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PASSPorT Extension for P-Charge-Info Header
draft-asveren-stir-p-charge-info-00

Abstract

This document extends the PASSport (Personal Assertion Token) specification defined in [RFC8225] to allow the inclusion of cryptographically signed assertions of authorization for the values populated in the 'Session Initiation Protocol (SIP) P-Charge-Info' header, which is used for conveying information about the entity to be charged for a particular real time session.

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1. Introduction

PASSport RFC 8225 [RFC8225] is a token format based on JSON Web Token (JWT) RFC 7519 [RFC7519] for conveying cryptographically signed information about the identities involved in personal communications; it is used with STIR RFC 8224 [RFC8224] to convey a signed assertion of the identity of the participants in real-time communications established via a protocol like SIP RFC 3261 [RFC3261]. This specification extends PASSport to allow cryptographic-signing of the 'SIP P-Charge-Info' header [RFCXXX], which is used to provide information about the party to be charged for a real time session.

'SIP P-Charge-Info' header could be spoofed and abused by unauthorized entities. Compromise of the 'SIP P-Charge-Info' header would allow charging fraud.

Extension mechanisms defined in RFC8225 can be utilized to cryptographically sign the 'SIP P-Charge-Info' header. This would allow a receiving entity to verify the validity of this header.

This specification documents an extension to PASSport and the associated STIR mechanisms to provide a function to sign the 'SIP P-Charge-Info' header.

2. Requirements Language

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

3. PASSPortT 'pci' Claim

This specification defines a new JSON Web Token claim for "pci", which provides an assertion for information in 'SIP P-Charge-Info' header.

The creator of a PASSPortT object adds a "ppt" value of "pci" to the header of a PASSPortT object, in which case the PASSPortT claims MUST contain a "pci" claim, and any entities verifying the PASSPortT object will be required to understand the "ppt" extension in order to process the PASSPortT in question. A PASSPortT header with the "ppt" included will look as follows:

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

The "pci" claim will provide an assertion for information in the 'SIP P-Charge-Info' header as defined in [RFCXXX] .

After the header and claims PASSPortT objects have been constructed, their signature is generated normally per the guidance in [RFC8225]. The credentials (i.e., Certificate) used to create the signature must have authority over the "pci" claim and there is only one authority per claim. If P-Charge-Info header is added or by the intermediaries along the path, intermediaries must generate a new "pci" header and sign the claim with its own authority.

The following is an example "pci" claim for a 'SIP P-Charge-Info' header field with a value of "12125550100"

```
{
  "orig": {"tn": "12155550112"},
  "dest": [{"tn": "12125550113"}],
  "iat": 1443208345,
  "pci": [{"tn": "12125550100"}]
}
```

4. Using 'pci' in SIP

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

4.1. Authentication Service Behavior

An authentication service adds an Identity header field containing the "pci" PASSporT type to an SIP request only if it adds a P-Charge-Info header to the request. Whether to add such an Identity header is controlled by local policy. When adding an Identity header field with a PASSporT object containing a "pci" claim, SIP authentication services MUST also add a "ppt" parameter to that Identity header with a value of "pci". The resulting Identity header field to add to the message might look as follows:

```
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I \
joiaHR0cHM6Ly9jZXJ0LmV4YWlwbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \
kZXN0Ijpw7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImhhdC \
I6IjE0NDMyMDgzNDUiLCJvcmlnIjpw7InRuIjoimTIxNTU1NTEyMTIifX0.r \
q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs \
ojNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org \
/biloxi.cert>;alg=ES256;ppt="pci"
```

4.2. Verification Service Behavior

RFC 8224 [RFC8224] Section 6.2 Step 5 requires that specifications defining "ppt" values describe any additional verifier behavior. The behavior specified for the "pci" value of "ppt" is as follows. The verification service MUST extract the value associated with the "pci" key in a PASSporT with a "ppt" value of "pci". If the signature validates, then the verification service can use the value of the "pci" claim as validation that P-Charge-Info in the received request is authentic. The verifier MUST also ensure that the generator of Identity header is authorized to declare the value used for P-Charge-Info as the party to be charged. How this can be achieved is out of the scope of this specification.

4.3. Other Behavior

An entity dropping P-Charge-Info MUST drop the corresponding Identity header with "ppt" parameter value of "pci".

5. IANA Considerations

This specification requests that the IANA add a new claim to the JSON Web Token Claims registry as defined in RFC 7519 [RFC7519].

Claim Name: "pci"

Claim Description: Party to be charged for a session

Change Controller: IESG

Specification Document(s): [RFCThis]

6. Security Considerations

This specification describes a security feature, and is primarily concerned with increasing security for information regarding the party to be charged for a real time session.

A malicious entity may add a P-Charge-Info value and a corresponding Identity header for charge abuse. This would be detected either because the signature validation fails or because the malicious entity does not have authority to declare the value of P-Charge-Info as the party to be charged.

A malicious entity may drop the P-Charge-Info and the corresponding Identity header. This would cause information about the actual party to charge not being present for a receiver entity which otherwise would use it for billing purposes. One way to avoid this type of attack would be, for example, to enforce presence of P-Charge-Info header by the billing entity and reject the session if there is none. This check may be performed only for certain sessions based on origination and/or destination identity for the call.

7. Acknowledgements

8. Informative References

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Session Initiation Protocol (SIP) Call Flow Examples with PASSport
Diversion and History-Info
draft-barnes-stir-passport-div-hi-callflows-02

Abstract

This document focuses on use cases and call flows which include the History-Info header field and a SIP Identity header field with a PASSport with a "div" claim in cases of retargeting. These use cases are derived from those provided in the SIP History-Info call flows document. The objective is to describe the optimal way to correlate the History-Info header fields with a PASSport with diversion information to increase the level of confidence in the History-Info header field by the terminating entity making use of the information.

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1. Overview

Many services that use SIP require the ability to determine why and how the call arrived at a specific application. The use cases provided in [RFC7131] illustrate the use of the History-Info header field [RFC7044] for example applications and common scenarios. The document [I-D.ietf-stir-passport-divert] extends the PASSport, defined in [RFC8225] to cryptographically-sign the calling party information, to include an indication that a call has been diverted from its original destination to a new one. This document discusses the applicability and use of this PASSport extension for diverted calls in the context of scenarios for which use of the History-Info header field is essential for processing by the terminating entity. Descriptions of the example use cases, call flow diagrams and messaging details including both History-Info header field and a SIP Identity header field with a PASSport capturing the retargeted identity are provided.

2. Conventions and Terminology

The term "retarget" is used as defined in [RFC7044]. The term "divert" refers to a specific type of retargeting and is used per the context in [I-D.ietf-stir-passport-divert]. The terms "location service", "redirect" and "address-of-record (AOR)" are used consistent with the terminology in [RFC3261].

3. Detailed call flows

The scenarios in this section provide sample use cases for the History-Info header along with a PASSporT(s) containing the retargeted identity for informational purposes only. They are not intended to be normative. In many cases, only the relevant messaging details are included in the body of the call flow.

The current objective of these call flows is for discussion purposes to determine if the current set of information proposed to be captured in the PASSporT in cases of retargeting is sufficient. It is anticipated that the cases where a "div" PASSporT is added would be cases where the a History-Info header field has been added and tagged "mp", indicating the hi-targeted-to-URI represents a user other than the target user associated with the Request-URI in the incoming request that was retargeted.

Given that the History-Info header field captures a full set of information as to why a request is retargeted, it might seem reasonable to just add the PASSporT to the History-Info header field as opposed to adding a new Identity header field in cases of retargeting. However, in that case, that would then require the terminating user to search the History-Info entries to determine if the request was "diverted" and whether the identity at the point of retargeting was authenticated. An alternative is that rather than just adding the retargeted destination, the complete History-Info header field could be added to the PASSporT. This could increase the confidence at the terminating user that all the information is valid. At a minimum the "index" should be included as it's possible to have entries containing the same target. For example, a proxy forwards a request in the case of loose routing and then the request is retargeted at the next hop. Also, there are cases whereby the first entry with a specific tag is most relevant. Thus, being able to at least correlate the contents of that entry with a PASSporT with diverted information could be quite useful.

Editor's note: currently, there are only two examples - consumer and PBX voicemail. It's probably quite useful to document more of the flows once there is agreement on the best approach for correlating the information.

3.1. PBX Voicemail Example

A typical use case for voicemail is one whereby the original called party is not reachable and the call arrives at a voicemail system. In some cases multiple alternate destinations may be tried without success. The voicemail system typically requires the original called party information to determine the appropriate mailbox so an

appropriate greeting can be provided and the appropriate party notified of the message.

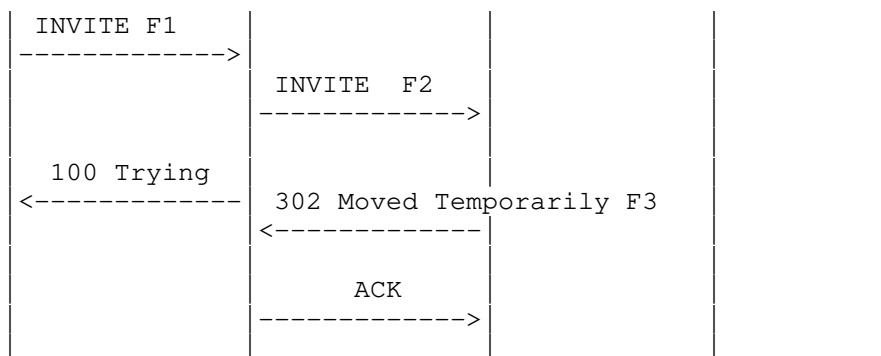
In this example, Alice calls Bob, whose SIP client is forwarded to Carol. Carol does not answer the call, thus it is forwarded to a VM (voicemail) server (VMS). In order to determine the appropriate mailbox to use for this call, the VMS needs the original target for the request. The original target is determined by finding the first hi-entry tagged with "rc" or "mp" and using the hi-entry referenced by the index of "rc" or "mp" header field parameter as the target for determining the appropriate mailbox. This first hi-entry is used to populate the "target" URI parameter as defined in [RFC4458].

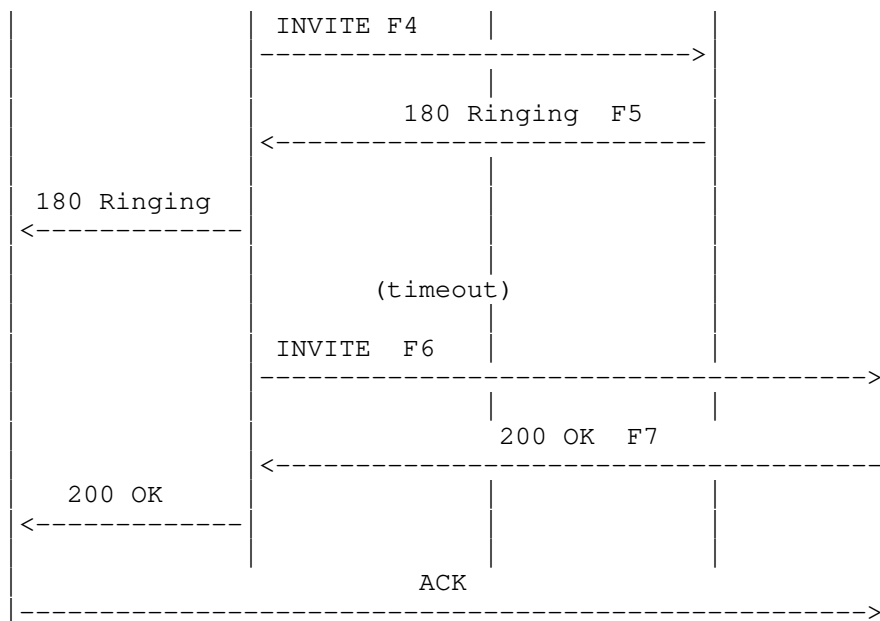
If the SIP Identity header field with "div" claims has been added by the entities retargeting, it can be ascertained that the call should be forwarded to Bob's voicemail prior to forwarding the call to voicemail. The value of the "tn" in the "div" field of the claim should match the hi-targeted-to URI in the hi-entry with the hi-index matching the "hi" value in the "div" claim.

The reason associated with the first hi-entry tagged with "rc" or "mp" (i.e., 302) could be used to provide a customized voicemail greeting and is used to populate the "cause" URI parameter as defined in [RFC4458]. Note that some VMSs may also (or instead) use the information available in the History-Info headers for custom handling of the VM based on how and why the call arrived at the VMS.

Furthermore it is the proxy forwarding the call to VMS that determines the target of the voicemail, it is the proxy that sets the target of voicemail which is also the entity that utilizes [RFC7044] to find the target which is usually based on local policy installed by the user or an administrator.

Alice	example.com	Bob	Carol	VM
12155551211		12155551212	12155551213	





F1 INVITE Alice -> Example.com

```

INVITE sip:bob@example.com SIP/2.0
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 70
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
Contact: Alice <sip:12155551211@example.com;user=phone>
Content-Length: <appropriate value>
  
```

[SDP Not Shown]

F2 INVITE Example.com -> Bob

```

INVITE sip:12155551212@example.com;user=phone SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK12s4
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 69
From: Alice <sip:alice@example.com>;tag=kkaz-
  
```

To: Bob <sip:bob@example.com>;tag=1928301774>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:12155551212@example.com;user=phone>;\
index=1.1;rc=1
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I \\
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \\
kZXN0Ijpw7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImhhdC \\
I6IjE0NDMyMDgzNDUiLCJvcmlnIjpw7InRuIjoimTIxNTU1NTEyMTIifX0.r \\
q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjplk-cpFYpFYs \\
ojNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org \\
/biloxi.cert>;alg=ES256
Contact: Alice <sip:12155551211@example.com;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F3 302 Moved Temporarily Bob -> Example.com

SIP/2.0 302 Moved Temporarily
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK12s4;\
received=192.0.2.101
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>;tag=2g22d-lnf
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:12155551212@example.com;user=phone>;\
index=1.1;rc=1
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I \\
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \\
kZXN0Ijpw7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImhhdC \\
I6IjE0NDMyMDgzNDUiLCJvcmlnIjpw7InRuIjoimTIxNTU1NTEyMTIifX0.r \\
q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjplk-cpFYpFYs \\
ojNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org \\
/biloxi.cert>;alg=ES256
Contact: <sip:carol@example.com>;mp=1
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F4 INVITE Example.com -> Carol

```
INVITE sip:12155551213@example.com;user=phone SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK4522
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 69
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:12155551212@example.com;user=phone?\\
Reason=SIP%3Bcause%3D302>;\\
index=1.1;rc=1
History-Info: <sip:carol@example.com;cause=480>;index=1.2;mp=1
History-Info: <sip:12155551213@example.com;user=phone;cause=480>;\\
index=1.2.1;rc=1.2
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I \\
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \\
kZXN0Ijpw7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sIm \\
I6IjE0NDMyMDgzNDUiLCJvcmlnIjpw7InRuIjoimTIxNTU1NTEyMTIifX0.r \\
q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjplk-cpFYpFYs \\
ojNCpTzO3QfPOlckGaS6hEck7w;info=<https://biloxi.example.org \\
/biloxi.cert>;alg=ES256
Identity:..sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS7L \\
eU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp \\
pPqOgluXndzHbG7mR6Rl9BnUhufVRbp51Mn3w0gfUs;; \\
info=<https://atlanta.example.com/atlanta.cert>;alg=ES256; \\
ppt=div
Contact: Alice <sip:12155551211@example.com;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>
```

[SDP Not Shown]

F5 180 Ringing Carol -> Example.com

```
SIP/2.0 180 Ringing
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK4522;\\
received=192.0.2.101
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>;tag=setss3x
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
```

```

History-Info: <sip:12155551212@example.com;user=phone?\
                Reason=SIP%3Bcause%3D302>;\
                index=1.1;rc=1
History-Info: <sip:carol@example.com;cause=480>;index=1.2;mp=1
History-Info: <sip:12155551213@example.com;user=phone;\
                cause=480>;index=1.2.1;rc=1.2
Contact: Carol <sip:12155551213@example.com;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F6 INVITE Example.com -> VM

INVITE sip:vm@192.0.2.6;target=sip:bob%40example.com;cause=480\
                SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK4523
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 69
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:sip:12155551212@example.com;user=phone?\
                Reason=SIP%3Bcause%3D302>;\
                index=1.1;rc=1
History-Info: <sip:carol@example.com;cause=480?\
                Reason=SIP%3Bcause%3D408>;\
                index=1.2;mp=1
History-Info: <sip:12155551213@example.com;user=phone;cause=480?\
                Reason=SIP%3Bcause%3D408408>;\
                index=1.2.1;rc=1.2
History-Info: <sip:vm@example.com;\
                target=sip:bob%40example.com;cause=480>;\
                index=1.3;mp=1
History-Info: <sip:vm@192.0.2.6;\
                target=sip:bob%40example.com;cause=480>;\
                index=1.3.1;rc=1.3
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IiA\
  joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ\
  kZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sIm\
  lhdCI6IjE0NDMyMDgzNDUiLCJvcmlnaWp7InRuIjoimTIxNTU1NTEyMTI\
  iFX0.r\
  q3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs\
  oJNCpTzO3QfP0lckGaS6hEck7w;info=<https://biloxi.example.org\
  /biloxi.cert>;alg=ES256
Identity: ..sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtYNS7L

```

```

eU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp
pPqOgluXndzHbG7mR6Rl9BnUhufVRbp5lMn3w0gfUs=; \
info=<https://atlanta.example.com/atlanta.cert>;alg=ES256;ppt=div
Identity: ... L2V4YWlwbGUuY2VydCJ9eyJhdHRlc3QiOiJBBIiwizGVzdCI6 \
eyJ0biI6IisxMjE1NTU1MTIxMyJ9LCJpYXQiOiIxNDcxMzc1NDE4Iiwib3JpZyI \
6eyJ0biI64oCdKzEyMTU1 NTUxMjEyIn0sIm9yaWdpZCI6IjEyM2U0NTY3LWU4O \
;info =<http://cert.example2.net/example.cert>;alg=ES256; ppt=div
Contact: Alice <sip:12155551213@example.com;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F7 200 OK VM -> Example.com

SIP/2.0 200 OK
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK4523;\
received=192.0.2.101
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>;tag=3dweggs
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:sip:sip:12155551212@example.com;user=phone?\
Reason=SIP%3Bcause%3D302>;\
index=1.1;rc=1
History-Info: <sip:carol@example.com;cause=480?Reason=SIP%3Bcause%3D\
408>;index=1.2;mp=1
History-Info: <sip:12155551213@example.com;user=phone;cause=480?\
Reason=SIP%3Bcause%3D\
408>;index=1.2.1;rc=1.2
History-Info: <sip:vm@example.com;\
target=sip:bob%40example.com;cause=480>;\
index=1.3;mp=1
History-Info: <sip:vm@192.0.2.6;\
target=sip:bob%40example.com;cause=480>;\
index=1.3.1;rc=1.3
Contact: <sip:vm@192.0.2.6>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

```

Figure 1: Enterprise Voicemail Example

The VMS can look at the last hi-entry and finds the target of the mailbox by looking at the URI entry in the "target" URI parameter in the hi-entry.

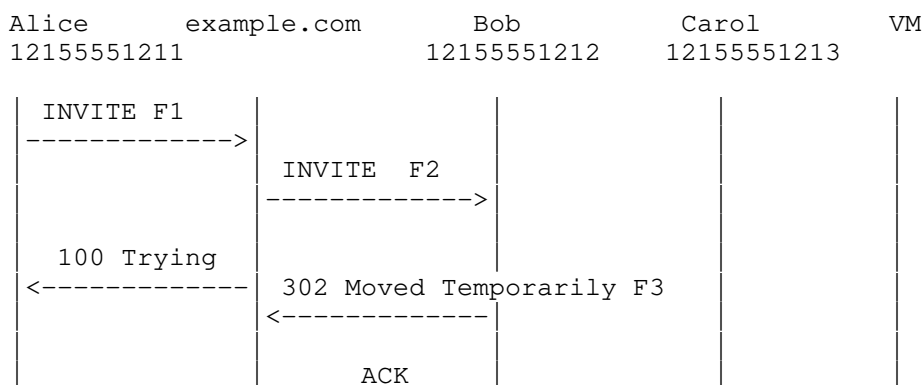
3.2. Consumer Voicemail Example

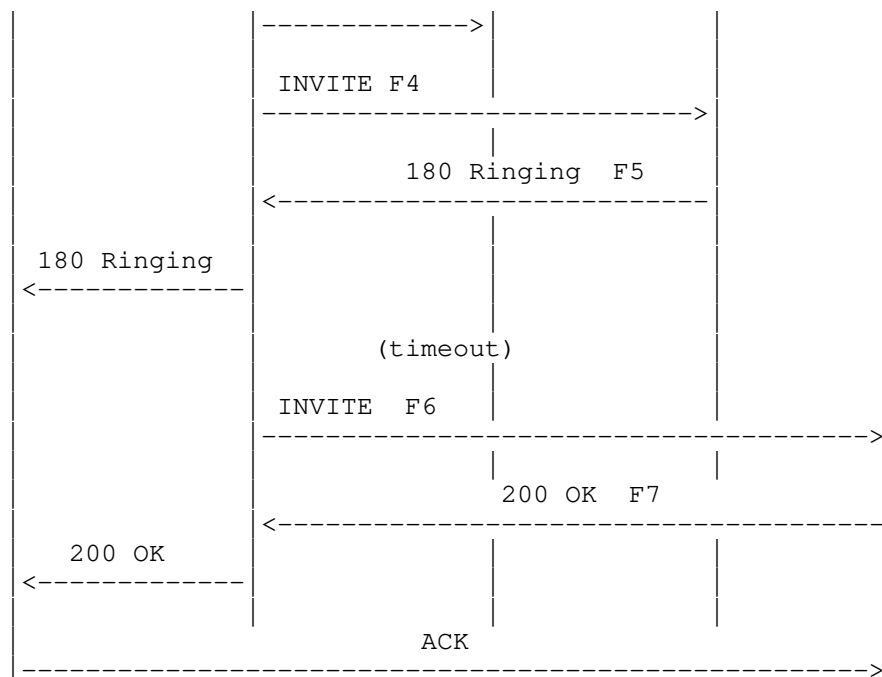
In the case of a consumer, when the call is retargeted, it is usually to another administrative domain. The voicemail system in these environment typically requires the last called party information to determine the appropriate mailbox so an appropriate greeting can be provided and the appropriate party notified of the message.

In this example, Alice calls Bob but Bob has temporarily forwarded his phone to his wife Carol. Carol does not answer the call, thus it is forwarded to a VM (voicemail) server (VMS). In order to determine the appropriate mailbox to use for this call, the VMS needs the appropriate target for the request. The last target is determined by finding the hi-entry referenced by the index of last hi-entry tagged with "mp" for determining the appropriate mailbox.

If the SIP Identity header field with "div" claims has been added by the entities retargeting, it can be ascertained that the call should be forwarded to Carol's voicemail prior to forwarding the call to voicemail. The value of the "tn" in the "div" field of the claim should match the hi-targeted-to URI in the hi-entry with the hi-index matching the "hi" value in the "div" field.

This hi-entry is used to populate the "target" URI parameter as defined in [RFC4458]. Note that some VMSs may also (or instead) use the information available in the History-Info headers for custom handling of the VM in terms of how and why the called arrived at the VMS.





F1 INVITE Alice -> Example.com

```

INVITE sip:12155551212@example.com;user=phone SIP/2.0
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 70
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-
To: Bob <sip:12155551212@example.com;user=phone>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
Contact: Alice <sip:12155551211@e192.0.2.3;user=phone>
Content-Length: <appropriate value>
  
```

[SDP Not Shown]

F2 INVITE Example.com -> Bob

```

INVITE sip:12155551212@192.0.2.5;user=phone SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK12s4
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
  
```

Max-Forward: 69
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-
To: Bob <sip:2155551212@example.com;user=phone>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
History-Info: <sip:12155551212@192.0.2.5>;index=1.1;rc=1
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6ImlhbnQ3NwB3J0IiwieDV1I \\
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \\
kZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImhhdC \\
I6IjE0NDMyMDgzNDUiLCJvcmlnIjp7InRuIjoimTIxNTU1NTEyMTIifX0.r \\
q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs \\
oJNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org \\
/biloxi.cert>;alg=ES256
Contact: Alice <sip:12155551211@192.0.2.3;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F3 302 Moved Temporarily Bob -> Example.com

SIP/2.0 302 Moved Temporarily
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK12s4;\
received=192.0.2.101
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-
To: Bob <sip:2155551212@example.com;user=phone>;tag=2241s3s-t
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
History-Info: <sip:12155551212@192.0.2.5;user=phone>;index=1.1;rc=1
Contact: <sip:12155551213@home.example.com;user=phone>;mp=1
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F4 INVITE Example.com -> Carol

INVITE sip:12155551213@example.com;user=phone SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK24s5
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 69
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-

To: Carol <sip:12155551213@home.example.com;user=phone>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
History-Info: <sip:12155551212@192.0.2.5;user=phone?\
Reason=SIP%3Bcause%3D302\
%3Btext%3D%22Moved%20Temporarily%22>\
;index=1.1;rc=1
History-Info: <sip:12155551213@home.example.com;user=phone>;\
index=1.2;mp=1
History-Info: <sip:12155551213@192.0.2.4;user=phone>;index=1.2.1;rc=1.2
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1Ii \\
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \\
kZXN0Ijpp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImhhdC \\
I6IjE0NDMyMDgzNDUiLCJvcmlnIjpp7InRuIjoimTIxNTU1NTEyMTIifX0.r \\
q3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs \\
ojNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org \\
/biloxi.cert>;alg=ES256
Identity:...sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS \\
7Ltrg9dlxkWzoeU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2 \\
EROvgtw0Lu5csIppPqOgluXndzHbG7mR6Rl9BnUhufVRbp51Mn3w0gfUs=; \\
info=<https://atlanta.example.com/atlanta.cert>;alg=ES256;ppt=div
Contact: Alice <sip:12155551211@192.0.2.3;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F5 180 Ringing Carol -> Example.com

SIP/2.0 180 Ringing
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bK24s5;\
received=192.0.2.101
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-
To: Carol <sip:12155551213@home.example.com;user=phone>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
History-Info: <sip:12155551212@192.0.2.5;user=phone?\
Reason=SIP%3Bcause%3D302\
%3Btext%3D%22Moved%20Temporarily%22>\
;index=1.1;rc=1
History-Info: <sip:12155551213@home.example.com;user=phone>;\
index=1.2;mp=1
History-Info: <sip:12155551213@192.0.2.4;user=phone>;index=1.2.1;rc=1.2

Contact: <sip:12155551213@192.0.2.4;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F6 INVITE Example.com -> VM

INVITE sip:vm@192.0.2.6;target=sip:sip:12155551213%40home.example.com\
SIP/2.0
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bKbbg4
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
Max-Forward: 69
From: Alice <sip:12155551211@example.com;user=phone>;tag=kkaz-
To: Carol <sip:12155551213@home.example.com;user=phone>
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:12155551212@example.com;user=phone>;index=1
History-Info: <sip:12155551212@192.0.2.5;user=phone?\
Reason=SIP%3Bcause%3D302\
%3Btext%3D%22Moved%20Temporarily%22>\
>;index=1.1;rc=1
History-Info: <sip:12155551213@home.example.com;user=phone>;\
index=1.2;mp=1
History-Info: <sip:12155551213@192.0.2.4;user=phone>;index=1.2.1;rc=1.2
History-Info: <sip:vm@example.com;\
target=sip:12155551213%40home.example.com;\
cause=408>;index=1.2.2;mp=1.2
History-Info: <sip:vm@192.0.2.5;\
target=sip:12155551213%40home.example.com;\
cause=408>;index=1.2.2.1;rc=1.2.2
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IiA6IjoiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ\kZXN0IjP7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sIm1hdC\I6IjE0NDMyMDgzNDUiLCJvcmlnIjP7InRuIjoimTIxNTU1NTEyMTIifX0.r\q3pjTlhoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjppjlk-cpFYpFYs\ojNCpTzO3QfPOLckGaS6hEck7w;info=<https://biloxi.example.org\biloxi.cert>;alg=ES256
Identity:..sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS \7Ltrg9dlxkWzoeU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2\EROvgtw0Lu5csIppPqOgluXndzHbG7mR6Rl9BnUhufVRbp51Mn3w0gfUs=; \info=<https://atlanta.example.com/atlanta.cert>;alg=ES256;ppt=div
Contact: Alice <sip:12155551211@192.0.2.3;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]

F7 200 OK VM -> Example.com

```
SIP/2.0 200 OK
Via: SIP/2.0/TCP proxy.example.com:5060;branch=z9hG4bKbbg4
Via: SIP/2.0/TCP 192.0.2.3:5060;branch=z9hG4bK42t2
From: Alice <sip:alice@example.com>;tag=kkaz-
To: Bob <sip:bob@example.com>;tag=3dweggs
Supported: histinfo
Call-Id: 12345600@example.com
CSeq: 1 INVITE
History-Info: <sip:bob@example.com>;index=1
History-Info: <sip:12155551212@example.com;user=phone?\
Reason=SIP%3Bcause%3D302\
%3Btext%3D%22Moved%20Temporarily%22>;\
index=1.1;rc=1
History-Info: <sip:12155551213@home.example.com;user=phone>;\
index=1.2;mp=1
History-Info: <sip:12155551213@192.0.2.4;user=phone>;index=1.2.1;rc=1.2
History-Info: <sip:vm@example.com;\
target=sip:12155551213%40home.example.com;\
cause=408>;index=1.2.2;mp=1.2
History-Info: <sip:vm@192.0.2.5;\
target=sip:12155551213%40home.example.com;\
cause=408>;index=1.2.2.1;rc=1.2.2

Contact: <sip:12155551213@192.0.2.4;user=phone>
Content-Type: application/sdp
Content-Length: <appropriate value>

[SDP Not Shown]
```

Figure 2: Consumer Voicemail Example

The VMS can look at the last hi-entry and find the target of the mailbox by looking for the "target" URI parameter in the hi-entry and the reason by the "cause" URI parameter in the same hi-entry.

4. Security Considerations

This document adds no new security considerations beyond those specified in [RFC7044] for the History-Info header field and [RFC8224] for the Identity header field.

5. IANA Considerations

This document has no IANA considerations.

5.1. Acknowledgements

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STIR Out-of-Band Architecture and Use Cases
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Abstract

The PASSport format defines a token that can be carried by signaling protocols, including SIP, to cryptographically attest the identity 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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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.

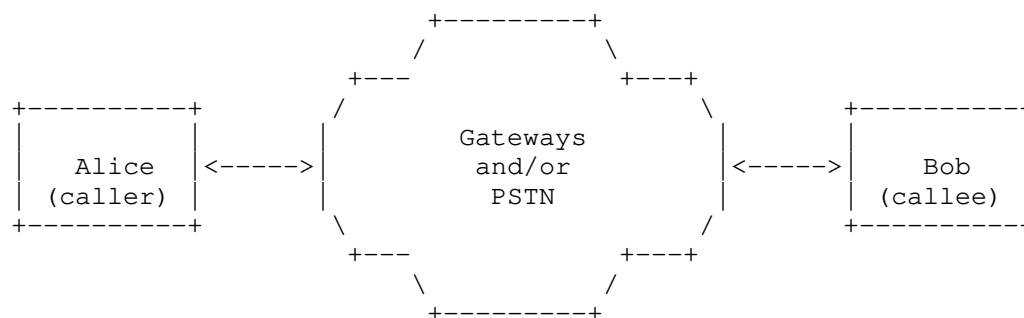
2. Terminology

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.

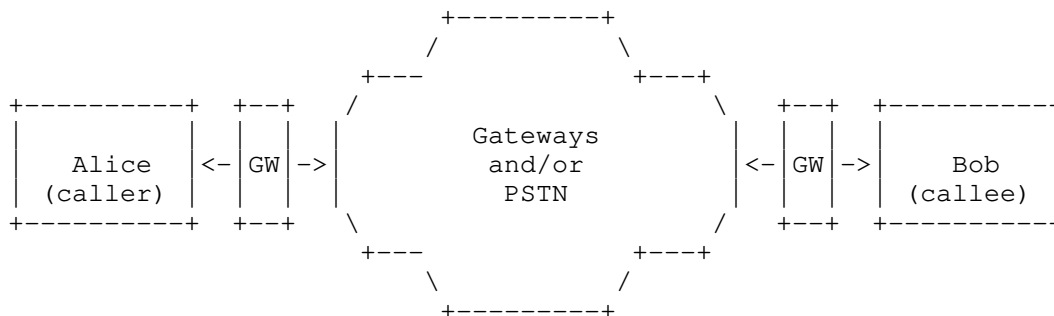
3. Operating Environments

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

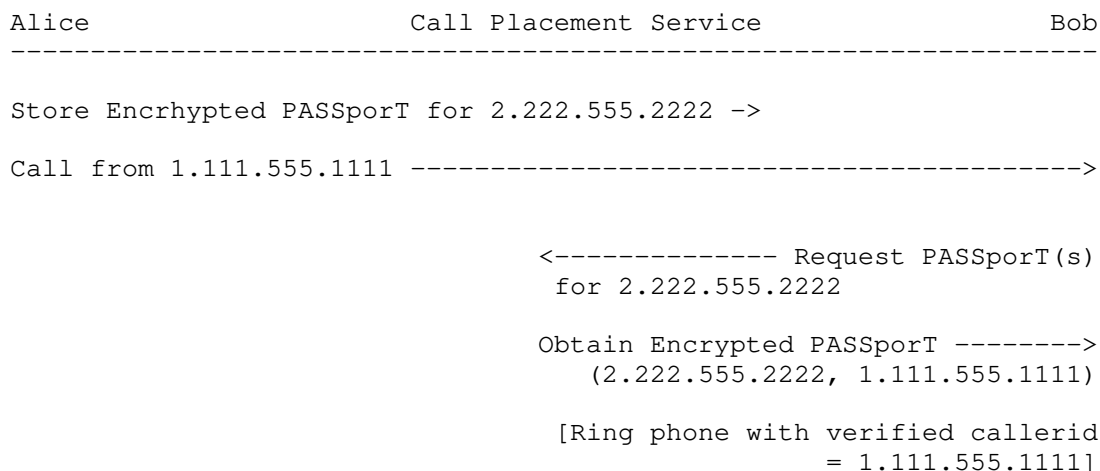
In this section, we discuss a high-level architecture for providing the service described in the previous sections. This discussion is deliberately sketchy, focusing on broad concepts and skipping over details. The intent here is merely to provide an overall architecture, not an implementable specification. 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 substitute 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:

Attacker	Callback Service	CPS	Bob

Place call to Bob ----->			
(from 111.555.1111)			
	Store PASSporT for		
	CS:Bob ----->		
Call from Attacker (forged CS caller-id info) ----->			
	Call from CS ----->		X
			<-- Retrieve PASSporT
			for CS:Bob
	PASSporT for CS:Bob ----->		
		[Ring phone with callerid =	
		111.555.1111]	

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:

Sender	CPS
Authenticate to CPS ----->	
Blinded(K_temp) ----->	
<----- Sign(K_cps, Blinded(K_temp))	
[Disconnect]	
Sign(K_cps, K_temp)	
Sign(K_temp, E(K_receiver, PASSporT)) --->	

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):

```
eyJhbGciOiJFUzI1NiIsInR5cCI6ImlBc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmN1ciJ9.eyJkZXN0Ijp7InRuIjpbIj1yMjI1NTUyMjIyIi19LCJpYXQiOiIxNTgzMjUxODEwXDEwIiwib3JpZyI6eyJ0biI6IjExMTE1NTUxMTE1In19.pn1j4K1LLHoRvzID0u3CT1e9Hq4xLNgZUTv45VbxmlD3IVvZuq4K0SA378vfp4x6wtY0KtDlDvpsereS438ZHaO
```

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:

```
rlWuoTpvBvWSHmV1AvVfVaE5pPV6VaOup3Ajo3W0VvjvrQI1VwbvnUE0pUZ6Y19w
MKW0YzI4LJ1joThho3WaY3Oup3Ajo3W0YzAypvW9r1WxMKA0Vvc7VaIlnFV6JlWm
nKN6LJkcL2INMKuuokOgMF5wo20vKK0fVzyuqPv6VwR0AQZLzQtmAQHvYPWipzyaV
w7VaEhVwlvbZGVkAGH1AGRLZGVvskOed3cwGlubeEjnxRTWp1ZuJfHafuq0-mW6S1
IbtSJfVU0e8Dwcwyx-pcSLcSLfbswAPcGmB3DsCBypxTnF6uRpx7j
```

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
```

```
rlWuoTpvBvWSHmVlAvVfVaE5pPV6VaOup3Ajo3W0VvjvrQl1VwbvnUE0pUZ6Yl9w
MKW0YzI4LJljoTHho3WaY3Oup3Ajo3W0YzAypvW9rlWxMKA0Vwc7VaIlNFV6JlWm
nKN6LJkcL2INMKuuOKOfMF5wo20vKK0fVzyuqPV6VwR0AQZlZQtmAQHvYPWipzyaV
wc7VaEhVwbvZGVkAGH1AGRlZGVvsK0ed3cwGlubEjnxRTwUPaJfjHafuq0-mW6S1
IBtSJFwU0e8Dwcwyx-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>
```

```
rlWuoTpvBvWSHmVlAvVfVaE5pPV6VaOup3Ajo3W0VvjvrQl1VwbvnUE0pUZ6Yl9w
MKW0YzI4LJljoTHho3WaY3Oup3Ajo3W0YzAypvW9rlWxMKA0Vwc7VaIlNFV6JlWm
nKN6LJkcL2INMKuuOKOfMF5wo20vKK0fVzyuqPV6VwR0AQZlZQtmAQHvYPWipzyaV
wc7VaEhVwbvZGVkAGH1AGRlZGVvsK0ed3cwGlubEjnxRTwUPaJfjHafuq0-mW6S1
IBtSJFwU0e8Dwcwyx-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 mitigate 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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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.

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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 operation 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:

```
eyJhbGciOiJFUzI1NiIsInBwdCI6ImRpdilzInR5cCI6InBhc3Nwb3J0IiwieDVlIjog1  
oiaHR0cHM6Ly93dCuZxhhbXBsZS5jb20vY2VydC5jZXIifQ.eyJkZXNOIjp7InRuI2  
jpbIjEyaMTU1NTUxMjE0Il19LCJkaXYiOmsidG4iOiIxMjE1NTU1NTEyMTMifSwiaWF3  
0IjoxNDQzMjA4MzQ1LlCJvcmlnIjp7InRuIjoimTIxNTU1NTEyMTMifX0.xBHWipDEE4  
J8a6Tsd3vCNqXanblsFiGUiaXwLiv0HLC9IICj6eG9jQd6WzeSSjHRBwxmChHhVIiMT5  
Sgilk3yxKux
```

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:eyJhbGciOiJIUzI1NiIsInR5cCI6ImlhbnQ3NwB3J0IiwieDVlIjoiaHR0cHM6Ly93d3cuZXBhbXBzS5jb20vY2VydC5jZXIifQ.eyJkZXNOIjp7InRuIjpbIjEyMTU1NTUxMjE0Il19LCJkaXyiOmsidG4iOiIxMjElNTU1NTEyMTIifX0.XBHwipDEEJ8a6TsdX6kUXAnblsFiGUiaXwLiv0HLC9IIcj6eG9jQd6WzeSSjHRBwxmChHhWiLmTSqILk3yCNkg; \ninfo=<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 is 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":{"eyJhbGciOiJIUzI1NiIsInR5cCI6ImlBhc3Nwb3J0IiwieDVlIjoiaHR0c \\  
HM6Ly93d3cuZXBhbXBsZS5jb20vY2VydC5jZXIifQ.eyJkZXN0Ijp7InRuIjpbIj \\  
EymTU1NTUsMjEzIl9LCjPjYXQiOjE0NDMyMDgzNDUsIm9yaWciOnsidG4iOiIxMj \\  
ElNTU1MTxMiJ9fQ.1bEzkzcNbKvgz4QoMx0_DJT2T8qFMDClSPqHPXl1WvbauzRJ \\  
RvYlZqQ0qqGTls8tJ_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:eyJhbGciOiJIUzI1NiIsInRwciI6ImRpdilvIiwidHlwIjoicGFzc3Bvc  
nQiLCJ4NXUiOiJodHRwczovL3d3dy5leGFtcGxlLmNvbS9jZXJ0LmNlciJ9.eyJkZX  
N0Ijp7InRuIjoimTIxNTU1NTEyMTQifSwiZGl2Ijp7InRuIjoimTIxNTU1NTUxMjEz  
In0sImIhdCI6MTQ0MzIwODM0NSwib3B0IjoizXlKaGJHY2lPaUpGVXpJMU5pSXNJbl  
I1YONJNklUQmhjM053YjNKMElpd2llRFYxSWpvaWFIUjBjSE02THk5M2QzY3VaWGho  
YlhCc1pTNWpiMjB2WTJWeWRDNWpaWElpZlEuZXlKa1pYTjBJanA3SW5SdUlcGJJak  
V5TVRVMU5UVXhNakV6SWwxOUxDSnBZWFFpT2pFME5ETXlNRGd6TkrVc0ltOXlhV2Np  
T25zaWRHNGlPaU14TWpFMU5UVTFNVEl4TWlKOWZRLjFiRXpremNOYkt2Z3o0UW9NeD  
BfREoyVDhxRk1EQzFzUHF1UFhsMVd2YmF1elJKUnZzBfpxUTBxZ0dUbFM4dEpfdlhq  
VmUwNl0zd3ZecmR6cEBoATl3Iiwib3JpZyI6eyJ0biI6IjEyMTU1NTUxMjEyIn19.C  
HeA9wRnrlh7paMe6RPhoATARpmFCXjmi_vF_HRz2O_oulB_R-G9xZNiLVvmvHv4gk6LI  
LaDV2y2VtHTLIEgmHig; \ninfo=<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 of 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":"12155551213",  
         "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

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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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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-----

MFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAE mzGM1VsO+3IqbMF54rQMaYKQftO4
hUYm9wv5wutLgEd9FsiTy3+4+Wa2O7pffOXPC0QzO+yD8hGEXGP/2mZo6w==

-----END PUBLIC KEY-----

-----BEGIN EC PRIVATE KEY-----

MHcCAQEEIFKCsFZ4Wsw3ZpBxgc4Z0sOjaXDdMk07Ny1fKg6OntAkoAoGCCqGSM49
AwEHoUQDQgAE mzGM1VsO+3IqbMF54rQMaYKQftO4hUYm9wv5wutLgEd9FsiTy3+4
+Wa2O7pffOXPC0QzO+yD8hGEXGP/2mZo6w==

-----END EC PRIVATE KEY-----

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PASSporT SHAKEN Extension (SHAKEN)
draft-ietf-stir-passport-shaken-08

Abstract

This document extends PASSporT, which is a token object that conveys cryptographically-signed information about the participants involved in communications. The extension is defined, corresponding to the SHAKEN specification, to provide both a specific set of levels-of-confidence in the correctness of the originating identity for a SIP based Communication Service Provider (CSP) telephone network originated call as well as an identifier that allows the CSP to uniquely identify the origin of the call within its network.

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1. Introduction

The Signature-based Handling of Asserted information using toKENs (SHAKEN) [ATIS-1000074] specification defines a framework for using Secure Telephone Identity Revisited (STIR) protocols including PASSporT [RFC8225], SIP Authenticated Identity Management [RFC8224] and the STIR certificate framework [RFC8226] for implementing the cryptographic validation of an authorized originator of telephone calls using SIP. Because the current telephone network contains both VoIP and TDM/SS7 originated traffic, there are many scenarios that need to be accounted for where PASSporT signatures may represent either direct or indirect call origination scenarios. The SHAKEN [ATIS-1000074] specification defines levels of attestation of the origination of the call as well as an origination identifier that can help create a unique association between the origin of a particular call to the point in the VoIP or TDM telephone network the call came from to identify, for example, either a customer or class of service that call represents. This document specifies these values as claims to extend the base set of PASSporT claims.

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.

In addition, the following terms are used in this document:

- o Verified association: is typically defined as an authenticated relationship between a customer and a device that initiated a call on behalf of that customer, for example, a subscriber account with a specific SIM card or set of SIP credentials.
- o PASSporT: Defined in [RFC8225] is a JSON Web Token [RFC7519] defined specifically for securing the identity of an initiator of personal communication. This document defines a specific extension to PASSporT.

3. Overview of 'shaken' PASSporT extension

The SHAKEN framework is designed to use PASSporT [RFC8225] as a method of asserting the telephone number calling identity. In addition to the PASSporT base claims, there are two additional claims that have been defined for the needs of a service provider to signal information beyond just the telephone identity. First, in order to help bridge the transition of the state of the current telephone network which has calls with no authentication and non-SIP [RFC3261] signaling not compatible with the use of PASSporT and Secure Telephone Identity (STI) in general, there is an attestation claim. This provides three levels of attestation, including a full attestation when the service provider can fully attest to the calling identity, a partial attestation, when the service provider originated a telephone call but can not fully attest to the calling identity, and a gateway attestation which is the lowest level of attestation and represents the service provider receiving a call from a non-PASSporT and non-STI supporting telephone gateway.

The second claim is a unique origination identifier that should be used by the service provider to identify different sources of telephone calls to support a traceback mechanism that can be used for enforcement and identification of a source of illegitimate calls.

The use of the compact form of PASSporT is not specified in this document and is not specified for use in SHAKEN [ATIS-1000074].

The next two sections define these new claims.

4. PASSporT 'attest' Claim

This indicator allows for both identifying the service provider that is vouching for the call as well as clearly indicating what information the service provider is attesting to. The 'attest' claim can be one of the following three values: 'A', 'B', or 'C'. These values correspond to 'Full Attestation', 'Partial Attestation', and 'Gateway Attestation', respectively. See [ATIS-1000074] for the definitions of these three levels of attestation.

5. PASSporT 'origid' Claim

The purpose of the 'origid' claim is described in [ATIS-1000074]. The value of 'origid' claim is a UUID as defined in [RFC4122]. Please refer to Section 10 for a discussion of the privacy considerations around the use of this value.

6. Example "shaken" PASSporT

```
Protected Header
{
  "alg":"ES256",
  "typ":"passport",
  "ppt":"shaken",
  "x5u":"https://cert.example.org/passport.cer"
}
Payload
{
  "attest":"A"
  "dest":{"tn":["12155550131"]}
  "iat":"1443208345",
  "orig":{"tn":["12155550121"]},
  "origid":"123e4567-e89b-12d3-a456-426655440000"
}
```

7. Using 'shaken' in SIP

The use of the 'shaken' PASSporT type and the claims 'attest' and 'origid' are formally defined in [ATIS-1000074] for usage in SIP [RFC3261] aligned with the use of the identity header field defined in [RFC8224].

8. 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,

- o attest
- o dest
- o iat
- o orig
- o origid

9. Security Considerations

This document defines a new PASSporT [RFC8225] extension. The considerations related to the security of the PASSporT object itself are the same as those described in [RFC8225].

[RFC8224] defines how to compare the values of the "dest", "orig" and "iat" claims against fields in a SIP containing a PASSporT as part of validating that request. The values of the new "attest" and "origid" claims added by this extension are not used in such a validation step. They are not compared to fields in the SIP message. Instead, they simply carry additional information from the signer to the consumer of the PASSporT. This new information shares the same integrity protection and non-repudiation properties as the base claims in the PASSporT.

10. Privacy Considerations

As detailed in [RFC3261] Section 26, SIP messages inherently carry identifying information of the caller and callee. The addition of STIR cryptographically attests that the signing party vouches for the information given about the callee, as is discussed in the Privacy Considerations of [RFC8224].

SHAKEN [ATIS-1000074] furthermore adds an 'origid' value to the STIR PASSporT, which is an opaque unique identifier representing an element on the path of a given SIP request. This identifier is generated by an originating telephone service provider to identify where within their network (e.g. a gateway or particular service element) a call was initiated; 'origid' can facilitate forensic analysis of call origins when identifying and stopping bad actors trying to spoof identities or make fraudulent calls.

The opacity of the 'origid' claim value is intended to minimize exposure of information about the origination of calls labelled with an 'origid' value. It is therefore RECOMMENDED that implementations generate a unique 'origid' value per call in such a way that only the generator of the 'origid' can determine when two 'origid' values

represent the same or different elements. If deployed systems instead use a common or related 'origid' for service elements in their network, the potential for discovering patterns through correlation of those calls exists. This could allow a recipient of calls to, for instance, learn that a set of callers are using a particular service or coming through a common gateway. It is expected that SHAKEN PASSporTs are shared only within an [RFC3324] trust domain and will be stripped before calls exit that trust domain, but this information still could be used by analytics on intermediary and terminating systems to reveal information that could include geographic location and even device-level information, depending on how the 'origid' is generated.

11. IANA Considerations

11.1. 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: "attest"

Claim Description: Attestation level as defined in SHAKEN framework

Change Controller: IESG

Specification Document(s): [RFCThis]

Claim Name: "origid"

Claim Description: Originating Identifier as defined in SHAKEN framework

Change Controller: IESG

Specification Document(s): [RFCThis]

11.2. PASSporT Types

This specification requests that the IANA add a new entry to the Personal Assertion Token (PASSporT) Extensions registry for the type "shaken" which is specified in [RFCThis].

12. Acknowledgements

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PASSport Extension for Resource Priority Authorization
draft-ietf-stir-rph-06

Abstract

This document extends the PASSport (Personal Assertion Token) 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, which is used for communications resource prioritization.

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1. Introduction

PASSporT [RFC8225] is a token format based on JSON Web Token (JWT) [RFC7519] for conveying cryptographically signed information about the identities involved in personal communications. PASSporT with STIR [RFC8224] provides a mechanism by which an authority on the originating side of a call via a protocol like SIP [RFC3261] can provide a cryptographic assurance of the validity of the calling party telephone number in order to prevent impersonation attacks.

[RFC4412] defines the 'SIP Resource-Priority' header field for communications 'Resource-Priority'. As specified in [RFC4412], the 'SIP Resource-Priority' header field may be used by SIP user agents [RFC3261] (including Public Switched Telephone Network (PSTN) gateways and SIP proxy servers) to influence prioritization afforded to communication sessions including PSTN calls (e.g., to manage scarce network resources during network congestion scenarios). However, the 'SIP Resource-Priority' header field could be spoofed and abused by unauthorized entities, the threat models and use cases of which are described in [RFC7375] and [RFC7340], respectively.

Compromise of the 'SIP Resource-Priority' header field [RFC4412] could lead to misuse of network resource (i.e., during congestion scenarios) resulting in impacts to 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 'SIP Resource-Priority' can use a PASSporT claim to cryptographically sign the 'SIP Resource-Priority' header field and convey assertion of the authorization for 'Resource-Priority'. Signed 'SIP Resource-Priority' header field will allow a receiving entity (including entities located in different network domains/boundaries) to verify the validity of assertions authorizing 'Resource-Priority' and to act on the information with confidence that the information has not been spoofed or compromised.

This specification documents an extension to PASSporT and the associated STIR mechanisms to provide a function to cryptographically sign the 'SIP Resource-Priority' header field. This PASSporT object is used to provide attestation of a calling user authorization for priority communications. This is necessary in addition to the PASSporT object that is used for calling user telephone number attestation. How this extension to PASSporT is used for real-time communications supported using 'SIP Resource-Priority' header field is outside the scope of this document. In addition, the PASSporT extension defined in this document is intended for use in environments where there are means to verify that the signer of the 'SIP Resource-Priority' header field is authoritative.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119] and in RFC 8174 [RFC8174].

3. PASSporT 'rph' Claim

This specification defines a new JSON Web Token claim for "rph", which provides an assertion for information in 'SIP Resource-Priority' header field.

The creator of a PASSporT object adds a "ppt" value of "rph" to the header of a PASSporT object, in which case the PASSporT claims MUST contain a "rph" 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": "rph",
  "alg": "ES256",
  "x5u": "https://www.example.org/cert.cer"
}
```

The "rph" claim will provide an assertion of authorization, "auth", for information in the 'SIP Resource-Priority' header field based on [RFC4412] and the syntax is:

```
{
  Resource-Priority = "Resource-Priority" : r-value,
  r-value= namespace "." r-priority
}
```

Specifically, the "rph" claim includes an assertion of the priority-level of the user to be used for a given communication session. The value of the "rph" claim is an Object with one or more keys. Each key is associated with a JSON Array. These arrays contain Strings that correspond to the r-values indicated in the 'SIP Resource-Priority' header field.

The following is an example "rph" claim for a 'SIP Resource-Priority' header field with one r-value of "ets.0" and with another r-value of "wps.0":

```
{
  "orig":{"tn":"12155550112"},
  "dest":[{"tn":"12125550113"}],
  "iat":1443208345,
  "rph":{"auth":["ets.0", "wps.0"]}
}
```

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, intermediaries must generate a new "rph" header and sign the claim with its own authority.

The use of the compact form of PASSporT is not specified in this document.

4. 'rph' in SIP

This section specifies SIP-specific usage for the "rph" claim in PASSporT.

4.1. Authentication Service Behavior

The Authentication Service will create the "rph" claim using the values discussed in section 3 of this document that are based on [RFC4412]. The construction of "rph" claim follows the steps described in Section 4.1 of [RFC8224].

The resulting Identity header for "rph" might look as follows (backslashes shown for line folding only):

```
Identity:eyJhbGciOiJFUzI1NiIsInBwdCI6InJwaCI6InR5cCI6InBhc3Nwb3J0\
IiwieDV1IjoiaHR0cHM6Ly93d3cuZXhhbXBsZS5jb20vY2Vydc5jZXIifQo.eyJkZ\
XN0Ijp7WyJ0biI6IjEyMTU1NTUwMTEyIn0sInJwaCI6eyJhdXRoIjpbImV0cy4wIiw\
JpZyI6eyJ0biI6IjEyMTU1NTUwMTEyIn0sInJwaCI6eyJhdXRoIjpbImV0cy4wIiw\
id3BzLjAiXX19Cg.s37S6VC8HM6Dl6YzJeQDsrZcwJ0lizxhUrA7f_98oWBHvo-cl\
-n8MIhoCr18vYYFy3blXvs3fslM_oos2P2Dyw;info=<https://www.example.\
org/cert.cer>;alg=ES256;ppt="rph"
```

A SIP authentication service will derive the value of "rph" from the 'SIP Resource-Priority' header field based on policy associated with service specific use of the "namespace ." r-priority" for r-values based on [RFC4412]. The authentication service derives the value of the PASSporT claim by verifying the authorization for 'SIP Resource-Priority' (i.e., verifying a calling user privilege for 'Resource-Priority' based on its identity) which might be derived from customer profile data or from access to external services.

[RFC4412] allows multiple "namespace ." priority value" pairs, either in a single 'SIP Resource-Priority' header field or across multiple 'SIP Resource-Priority' headers. An authority is responsible for signing all the content of a 'SIP Resource-Priority' header field for which it has the authority.

4.2. 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 "rph" is as follows:

The verification service MUST extract the value associated with the "auth" key in a full form PASSporT with a "ppt" value of "rph". If the signature validates, then the verification service can use the value of the "rph" claim as validation that the calling party is

authorized for 'SIP Resource-Priority' as indicated in the claim. This value would in turn be used for priority treatment in accordance with local policy for the associated communication service. If the signature validation fails, the verification service should infer that the calling party is not authorized for 'SIP Resource-Priority' as indicated in the claim. In such cases, the priority treatment for the associated communication service is handled as per the local policy of the verifier. In such scenarios, 'SIP Resource-Priority' header field SHOULD be stripped from SIP request and the network entities should treat the call as an ordinary call.

In addition, [RFC8224] Section 6.2 Step 4 requires the "iat" value in "rph" claim to be verified.

The behavior of a SIP UA upon receiving an INVITE containing a PASSporT object with a "rph" claim will largely remain a matter of implementation policy for the specific communication service. In most cases, implementations would act based on confidence in the veracity of this information.

5. Further Information Associated with 'Resource-Priority'

There may be additional information about the calling party or the call that could be relevant to authorization for 'SIP Resource-Priority'. This may include information related to the device subscription of the caller, or to any institutions that the caller or device is associated with, or even categories of institutions. All of these data elements would benefit from the secure attestations provided by the STIR and PASSporT frameworks. The specification of the "rph" claim could entail the optional presence of one or more such additional information fields applicable to 'SIP Resource-Priority'.

A new IANA registry has been defined to hold potential values of the "rph" array; see Section 6.2. The definition of the "rph" claim may have one or more such additional information field(s). Details of such "rph" claim to encompass other data elements are left for future version of this specification.

6. IANA Considerations

6.1. JSON Web Token Claims

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

- o Claim Name: "rph"

- o Claim Description: Resource Priority Header Authorization
- o Change Controller: IESG
- o Specification Document(s): Section 3 of [RFCThis]

6.2. PASSporT Types

This specification also requests that the IANA creates a new entry to the PASSporT Types registry for the type "rph" which is specified in [RFCThis]. In addition, another registry needs to be created in which each entry must contain two fields: the name of the "rph" type and the specification in which the type is described. This registry is to be initially populated with a single value for "auth" which is specified in [RFCThis]. Registration of new "rph" types shall be under the specification required policy.

7. Security Considerations

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

7.1. Avoidance of replay and cut and paste attacks

The PASSporT extension with a "ppt" value of "rph" MUST only be sent with SIP INVITE when 'Resource-Priority' header field is used to convey the priority of the communication as defined in [RFC4412]. To avoid replay, and cut and paste attacks, the recommendations provided in Section 12.1 of [RFC8224] MUST be followed.

7.2. Solution Considerations

Using extensions to PASSporT tokens with a "ppt" value of "rph" requires knowledge of the authentication, authorization, and reputation of the signer to attest to the identity being asserted, including validating the digital signature and the associated certificate chain to a trust anchor. The following considerations should be recognized when using PASSporT extensions with a "ppt" value of "rph":

- o A signer is only allowed to sign the content of a 'SIP Resource-Priority' header field for which it has the proper authorization. Before signing tokens, the signer MUST have a secure method for authentication of the end user or the device being granted a token.

- o The verification of the signature MUST include means of verifying that the signer is authoritative for the signed content of the resource priority namespace in the PASSporT.

7.3. Acknowledgements

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8.2. Informative References

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