu5AZzq6A9R6dQZngK7T62em8MUt1FLm52t+eX6xO"
}
```

An example of a PASSporT claims object that includes the "jcd" which is optional, but will also include the mandatory "nam" object is shown next (with line breaks for readability only).

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12155551001"},
   "iat":1443208345,
   "rcd":{"nam":"James Bond","jcd":["vcard",[["version",{},"text","4.0"],
       ["fn",{},"text", "James Bond"],
       ["n",{},"text",["Bond","James","","","Mr."]],
       ["adr",{"type":"work"},"text",
         ["","","3100 Massachusetts Avenue NW","Washington","DC","20008","USA"]
       ],
       ["email",{},"text","007@mi6-hq.com"],
       ["tel",{"type":["voice","text","cell"],"pref":"1"},"uri",
        "tel:+1-202-555-1000"],
       ["tel",{"type":["fax"]},"uri","tel:+1-202-555-1001"],
       ["bday",{},"date","19241116"],
       ["logo",{},"uri",
       "https://upload.wikimedia.org/wikipedia/en/c/c5/Fleming007impression.jpg"
       ]]]}}
```

In an example PASSporT where a jCard is linked via HTTPS URL and "jcl" a jCard file served at a particular URL will be created.

An example jCard JSON file is shown as follows:

```
["vcard",
  [
    ["version", {}, "text", "4.0"],
    ["fn", {}, "text", "James Bond"],
    ["n", {}, "text", ["Bond", "James", "", "", "Mr."]],
    ["adr", {"type":"work"}, "text",
      ["", "", "3100 Massachusetts Avenue NW", "Washington", "DC", "20008",
      "USA"]
    ],
    ["email", {}, "text", "007@mi6-hq.com"],
    ["tel", { "type": ["voice", "text", "cell"], "pref": "1" }, "uri",
      "tel:+1-202-555-1000"],
    ["tel", { "type": ["fax"] }, "uri", "tel:+1-202-555-1001"],
    ["bday", {}, "date", "19241116"]
    ["logo", {}, "uri",
    "https://upload.wikimedia.org/wikipedia/en/c/c5/Fleming007impression.jpg"]
  ]
]
```

If that jCard is hosted at the example address of "https://example.org/james_bond.json", the corresponding PASSporT claims object would be as follows (with line breaks for readability only):

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12155551001"},
   "iat":1443208345,
   "rcd":{"nam":"James Bond","jcl":"https://example.org/james_bond.json"}
   }
```

If we were to add a "rcdi" integrity claim to the last example, the corresponding PASSporT claims object would be as follows (with line breaks for readability only):

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12155551001"},
   "iat":1443208345,
   "rcd":{"nam":"James Bond","jcl":"https://example.org/james_bond.json"}
   "rcdi":"sha256-H8BRh8j48O9oYatfu5AZzq6A9R6dQZngK7T62em8MUt1FLm52t+eX6xO"
   }
```

7. Compact form of "rcd" PASSporT

7.1. Compact form of the "rcd" PASSporT claim

Compact form of an "rcd" PASSporT claim has some restrictions but mainly follows standard PASSporT compact form procedures. For re-construction of the "nam" claim the string for the display-name in

the From header field. For re-construction of the "jcl", the Call-Info header as with purpose "jcard" defined in [I-D.wendt-sipcore-callinfo-rcd] MUST be used. "jcd" claim MAY NOT be used as part of compact form.

7.2. Compact form of the "rcdi" PASSporT claim

Compact form of an "rcdi" PASSPorT claim shall be re-constructed following the same "rcdi" defined digest procedures in this document of all of the content and referenced URI content once downloaded.

7.3. Compact form of the "crn" PASSporT claim

Compact form of a "crn" PASSporT claim shall be re-constructed using the "reason" parameter of a Call-Info header as defined by [I-D.wendt-sipcore-callinfo-rcd].

8. Further Information Associated with Callers

Beyond naming information and the information that can be contained in a jCard [RFC7095] object, there may be additional human-readable information about the calling party that should be rendered to the end user in order to help the called party decide whether or not to pick up the phone. This is not limited to information about the caller, but includes information about the call itself, which may derive from analytics that determine based on call patterns or similar data if the call is likely to be one the called party wants to receive. Such data could include:

- information related to the location of the caller, or
- any organizations or institutions that the caller is associated with, or even categories of institutions (is this a government agency, or a bank, or what have you), or
- hyperlinks to images, such as logos or pictures of faces, or to similar external profile information, or
- information that will be processed by an application before rendering it to a user, like social networking data that shows that an unknown caller is a friend-of-a-friend, or reputation scores derived from crowdsourcing, or confidence scores based on broader analytics about the caller and callee.

All of these data elements would benefit from the secure attestations provided by the STIR and PASSporT frameworks. A new IANA registry has been defined to hold potential values of the "rcd" array; see

Section 14.3. Specific extensions to the "rcd" PASSporT claim are left for future specification.

While in the traditional telephone network, the business relationship between calling customers and their telephone service providers is the ultimate root of information about a calling party's name, some other forms of data like crowdsourced reputation scores might derive from third parties. It is more likely that when those elements are present, they will be in a third-party "rcd" PASSporT.

9. Third-Party Uses

While rich data about the call can be provided by an originating authentication service, the terminating side or an intermediary in the call path could also acquire rich call data by querying a third-party service. Such a service effectively acts as a STIR Authentication Service, generating its own PASSporT, and that PASSporT could be attached to a SIP call by either the originating or terminating side. This third-party PASSporT attests information about the calling number, rather than the call or caller itself, and as such its RCD MUST NOT be used when a call lacks a first-party PASSporT that assures verification services that the calling party number is not spoofed. It is intended to be used in cases when the originating side does not supply a display-name for the caller, so instead some entity in the call path invokes a third-party service to provide rich caller data for a call.

In telephone operations today, a third-party information service is commonly queried with the calling party's number in order to learn the name of the calling party, and potentially other helpful information could also be passed over that interface. The value of using a PASSporT to convey this information from third parties lies largely in the preservation of the original authority's signature over the data, and the potential for the PASSporT to be conveyed from intermediaries to endpoint devices. Effectively, these use cases form a sub-case of out-of-band [I-D.ietf-stir-oob] use cases. The manner in which third-party services are discovered is outside the scope of this document.

An intermediary use case might look as follows: a SIP INVITE carries a display name in its From header field value and an initial PASSporT object without the "rcd" claim. When the a terminating verification service implemented at a SIP proxy server receives this request, and determines that the signature is valid, it might query a third-party service that maps telephone numbers to calling party names. Upon receiving the PASSport in a response from that third-party service, the terminating side could add a new Identity header field to the request for the "rcd" PASSporT object provided by the third-party

service. It would then forward the INVITE to the terminating user agent. If the display name in the "rcd" PASSporT object matches the display name in the INVITE, then the name would presumably be rendered to the end user by the terminating user agent.

A very similar flow could be followed by an intermediary closer to the origination of the call. Presumably such a service could be implemented at an originating network in order to decouple the systems that sign for calling party numbers from the systems that provide rich data about calls.

In an alternative use case, the terminating user agent might query a third-party service. In this case, no new Identity header field would be generated, though the terminating user agent might receive a PASSporT object in return from the third-party service, and use the "rcd" field in the object as a calling name to render to users while alerting.

9.1. Signing as a Third Party

A third-party PASSporT, which contains such an "iss" element, will necessarily be signed with credentials that do not have authority over the identity that appears in the "orig" element of the PASSporT claims. The presence of "iss" signifies that a different category of credential is being used to sign a PASSporT than the [RFC8226] certificates used to sign STIR calls; it is instead a certificate that identifies the source of the "rcd" data. How those credentials are issued and managed is outside the scope of this specification; the value of "iss" however MUST reflect the Organization (O) field of the certificate used to sign a third-party PASSporT. Relying parties in STIR have always been left to make their own authorization decisions about whether or not the trust the signers of PASSporTs, and in the third-party case, where an entity has explicitly queried a service to acquire the PASSporT object, it may be some external trust or business relationship that induces the relying party to trust a PASSporT.

An example of a Third Party issued PASSporT claims object is as follows.

```
{  "orig":{"tn":"12025551000"},
   "dest":{"tn":"12025551001"},
   "iat":1443208345,
   "iss":"Example, Inc.",
   "rcd":{"nam":"James Bond"} }
```

10. Levels of Assurance

As "rcd" can be provided by either first or third parties, relying parties could benefit from an additional claim that indicates the relationship of the attesting party to the caller. Even in first party cases, this admits of some complexity: the Communications Service Provider (CSP) to which a number was assigned might in turn delegate the number to a reseller, who would then sell the number to an enterprise, in which case the CSP might have little insight into the caller's name. In third party cases, a caller's name could derive from any number of data sources, on a spectrum between public data scraped from web searches to a direct business relationship to the caller. As multiple PASSporTs can be associated with the same call, potentially a verification service could receive attestations of the caller name from multiple sources, which have different levels of granularity or accuracy.

Therefore PASSporTs that carry "rcd" data SHOULD also carry an indication of the relationship of the generator of the PASSporT to the caller. [TBD claim - take from SHAKEN?]

11. Using "rcd" in SIP

This section specifies SIP-specific usage for the "rcd" claim in PASSporT, and in the SIP Identity header field value. Other using protocols of PASSporT may define their own usages for the "rcd" claim.

11.1. Authentication Service Behavior

An authentication service creating a PASSporT containing a "rcd" claim MAY include a "ppt" for "rcd" or not. Third-party authentication services following the behavior in Section 9.1 MUST include a "ppt" of "rcd". If "ppt" does contain a "rcd", then any SIP authentication services MUST add a "ppt" parameter to the Identity header containing that PASSporT with a value of "rcd". The resulting Identity header might look as follows:

```
Identity: "sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS7Ltrg9dlxkWzo
    eU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp
    pPqOg1uXndzHbG7mR6Rl9BnUhHufVRbp51Mn3w0gfUs="; \
    info=<https://biloxi.example.org/biloxi.cer>;alg=ES256;ppt="rcd"
```

This specification assumes that by default, a SIP authentication service will derive the value of "rcd", specifically only for the "nam" key value, from the display-name component of the From header field value of the request, alternatively for some calls this may come from the P-Asserted-ID header. It is however a matter of

authentication service policy to decide how it populates the value of "rcd" and "nam" key, which MAY also derive from other fields in the request, from customer profile data, or from access to external services. If the authentication service generates a PASSporT object containing "rcd" with a value that is not equivalent to the From header field display-name value, it MUST use the full form of the PASSporT object in SIP.

11.2. Verification Service Behavior

[RFC8224] Section 6.2 Step 5 requires that specifications defining "ppt" values describe any additional verifier behavior. The behavior specified for the "ppt" values of "rcd" is as follows. If the PASSporT is in compact form, then the verification service SHOULD extract the display-name from the From header field value, if any, and use that as the value for the "rcd" key when it recomputes the header and claims of the PASSporT object. If the signature validates over the recomputed object, then the verification should be considered successful.

However, if the PASSport is in full form with a "ppt" value of "rcd", then the verification service MUST extract the value associated with the "rcd" "nam" key in the object. If the signature validates, then the verification service can use the value of the "rcd" "nam" key as the display name of calling party, which would in turn be rendered to alerted users or otherwise leveraged in accordance with local policy. This will allow SIP networks that convey the display name through a field other than the From header field to interoperate with this specification.

The third-party "rcd" PASSporT cases presents some new challenges, as an attacker could attempt to cut-and-paste such a third-party PASSporT into a SIP request in an effort to get the terminating user agent to render the display name or confidence values it contains to a call that should have no such assurance. A third-party "rcd" PASSporT provides no assurance that the calling party number has not been spoofed: if it is carried in a SIP request, for example, then some other PASSporT in another Identity header field value would have to carry a PASSporT attesting that. A verification service MUST determine that the calling party number shown in the "orig" of the "rcd" PASSporT corresponds to the calling party number of the call it has received, and that the "iat" field of the "rcd" PASSporT is within the date interval that the verification service would ordinarily accept for a PASSporT.

Verification services may alter their authorization policies for the credentials accepted to sign PASSporTs when third parties generate PASSporT objects, per Section 9.1. This may include accepting a

valid signature over a PASSporT even if it is signed with a credential that does not attest authority over the identity in the "orig" claim of the PASSporT, provided that the verification service has some other reason to trust the signer. No further guidance on verification service authorization policy is given here.

The behavior of a SIP UAS upon receiving an INVITE containing a PASSporT object with a "rcd" claim will largely remain a matter of implementation policy. In most cases, implementations would render this calling party name information to the user while alerting. Any user interface additions to express confidence in the veracity of this information are outside the scope of this specification.

12. Using "rcd" as additional claims to other PASSporT extensions

Rich Call Data, including, for example, calling name information, is often data that is additive data to the personal communications information defined in the core PASSporT data required to support the security properties defined in [RFC8225]. For cases where the entity that is originating the personal communications and additionally is supporting the authentication service and also is the authority of the Rich Call Data, rather than creating multiple identity headers with multiple PASSporT extensions or defining multiple combinations and permutations of PASSporT extension definitions, the authentication service can alternatively directly add the "rcd" claims to the PASSporT it is creating, whether it is constructed with a PASSporT extension or not.

12.1. Procedures for applying "rcd" as claims only

For a given PASSporT using some other extension than "rcd", the Authentication Service MAY additionally include the "rcd" claim as defined in this document. This would result in a set of claims that correspond to the original intended extension with the addition of the "rcd" claim.

The Verification service that receives the PASSporT, if it supports this specification and chooses to, should interpret the "rcd" claim as simply just an additional claim intended to deliver and/or validate delivered Rich Call Data.

12.2. Example for applying "rcd" as claims only

In the case of [RFC8588] which is the PASSporT extension supporting the SHAKEN specification [ATIS-1000074], a common case for an Authentication service to co-exist in a CSP network along with the authority over the calling name used for the call. Rather than require two identity headers, the CSP Authentication Service can

apply both the SHAKEN PASSporT claims and extension and simply add the "rcd" required claims defined in this document.

For example, the PASSporT claims for the "shaken" PASSporT with "rcd" claims would be as follows:

```
Protected Header
{
   "alg":"ES256",
   "typ":"passport",
   "ppt":"shaken",
   "x5u":"https://cert.example.org/passport.cer"
}
Payload
{
   "attest":"A",
   "dest":{"tn":["12025551001"]},
   "iat":1443208345,
   "orig":{"tn":"12025551000"},
   "origid":"123e4567-e89b-12d3-a456-426655440000",
   "rcd":{"nam":"James Bond"}
}
```

A Verification Service that supports "rcd" and "shaken" PASSporT extensions will be able to receive the above PASSporT and interpret both the "shaken" claims as well as the "rcd" defined claim.

If the Verification Service only understands the "shaken" extension claims but doesn't support "rcd", the "rcd" can simply be ignored and disregarded.

13. Acknowledgements

We would like to thank David Hancock, Robert Sparks, Russ Housley, and Eric Burger for helpful suggestions and comments.

14. IANA Considerations

14.1. JSON Web Token Claim

This specification requests that the IANA add three new claims to the JSON Web Token Claims registry as defined in [RFC7519].

Claim Name: "rcd"

Claim Description: Rich Call Data Information

Change Controller: IESG

Specification Document(s): [RFCThis]

Claim Name: "rcdi"

Claim Description: Rich Call Data Integrity Information

Change Controller: IESG

Specification Document(s): [RFCThis]

Claim Name: "crn"

Claim Description: Call Reason

Change Controller: IESG

Specification Document(s): [RFCThis]

14.2. PASSporT Types

This specification requests that the IANA add a new entry to the PASSporT Types registry for the type "rcd" which is specified in [RFCThis].

14.3. PASSporT RCD Types

This document requests that the IANA create a new registry for PASSporT RCD types. Registration of new PASSporT RCD types shall be under the Specification Required policy.

This registry is to be initially populated with three values, "nam", "jcd", and "jcl", which are specified in [RFCThis].

15. Security Considerations

Revealing information such as the name, location, and affiliation of a person necessarily entails certain privacy risks. Baseline PASSporT has no particular confidentiality requirement, as the information it signs over in a using protocol like SIP is all information that SIP carries in the clear anyway. Transport-level security can hide those SIP fields from eavesdroppers, and the same confidentiality mechanisms would protect any PASSporT(s) carried in SIP.

16. References

16.1. Normative References

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16.2. Informative References

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STIR
Internet-Draft
Intended status: Standards Track
Expires: January 14, 2021

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July 13, 2020

Assertion Values for a Resource Priority Header Claim and a SIP Priority Header Claim in Support of Emergency Services Networks
draft-ietf-stir-rph-emergency-services-02

Abstract

This document adds new assertion values for a Resource Priority Header ("rph") claim and a new SIP Priority Header claim ("sph") for protection of the "psap-callback" value as part of the "rph" PASSporT extension, in support of the security of Emergency Services Networks for emergency call origination and callback.

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 January 14, 2021.

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1. Introduction

Personal Assertion Token (PASSporT) Extension for Resource Priority Authorization [RFC8443] extended the Personal Assertion Token (PASSporT) specification defined in [RFC8225] to allow the inclusion of cryptographically signed assertions of authorization for the values populated in the Session Initiation Protocol (SIP) "Resource-Priority" header field [RFC4412], which is used for communications resource prioritization and the SIP "Priority" header field, used for categorizing the priority use of the call.

Compromise of the SIP "Resource-Priority" header field could lead to misuse of network resources (i.e., during congestion scenarios), impacting the application services supported using the SIP "Resource-Priority" header field.

[RFC8225] allows extensions by which an authority on the originating side verifying the authorization of a particular communication for the SIP "Resource-Priority" header field or the SIP "Priority" header field can use PASSPorT claims to cryptographically sign the information associated with either the SIP "Resource-Priority" or "Priority" header fields and convey assertion of those values by the signing party authorization. A signed SIP "Resource-Priority" or "Priority" header fields will allow a receiving entity (including entities located in different network domains/boundaries) to verify

the validity of assertions to act on the information with confidence that the information has not been spoofed or compromised.

This document adds new assertion values for a Resource Priority Header ("rph") claim defined in [RFC8443], in support of Emergency Services Networks for emergency call origination and callback. This document also defines a new claim, "sph", including protection of the SIP Priority header for the indication of an emergency service call-back assigned the value "psap-callback" as defined in [RFC7090]. The use of these new assertion values for real-time communications supported using the SIP 'Resource-Priority' and 'Priority' header fields for emergency services is introduced in [I-D.rosen-stir-emergency-calls] but otherwise out-of-scope of this document. In addition, the PASSPorT claims and values defined in this document are intended for use in environments where there are means to verify that the signer of the SIP 'Resource-Priority' and 'Priority' header fields is authoritative.

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. New Assertion Values for "rph" claim

This specification defines new assertions values for:

* "ESorig": Emergency Services call origination
* "EScallback": Emergency Services callback.

3.1. ESorig

When using "ESorig" as the "rph" assertion value, the "orig" claim of the PASSporT MUST represent the calling party number that initiates the call to emergency services. The "dest" claim MUST either be a country or region specific dial string (e.g., "911" for North America or "112" GSM defined string used in Europe and other countries) or "urn:service:sos" as defined in TBD, representing the emergency services destination of the call.

The following is an example of an "rph" claim for SIP 'Resource-Priority' header field with a "ESorig" assertion:

```
{
  "orig":{"tn":"12155551212"},
  "dest":{["uri":"urn:service:sos"]},
  "iat":1443208345,
  "rph":{"ESorig":["esnet,x"]}
}
```

3.2. EScallback

When using "EScallback" as the "rph" assertion value, the "orig" claim of the PASSporT MUST represent the emergency network telephone number. The "dest" claim MUST be the telephone number representing the original calling party of the emergency service call that is being called back.

The following is an example of an "rph" claim for SIP 'Resource-Priority' header field with a "EScallback" assertion:

```
{
  "orig":{"tn":"12155551213"},
  "dest":{["tn":"12155551212"]},
  "iat":1443208345,
  "rph":{"EScallback":["esnet,x"]}
}
```

After the header and claims PASSporT objects have been constructed, their signature is generated normally per the guidance in [RFC8225] using the full form of PASSPorT. The credentials (i.e., Certificate) used to create the signature must have authority over the namespace of the "rph" claim, and there is only one authority per claim. The authority MUST use its credentials associated with the specific service supported by the resource priority namespace in the claim. If r-values are added or dropped by the intermediaries along the path, the intermediaries must generate a new "rph" header and sign the claim with their own authority.

4. The SIP Priority header "sph" claim

As discussed in [I-D.rosen-stir-emergency-calls], and as defined in [RFC7090] the SIP Priority header may be set to the value "psap-callback" for emergency services callback calls. Because some SIP networks may act on this value and provide priority or other special routing based on this value, it is important to protect and validate the authoritative use associated with it.

Therefore, we define a new claim key as part of the "rph" PASSporT, "sph", which MUST be used only for authorized emergency callbacks and correspond to a SIP Priority header with the value "psap-callback".

The value of the "sph" claim key should only be "psap-callback" to match the SIP Priority header field value for authorized emergency services callbacks.

The following is an example of an "sph" claim for SIP 'Priority' header field with the value "psap-callback":

```
{
  "orig":{"tn":"12155551213"},
  "dest":{["tn":"12155551212"]},
  "iat":1443208345,
  "rph":{"EScallback":["esnet,x"]},
  "sph":"psap-callback"
}
```

5. Order of Claim Keys

The order of the claim keys MUST follow the rules of [RFC8225] Section 9; the claim keys MUST appear in lexicographic order. Therefore, the claim keys discussed in this document appear in the PASSporT Payload in the following order,

- dest
- iat
- orig
- rph
- sph

6. Compact Form of PASSporT

The use of the compact form of PASSporT is not specified in this document or recommended for 'rph' PASSporTs.

7. IANA Considerations

7.1. PASSporT Resource Priority Header (rph) Types

This specification requests that the IANA add two new assertion values to the "PASSporT Resource Priority Header (rph) Types" Registry as defined in [RFC8443].

The following assertion values will be added to the registry:

* "ESorig": Emergency Services call origination
* "EScallback": Emergency Services callback

rph Type	Reference
ESorig	[this RFC]
EScallback	[this RFC]

7.2. JSON Web Token claims

This specification requests that the IANA add two new claims to the JSON Web Token Claims registry as defined in [RFC7519].

Claim Name: "sph"

Claim Description: SIP Priority header field

Change Controller: IESG

Specification Document(s): [RFCThis]

8. Security Considerations

The security considerations discussed in [RFC8224], Section 12, are applicable here.

9. References

9.1. Normative References

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Network Working Group
Internet-Draft
Intended status: Informational
Expires: January 14, 2021

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July 13, 2020

Out-of-Band STIR for Service Providers
draft-peterson-stir-servprovider-oob-01

Abstract

The Secure Telephone Identity Revisited (STIR) framework defines means of carrying its Persona Assertion Tokens (PASSporTs) either in-band, within the headers of a SIP request, or out-of-band, through a service that stores PASSporTs for retrieval by relying parties. This specification defines a way that the out-of-band conveyance of PASSporTs can be used to support large service providers, for cases in which in-band STIR conveyance is not universally available.

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1. Introduction

STIR [RFC8224] provides a cryptographic assurance of the identity of calling parties in order to prevent impersonation, which is a key enabler of unwanted robocalls, swatting, vishing, voicemail hacking, and similar attacks (see [RFC7340]). The STIR out-of-band [I-D.ietf-stir-oob] framework enables the delivery of PASSporT [RFC8225] objects through a Call Placement Service (CPS), rather than carrying them within a signaling protocol such as SIP. Out-of-band conveyance is valuable when end-to-end SIP delivery of calls is partly or entirely unavailable due to network border policies, calls routinely transitting a gateway to the PSTN, or similar circumstances.

While out-of-band STIR can be implemented as an open Internet service, it then requires complex security measures to enable the CPS function without allowing the CPS to collect data about the parties placing calls. This specification describes CPS implementations that act specifically on behalf of service providers who will be processing the calls that STIR secures, and who thus will learn about the parties to communication independently, so an alternative security architecture becomes possible.

Environments that might support this flavor of STIR out-of-band include carriers, large enterprises, call centers, or any Internet service that aggregates on behalf of a large number of telephone endpoints.

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. Service Provider Deployment Architecture for Out-of-Band STIR

The architecture in this specification assumes that every participating service provider will advertise one or more designated CPS instances. A service provider's CPS serves as a place where callers can deposit a PASSporT when attempting to place a call to a subscriber of the destination service provider; if the caller's domain supports in-band STIR, this can be done at the same time as an in-band STIR call is placed. The terminating service provider could operate the CPS themselves, or a third party could operate the CPS on the destination's behalf. This model does not assume a monolithic CPS that acts on behalf of all service providers, but nor does it prohibit multiple service providers from sharing a CPS provider.

The process of locating a destination CPS and submitting a PASSporT requires Internet connectivity between the call originator and the destination network. Ordinarily, that network connectivity could be leveraged to initiate a SIP session, during which in-band STIR could be used. The applicability of this architecture is therefore to those cases where, for whatever reason, SIP calls cannot reliably be placed end-to-end, but an HTTP transaction can reliably be sent to the destination network from the out-of-band authentication service (OOB-AS) in the caller's network. It is hoped that as IP connectivity between telephone providers increases, there will be less need for an out-of-band mechanism, but it can serve as a fallback mechanism in cases where service providers cannot predict whether end-to-end delivery of SIP calls will occur.

4. Advertising a CPS

Many services providers have bilateral agreements to peer with one another, and in those environments, identifying their respective CPS's could be a simple matter of provisioning. In more pluralist environments, some mechanism is needed to discover the CPS associated with the target of a call.

In order to allow the CPS chosen by a service provider to be discovered securely, this specification defines a CPS advertisement. Effectively, a CPS advertisement is a document which contains the URL of a CPS, as well as any information needed to determine which

PASSporTs should be submitted to that CPS. An advertisement may be signed with a STIR [RFC8226] credential, or another credential that is trusted by the participants in a given STIR environment. The advantage to signing with STIR certificates is that they contain a "TNAuthList" value indicating the telephone network resources that a service provider controls. This information can be matched with a TNAuthList value in the CPS advertisement to determine whether the signer has the authority to advertise a particular CPS as the proper destination for PASSporTs.

The format of a service provider CPS advertisement is a simple JSON object containing one or more pairs of TNAuthList values pointing to the URIs of CPSs, e.g. { "1234":"https://cps.example.com" }. TNAuthList values can be either Service Provider Codes (SPCs) or telephone numbers or number ranges. CPS URIs MUST be HTTPS URIs. [More TBD].

CPS advertisements could be made available through existing or new databases, potentially aggregated across multiple service providers and distributed to call originators as necessary. They could be discovered during the call routing process, including through a DNS lookup. They could be shared through a distributed database among the participants in a multilateral peering arrangement.

An alternative to CPS advertisements that may be usable in some environments is adding a field to STIR [RFC8226] credentials issued to individual service providers. As these certificates are themselves signed by a CA, the URI would be bound securely to the service provider. As STIR assumes a community of relying parties who trust these credentials, this method perhaps best mirrors the trust model required to allow a CPS to authorize PASSporT submission and retrieval.

5. Submitting a PASSporT

Submitting a PASSporT to a CPS as specified in the STIR out-of-band framework [I-D.ietf-stir-oob] requires security measures which are intended to prevent the CPS from learning the identity of the caller (or callee), to the degree possible. In this service provider case, however, the CPS is operated by the service provider of the callee (or an entity operating on their behalf), and as such the information that appears in the PASSporT is redundant with call signaling that the terminating party will receive anyway. Therefore, the service provider out-of-band framework does not attempt to conceal the identity of the originating or terminating party from the CPS.

An out-of-band authentication service (OOB-AS) forms a secure connection with the target CPS. This may happen at the time a call

is being placed, or it may be a persistent connection, if there is a significant volume of traffic sent over this interface. The OOB-AS SHOULD authenticate itself to the CPS using its STIR credential [RFC8226]the same one it would use to sign calls via mutual TLS; this helps mitigate the risk of flooding that more open OOB implementations may face. Furthermore, use of mutual TLS prevents attackers from replaying captured PASSporTs to the CPS. A CPS makes its own policy decision as to whether it will accept calls from a particular OOB-AS, and at what volumes.

Service provider out-of-band PASSporTs do not need to be encrypted for storage at the CPS, although use of transport-layer security to prevent eavesdropping on the connection between the CPS and OOB-ASs is REQUIRED. PASSporTs will be submitted to the CPS at the time they are created by an AS; if the PASSporT is also being used for in-band transit within a SIP request, the PASSporT can be submitted to the CPS before or after the SIP request is sent, at the discretion of the originating domain. An OOB-AS will use a REST interface to submit PASSporTs to the CPS as described in [I-D.ietf-stir-oob] Section 9 [more TBD]. PASSporTs are persisted by the CPS for as long as is required for them to be retrieved (see the next section), but in any event for no longer than the freshness interval of the PASSporT itself (a maximum of sixty seconds).

6. PASSporT Retrieval

The STIR out-of-band framework [I-D.ietf-stir-oob] proposes two means that called parties can acquire PASSporTs out-of-band: through a retrieval interface, or through a subscription interface. In the service provider context, where many calls occur simultaneously, an out-of-band capable verification service may therefore operate in one of two modes: it can either pull PASSporTs from the CPS after calls arrive, or receive push notifications from the CPS for incoming calls.

If a CPS serves only one service provider, then all PASSporTs submitted to the CPS are made available to the OOB-VS of that provider; indeed, the CPS and OOB-VS may be colocated or effectively operated as a consolidated system. In a multi-provider environment, the STIR credential of the terminating domain can be used by the CPS to determine the range of TNAuthLists for which an OOB-VS is entitled to receive PASSporTs. Note that a CPS will need to inspect the "dest" element of a PASSporT to determine which OOB-VS should receive the PASSporT in this case. [TBD: Which sub/not protocol to use for the case where the CPS and OOB-VS are not composed in a single function?]

Pulling of PASSporTs from the CPS will follow the basic REST flow described in [I-D.ietf-stir-oob] Section 9. In the push interface case, exactly how a CPS determines which PASSporTs to send to an out-of-band verification service is a matter of implementation. An OOB-VS could for example subscribe to a range of telephone numbers, which will be directed to that OOB-VS by the CPS (provided the OOB-VS is authorized to receive them by the CPS).

In the pull model, a terminating service provider contacts the CPS via its OOB-VS after having received a call in cases when the call signaling does not itself carry a STIR signature. In the push model, a PASSporT might be sent to the OOB-VS either before or after unsigned call signaling has been received by the terminating domain. Domains using the push model may therefore need to adopt a model where call signaling is held momentarily in order to await the potential arrival of a PASSporT at the OOB-VS. The exact timing of this, and its interaction with the substitution attack described in [I-D.ietf-stir-oob] Section 7.4, will be the covered by future versions of this specification.

7. Gateways

In some deployment architectures, gateways might perform a function that interfaces with a CPS for the retrieval or storage of PASSporTs. For example, a closed network of in-band STIR providers may send SIP INVITEs to a gateway in front of a traditional PSTN tandem that services a set of legacy service providers. In that environment, a gateway might take a PASSporT out of in-band SIP INVITEs and store it in a CPS that was established to handle requests for one or more legacy providers, who in turn consume those PASSporTs through an OOB-VS to assist in robocall mitigation and similar functions.

The simplest way to interface a gateway performing this sort of function for a service provider CPS system is to issue credentials to the gateway that allow it to act on behalf of the legacy service providers it supports: this would allow it to both add PASSporTs to the CPS acting on behalf of the legacy providers, and also to create PASSporTs for in-band STIR conveyance from the legacy-providers to terminating service providers in the closed STIR network.

8. Acknowledgments

We would like to thank Alex Fenichel for contributions to this specification.

9. IANA Considerations

This memo includes no request to IANA.

10. Security Considerations

TBD.

11. Informative References

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stir
Internet-Draft
Intended status: Standards Track
Expires: September 10, 2020

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March 9, 2020

Non-Interactive Emergency Calls
draft-rosen-stir-emergency-calls-00

Abstract

Emergency calls from citizens to authorities, and call back of such emergency calls by authorities to citizens need assurances that headers intended to get appropriate priority from the networks they traverse, and in some cases, appropriate routing. Protection of the SIP Resource Priority Header and the SIP Priority header is needed for such calls. This document describes the environment for placing emergency calls and call backs which motivate the need and use of the mechanisms described in other documents

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1. Introduction

[RFC6643] describes how devices use the Internet to place emergency calls and how Public Safety Answering Points (PSAPs) handle Internet emergency calls. In traditional telephone networks, emergency calls are not afforded any priority in the network. Emergency calls are marked with a Service URN, [RFC5031].

Sometimes, the emergency services need to call the person that placed an emergency call after the original emergency call was terminated. This is a case of "call-back". [RFC7090] discusses using SIP Priority to mark a call as a call back. The Resource Priority Header, [RFC4412] defines a way to request the network afford priority in resources: The 'Priority' header field describes the importance that the SIP request should have for the receiving human or its agent. For example, that header may be factored into decisions about call routing to mobile devices and assistants and about call acceptance when the call destination is busy. The 'Priority' header field does not affect the usage of PSTN gateway or proxy resources, for example. In addition, any User Agent Client (UAC) can assert any 'Priority' value, and usage of 'Resource-Priority' header field values is subject to authorization.

This document describes the environment for placing emergency calls on the Internet, which has different capabilities than the PSTN, as well as call backs across the Internet and describes the requirements for protecting them with the "stir" mechanism.

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.

SIP is the Session Initiation Protocol [RFC3261]

PSAP is a Public Safety Answering Point, the call center for emergency calls.

3. Emergency Calls

SIP signaling for emergency calls is defined in [RFC6881]. An emergency call is marked with a Service URN [RFC5031] in the Request-URI field. RFC6881 does not have any recommendations for the Resource Priority Header. Emergency calls will make use of the stir mechanism to assure the PSAP that the calling party identifier is accurate. There are numerous cases of what is called "swatting" where an emergency call with a spoofed identity is placed and the caller fraudulently reports serious criminal activity at some address, prompting the authorities to respond with significant force (SWAT team). By validating the identity, authorities hope swatting will become much less possible.

It is desirable in some networks to be able to provide some priority in the call handling network for emergency calls, even though the PSTN does not do that. [RFC7135] defines the "esnet" namespace, and 4 priority levels "for local emergency session establishment to a public safety answering point (PSAP), between PSAPs, and between a PSAP and first responders and their organizations. ". There is presently no recommendation for what priority level to assign to emergency calls. There are other documents [i3] that describe how to use the esnet values within an Emergency Services IP Network, which is distinct from the originating service provider networks, over which emergency calls may be placed.

This document recommends that emergency calls from outside an Emergency Services IP Network be assigned esnet.0. This document makes no recommendations on what originating service provider networks actually provide for resource priority other than to note the obvious: emergency calls should receive some priority for resources.

Whatever the network does with the RPH value, it is desirable to protect it from manipulation and

[I-D.ietf-stir-rph-emergency-services] provides the mechanism to accomplish that.

4. Emergency Call-backs

After an emergency call is placed, it is sometimes necessary for the PSAP, or a responder, to call the caller back. This call is placed by the authorities back to the original caller. [RFC7090] describes the use of the SIP Priority header field, with the value "psap-callback" to mark such calls and describes how called networks may use that marking. RFC7090 does not describe any priority, and does not mention use of the Resource Priority header field. There is no protection against misuse of the SIP Priority field, and because, as RFC7090 illustrates, it may affect routing, it is very desirable to protect it from modification.

This document recommends that emergency calls-backs from authorities outside an ESInet contain a Resource Priority header field and be assigned esnet.0. This document makes no recommendations on what service provider networks actually provide for resource priority other than to note the obvious: emergency calls-backs should receive some priority for resources.

Many countries are starting to adopt the emergency calling paradigms promulgated by the IETF. For example, in North America, the [i3] standard defines IP based emergency calling networks, drawing from IETF work. In those systems, a PKI is being created, with a trusted root, the "PSAP Credentialing Agency" (PCA). The PCA provides a root of trust that could be used to sign call-backs protecting the SIP Priority and Resource Priority header fields.

5. IANA Considerations

There are no actions requested of IANA in this document

6. Security Considerations

TBD

7. Acknowledgments

TBD

8. References

8.1. Normative References

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