

PASSport Extension for Diverted Calls
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Abstract

This document extends PASSport, which conveys cryptographically-signed information about the people involved in personal communications, 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

PASSporT [[RFC8225](#)] is a token format based on JWT [[RFC7519](#)] for conveying cryptographically-signed information about the people involved in personal communications; it is used with STIR [[RFC8224](#)] 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 originally 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 as 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 fact that the original called party number is not always the number to which a call is delivered. The address in the To header field value of SIP requests is not supposed to change, accordingly to baseline [\[RFC3261\]](#), as it is the Request-URI that is supposed to be updated when a call is retargeted, but practically speaking some operational environments do alter the To header field. There are a number of potential ways for intermediaries to indicate that such a forwarding operating has taken place. 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 can both capture 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 original called number in PASSporT no longer reflects the destination to which a call is likely to be delivered. Verification services and the relying parties who make authorization decisions about communications may use this indication to confirm that a legitimate retargeting of the call has taken place, rather than a cut-and-paste attack. In support of this goal, this specification also defines a nesting mechanism for PASSporTs that allows the original unmodified PASSporT to be conveyed to relying parties.

2. Terminology

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

3. PASSporT 'div' Claim

This specification defines a new JSON Web Token claim for "div" 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 (without removing the original PASSporT). Note that a new PASSporT is only necessary when the canonical form of the "dest" identifier (per the canonicalization procedures in [\[RFC8224\] Section 8](#)) changes due to this retargeting. "div" is typically populated with a destination

address found in the "dest" field of PASSporT received by the retargeting entity, though it may include other elements as well, including a copy of the original PASSporT. These new PASSporT generated by retargeting entities MUST include the "div" PASSporT type, and an "x5u" field pointing to a credential that the retargeting entity controls. The new PASSporT header will look as follows:

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

A PASSporT claims object containing "div" is populated with a modification of the original token before the call was retargeted: at a high level, the original identifier for the called party in the "dest" array will become the "div" claim in the new PASSporT. If the "dest" array of the original PASSporT contains multiple identifiers, the retargeting entity MUST select only one them to occupy the "div" field in the new PASSporT. and in particular, 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" array of the new PASSporT. The "orig" value MUST be copied into the new PASSporT from the original PASSporT received by the retargeting entity. The retargeting entity SHOULD retain the "iat" value 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 extension claims should be copied from the original PASSporT to the "div" PASSporT.

So, for an original PASSporT 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 with "div" would look as follows:

```
{ "orig":{"tn":"12155551212"},  
  "dest":{"tn":"12155551214"},  
  "iat":1443208345,  
  "div":{"tn":"12155551213"} }
```


Note that the "div" claim may contain other elements than just a destination, including a copy of the original PASSport (see [Section 3.1](#)). 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.

[3.1](#). Nesting the original PASSport in 'div'

In some use cases, instead of having multiple unconnected PASSports associated with a single call, it makes more sense to nest the PASSports, explicitly relating two PASSports to one another. For example, when storing a PASSport with "div" at a Call Placement Service (CPS) for STIR out-of-band [\[I-D.ietf-stir-oob\]](#) scenarios, clients MUST include an "opt" element within "div". "opt" (see [Section 5](#)) contains the full form of the original PASSport from which the "div" was generated. If the diverting entity originally received that PASSport encrypted, it MUST decrypt it before storing it in "opt." The entire "div" PASSport would then be signed and re-encrypted normally for storage at an out-of-band Call Placement Service (CPS).

The "opt" extension is RECOMMENDED for use within in-band SIP use cases as well. The alternative, having multiple Identity headers in a SIP request, could be confusing for some verification services. However, nested PASSports could result in lengthy Identity headers, and some operational experience is needed to ascertain how viable multiple layers of nesting will be.

[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 using protocols of 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 containing the "div" PASSport type to an SIP request that already contains at least one Identity header field; it MUST NOT add a "div" request to an INVITE that contains no other Identity headers fields. Note that the authentication service doing so does not remove or replace any existing Identity header fields, it simply adds a new one. When adding an Identity header field with a PASSport object containing a "div" claim, SIP authentication services MUST also add a "ppt" parameter to that Identity header with a value of "div". The resulting compact form Identity header field to add to the message might look as follows:

```
Identity: ..sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtYNS7Ltrg9dlxkWzo
    eU7d70V8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp
    pPq0g1uXndzHbG7mR6Rl9BnUhHufVRbp51Mn3w0gfUs=; \
    info=<https://biloxi.example.org/biloxi.cer>;alg=ES256;ppt="div"
```

A SIP authentication service typically will derive the new value of "dest" 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 no specific interaction between the "div" mechanism and those SIP header fields. 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 (like History-Info) that record retargeting will likely not require a "div" PASSport.

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 "div" value of "ppt" is as follows.

In order to use the "div" extension, 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" necessary refers to an earlier PASSport already in the message. In particular, the verification service must find a PASSport associated with the call, one created earlier, that contains a "dest" claim with a value equivalent to the "div" claim in the current 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. 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 ultimate destination; this can help the verification service to determine that original PASSport in the call was not simply used in a cut-and-paste attack. This will help relying parties to make 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.

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 divert PASSports to their originals.

5. Definition of 'opt'

The presence of an "opt" 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 by "div".

"opt" MUST contain a quoted base64 encoded full-form PASSporT; it MUST NOT contain a compact form PASSporT. A "div" PASSporT containing the "opt" would look as follows:

```
{
  "orig":{"tn":"12155551212"},
  "dest":{"tn":"12155551214"},
  "iat":1443208345,
  "div":{"tn":"12155551213",
  "opt":"eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I
  joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ
  kZXN0Ijpw7InVyaSI6WyJzaXA6YWxpy2VAZxhhbXBsZS5jb20iXX0sImhdc
  \I6IjE0NDMyMDgzNDUiLCJvcmlnIjpw7InRuIjoimTIxNTU1NTEyMTIifX0.r
  \q3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjppjlk-cpFYpFYs
  \ojNCpTz03QfP0lckGaS6hEck7w"} }
```

6. '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 its "dest" value designates a different original 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 difficult for the operations of baseline STIR: when the 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 requirement 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 to attest that 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" 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 nested "div" PASSporT per 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 intermediaries that redirect requests MAY therefore convey one or more PASSporTs in the backwards direction within Identity headers. This document consequently updates [[RFC8224](#)] to permit carrying Identity headers in SIP 300-class responses. It is left to authentication services to determine which Identity headers should be copied into any new requests resulting from the redirection, if any: use of these Identity headers 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.

7. 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 may appear in "div" corresponding to the History-Info header field index parameter value. So for a History-Info header with an index value of "1.2.1", the claims object 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".

8. Acknowledgments

We would like to thank Robert Sparks for contributions to this document.

9. IANA Considerations

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

Claim Name: "div"

Claim Description: New Target of a Call

Change Controller: IESG

Specification Document(s): [RFCThis]

10. 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 the original 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.

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