**A****TIS-0x0000x**

ATIS Standard on

**Signature-Based Handling of Asserted Information Using Tokens (SHAKEN):**

**SHAKEN Support of "div" PASSporT**

**Alliance for Telecommunications Industry Solutions**

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**Abstract**

The base SHAKEN specification provides replay-detection mechanisms to identify cases where a malicious entity attempts to masquerade as another user by replaying parts of a legitimate INVITE request. However, these mechanisms don’t cover cases where the INVITE is replayed within the short Date freshness window. This technical report describes how the mechanisms defined by [draft-ietf-stir-passport-divert] can be integrated within the SHAKEN framework to close this replay attack window.

**Foreword**

The Alliance for Telecommunications Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The [**COMMITTEE NAME**] Committee [**INSERT MISSION**]. [**INSERT SCOPE**].

The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages. The word *may* denotes a optional capability that could augment the standard. The standard is fully functional without the incorporation of this optional capability.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, [**COMMITTEE NAME**], 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, [**COMMITTEE NAME**], which was responsible for its development, had the following leadership:

[**LEADERSHIP LIST**]

The **[SUBCOMMITTEE NAME]** Subcommittee was responsible for the development of this document.

**Revision History**

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# Scope & Purpose

## Scope

This document describes how the PASSporT "div" extension defined in [draft-ietf-stir-divert] can be utilized within the SHAKEN framework to provide end-to-end SHAKEN authentication for calls that are retargeted by features such as call-forwarding.

## Purpose

The SHAKEN authentication service in an originating network asserts two telephone numbers in the "shaken" PASSporT; the number identifying the originator of the call in the "orig" claim, and the number identifying the destination of the call in the "dest" claim. The originating number is included to cryptographically assert that the calling TN identifies the calling user. The destination TN is included to provide protection from replay attacks where a man-in-the-middle replays a valid Identity header in a new INVITE sent to a different destination TN. In addition, PASSporT contains an "iat" claim that specifies the timestamp that the PASSporT was created. Including the "iat” claim further limits the time associated with a potential replay of the specific "orig" and "dest" claims, to prevent a potential malicious flood of validated calls to the same destination TN.

There are a number of call features that can legitimately retarget an INVITE request to a new destination. Examples include the various forms of call forwarding, where a call is diverted from the original destination to a new forward-to destination, simultaneous ringing, where a call to the dialed TN is simultaneously offered to additional TN(s), and toll-free number routing, where the dialed toll-free TN is replaced with its assigned routing TN. These features break the end-to-end call authentication model of SHAKEN/STIR since the verification service in the terminating network is unable to distinguish between an INVITE that has been legitimately retargeted, and an INVITE that has been maliciously replayed within the "iat" freshness window.

This document describes how the mechanisms defined in [draft-ietf-stir-passport-divert] enable SHAKEN to authenticate each retargeted leg of the call, so that a terminating network verification service has sufficient information to distinguish between an INVITE that has been legitimately retargeted, and an INVITE that has been maliciously replayed within the "iat" freshness window.

### Document Organization

Section 4 provides an informative overview of the PASSporT "div" extension, and how it enables end-to-end delivery of SHAKEN authentication information for retargeted calls.

Section 5 specifies the normative requirements to add support [draft-ietf-stir-passport-divert] to SHAKEN.

Appendix A describes how the normative requirements in Section 5 can be applied to a sample of real-world deployment use cases.

Appendix B shows an example of a SIP Identity header containing a "div" PASSporT

# Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ATIS-1000074, *Signature-based Handling of Asserted Information using Tokens (SHAKEN).*

RFC 8225, *Personal Assertion Token.*[[1]](#footnote-1)

RFC 8224, *Authenticated Identity Management in the Session Initiation Protocol.*1

RFC 8226, *Secure Telephone Identity Credentials: Certificates.*1

draft-ietf-stir-passport-shaken, *PASSporT SHAKEN Extension.* 1

draft-ietf-stir-passport-divert, *PASSporT Extension for Diverted Calls.* 1

IETF RFC 3325, *Private Extensions to SIP for Asserted Identity within Trusted Networks.*1

IETF RFC 3261, *SIP: Session Initiation Protocol.*1

RFC 5806, *Diversion Indication in SIP*. 1

RFC 7044, *An Extension to the Session Initiation Protocol (SIP) for Request History Information*. 1

TS 24.229, IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP). [[2]](#footnote-2)

# Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < <http://www.atis.org/glossary> >.

## Definitions

**Call Diversion:** Any call feature that updates the destination telephone number of a call to a new or alternate telephone number. Example call features include the various forms of call forwarding, find-me/follow-me (simultaneous or sequential ringing), and automatic call distribution.

**Redirect:** As defined in [RFC 3261], "redirect" refers to the process where a SIP entity redirects a SIP request to a new destination by responding to the request with a 3xx Redirection class response. This specification addresses redirection only for INVITE requests, and only for the case where the 3xx response is handled by a recursing SIP proxy that retargets the INVITE request to the new destination.

**Retarget:** As defined in [RFC 7044], "retarget" refers to the process where a SIP entity updates the Request-URI of a SIP request. This specification narrows the scope of the [RFC 7044] definition to include only INVITE requests, and only for cases where the update changes the canonical value of the telephone number identified by the INVITE Request-URI.

## Acronyms & Abbreviations

|  |  |
| --- | --- |
| 3GPP | 3rd Generation Partnership Project |
| ATIS | Alliance for Telecommunications Industry Solutions |
| CSCF | Call Session Control Function |
| HTTPS | Hypertext Transfer Protocol Secure |
| IBCF | Interconnection Border Control Function |
| IETF | Internet Engineering Task Force |
| IMS | IP Multimedia Subsystem |
| IP | Internet Protocol |
| JSON | JavaScript Object Notation |
| JWS | JSON Web Signature |
| NNI | Network-to-Network Interface |
| OCSP | Online Certificate Status Protocol |
| PASSporT | Personal Assertion Token |
| PBX | Private Branch Exchange |
| PKI | Public Key Infrastructure |
| SHAKEN | Signature-based Handling of Asserted information using toKENs |
| SIP | Session Initiation Protocol |
| SKS | Secure Key Store |
| SPID | Service Provider Identifier |
| STI | Secure Telephone Identity |
| STI-AS | Secure Telephone Identity Authentication Service |
| STI-CA | Secure Telephone Identity Certification Authority |
| STI-CR | Secure Telephone Identity Certificate Repository |
| STI-VS | Secure Telephone Identity Verification Service |
| STIR | Secure Telephone Identity Revisited |
| TLS | Transport Layer Security |
| TN | Telephone Number |
| TrGW | Transition Gateway |
| UA | User Agent |
| URI | Uniform Resource Identifier |
| UUID | Universally Unique Identifier |
| VoIP | Voice over Internet Protocol |

# Overview

The baseline SHAKEN framework and the core STIR protocols from which SHAKEN is based support the end-to-end call authentication for the common 2-way call scenario where user-a calls user-b. For this case, the originating network generates a PASSporT containing "orig", "dest" and "iat" claims to assert that the calling telephone number (TN) is authorized to be used as the originating identity for that specific call. The terminating network can then verify that the PASSporT signature is valid, and that the "dest" claim matches the target called TN, to determine with a high degree of certainty that the calling TN identifies the calling user.

However, for call scenarios where a call is retargeted, the verification process becomes less certain due to the fact that the PASSporT "dest" claim may no longer match the target called TN. Based only on the SHAKEN Identity header from the first leg of the call, the verification service is unable to validate the associated changed telephone destinations. This document presents the solution for extending the SHAKEN framework to support these call retargeting scenarios.

[draft-ietf-stir-passport-divert] defines a PASSporT extension, "div", as a basis for accommodating the retargeting that may occur for various SIP call diversion applications. The “div” PASSporT provides an indication that the original called number in the “shaken” PASSporT no longer reflects the destination to which a call is likely to be delivered.

When an INVITE is retargeted, the "div" PASSporT extension enables an STI-AS to authenticate the TN of the retargeting entity. Therefore, when a retargeted INVITE request arrives at its final destination, a verification service (STI-VS) can use the received "div" PASSporT authentication information to verify the identity of each entity that retargeted the INVITE.

The basic “div” PASSporT operation is illustrated in Figure 1 for the call scenario where a call from TN-a to TN-b is forwarded to TN-c (TNs a/b/c are assigned to SP-a, SP-b and SP-c, respectively). The STI-AS authentication service in SP-a adds an Identity header field containing a "shaken" PASSporT to the INVITE request, as specified by [ATIS-1000074], where the “orig” and “dest” claims of the "shaken" PASSporT contain the calling and called TNs. When the call is forwarded, the SP-b authentication service replaces the received Identity header with a new Identity header containing a “div” PASSporT as specified in [draft-ietf-stir-passport-divert]. The "div" PASSPorT “orig” claim matches the “shaken” PASSporT “orig” claim (TN-a), the “dest” claim contains the forward-to TN (TN-c), and the “div” claim contains the TN of the forwarding entity (TN-b). The received “shaken” PASSporT is nested in the “opt” claim of the “div” PASSporT. When the INVITE arrives at SP-c, the STI-VS performs both "shaken" and “div authentication procedures. This includes verifying that there is an unbroken chain of authority from the INVITE Request-URI TN to the "shaken" PASSporT “dest” claim.



Figure 1. Using "div" PASSporT to authenticate the forwarding leg of call

What follows in this document is the specification of how the PASSporT "div" extension shall be used as part of the SHAKEN framework for providing end-to-end SHAKEN validation for diverted calls.

# Normative Requirements

This section contains the normative requirements to enable the end-to-end delivery of SHAKEN authentication information for diverted calls.

## STI-AS Base SHAKEN Authentication Assumptions

This document assumes that the base SHAKEN authentication procedures defined in [ATIS-1000074] require the STI-AS to populate the "shaken" PASSporT "dest" claim with the canonicalized value of the To header TN, as specified in [RFC 8224].

## STI-VS Base SHAKEN Verification Assumptions

On receiving an INVITE request containing an Identity header with a “shaken” PASSporT, the STI-VS will perform the base SHAKEN verification procedures as defined in [ATIS-1000074]. This document assumes that as part of base SHAKEN, when the received Identity header contains a “shaken” PASSporT, the STI-VS will use the canonicalized value of the To header TN as the locally created "dest" claim used during PASSporT signature verification.

## STI-AS "div" Authentication

The STI-AS shall provide "div" authentication services as defined in [draft-ietf-stir-passport-divert], with the following restrictions:

* The requirement that the INVITE request must contain at least one Identity header is qualified as the INVITE request shall contain at least one Identity header that in turn contains either a “shaken” PASSporT, or a "div" PASSporT with an "opt" claim that contains a nested "shaken" PASSporT,
* The "orig", "dest" and "div" claims shall be of type "tn",
* The "orig" claim value shall be copied from the “shaken” PASSporT "orig" claim.

## STI-VS "div" Verification

On receiving an INVITE request containing an Identity header with a “div” PASSporT, an STI-VS shall perform the “div” verification procedures defined in [draft-ietf-stir-passport-divert], with the following restrictions:

* The "div" PASSporT "orig", "dest" and "div" claims shall be of type “tn”,
* The “opt” claim shall contain a nested “shaken” PASSporT, plus zero or more “div” PASSporTs.

The STI-VS shall verify that the received "div" PASSporT, along with the PASSporT(s) nested in the received “div” PASSporT "opt" claim, create an unbroken chain of authority from the INVITE Request-URI TN to the “dest” claim of the nested "shaken" PASSporT. The STI-VS shall verify each “div” PASSporT as specified in this document. The STI-VS shall verify the “shaken” PASSporT as specified in [ATIS-1000074], with the following exception:

* Instead of using the canonicalized value of the TN from the To header field to validate the “shaken” PASSporT “dest” claim, the STI-VS shall use the “div” claim from the “div” PASSporT that is adjacent to the “shaken” PASSporT in the authority chain, as specified in [draft-ietf-stir-passport-divert].

## In-network Call Diversion

The STI-AS shall perform "div" authentication as specified in section 5.3 for in-network call diversion; i.e., where an in-network call feature or routing function retargets an INVITE request by updating the canonical value of the TN contained in the Request-URI of an INVITE request. As specified in [draft-ietf-stir-passport-divert], an authentication service adds an Identity header containing a "div" PASSporT only if the SIP request contains at least one Identity header field. Therefore, if the retargeted INVITE request does not contain an Identity header, then the STI-AS of the retargeting network may choose to either skip authentication altogether, or to perform authentication based on local policy; e.g., perform base SHAKEN authentication with Gateway attestation.

When providing authentication services for an originating INVITE request where the canonicalized values of the To header and Request-URI TNs do not match, the STI-AS of the originating SP shall first perform SHAKEN authentication as specified in [ATIS-1000074], and then perform “div” authentication as described in this document. The resulting INVITE request shall contain a single Identity header containing a “div” PASSporT, with an “opt” claim containing the nested “shaken” PASSporT. The “div” PASSporT shall provide an intact chain of authority from the Request-URI TN to the “shaken” PASSporT “dest” claim.

Note: The case described in the above paragraph, where the originating network authentication service discovers a mismatch between the To header and Request-URI TNs, can occur when a toll-free routing database dip in the originating network returns the toll-free routing number. This can create the situation where the To header contains the dialed 8YY number, while the Request-URI contains the routing TN assigned to that 8YY number. After completing the authentication procedures as specified in the above paragraph, the TN-related claims of the two PASSporTs are populated as follows:

**“shaken” PASSporT TN claims:**

* “orig” contains calling TN from P-Asserted-Identity header
* “dest” contains dialed 8YY number from To header

**“div” PASSporT TN claims**

* “orig” contains calling TN from “shaken” PASSporT “orig” claim
* “div” contains dialed 8YY number from “shaken” PASSporT “dest” claim
* “dest” contains toll-free routing TN from Request-URI

## End-user Device Call Diversion

Certain types of end-user devices such as SIP-PBXs are capable of diverting incoming calls received from the host SP to a new destination in the global network. The end-user device diverts the call either by redirecting the incoming INVITE request with a 302 Moved Temporarily response, or by retargeting the incoming INVITE request to establish the divert-to call leg. The requirements in this section apply to the case where device capabilities and service provider policies enable the end-user device to divert calls using either of these mechanisms.

### Call Diversion by Redirecting the INVITE Request

If host SP policies allow the end-user device to divert calls via redirection, then the host SP shall consume the 302 response, and retarget the INVITE request on behalf of the end-user device. The SP STI-AS shall perform "div" authentication for the retargeting event before sending the INVITE to the new destination.

### Call Diversion by Retargeting the INVITE Request

The STI-AS provides authentication services for INVITE requests received from an end-user device. When the request is a retargeted INVITE, the type of authentication performed will depend on the capabilities of the end-user device, and the policies of the host SP in how it uses information in retargeted INVITE requests to provide SHAKEN authentication information to downstream entities.

During terminating call processing of an inbound INVITE request destined for an end-user device, the terminating host SP STI-VS shall verify the Identity header contained in the terminating INVITE request as specified by [ATIS-1000074], and in section 5.4 of this document. The host SP shall convey the verification results in the INVITE request sent to the end-user device using the tel URI "verstat" parameter, as specified in [3gpp TS 24.229]. If allowed by local policy, the terminating SP shall not remove the Identity headers from the INVITE request sent to the end-user device.

When the host SP receives an INVITE request from the end-user device, the STI-AS shall provide authentication services based on the contents of the request. If the information contained in the INVITE request indicates that the request has been retargeted by the end-user device, and the INVITE contains an Identity header with a "shaken" PASSporT, or with a “div” PASSporT that contains a nested “shaken” PASSporT, then the STI-AS shall perform “div” authentication as specified in section 5.3. The criteria used to determine that an INVITE request has been retargeted by an end-user device shall be based on the capabilities of the end-user device, and the policies of the host SP. For example, an SP could apply the following criteria to determine that an INVITE has been retargeted:

* The INVITE is received from a device that is capable of and allowed to retarget INVITEs,
* Local policy dictates that Identity headers are included in inbound INVITE requests sent to the end-user device,
* The received INVITE contains one or more instances of a SIP header that indicates retargeting has occurred (e.g., Diversion, History-Info, Referred-By), and the instance of the header that identifies the retargeted entity contains a TN that the end-user device is authorized to use, based on the full attestation criteria defined by [ATIS-1000074].

If the received INVITE contains information that indicates it was retargeted internally by the end-user device before being retargeted to an externally assigned TN (i.e., the INVITE was retargeted multiple times), then the STI-AS shall perform "div" authentication in order to create an unbroken chain of authority from the "shaken" PASSporT "dest" claim to the final retargeted TN (the Request-URI TN). The STI-AS can do this either by performing "div" authentication for each retargeting event, or by performing "div" authentication for a single retargeting event that links the ”shaken” PASSporT "dest" claim to the Request-URI TN.

If the information contained in an INVITE request received from an end-user device indicates that the request has not been retargeted, then the STI-AS shall remove any Identity headers contained in the request and perform base SHAKEN authentication as defined in [ATIS-1000074].

If the information contained in an INVITE request received from an end-user device indicates that the request has been retargeted, but the request does not contain an Identity header, then the STI-AS shall perform base SHAKEN authentication as defined in [ATIS-1000074]. If the TN in the To header field does not match the Request-URI TN (which would normally be the case when the INVITE is retargeted), then the STI-AS shall additionally perform "div" authentication to create an unbroken chain of authority from “shaken” PASSporT “dest” claim to the Request-URI TN.

If the information contained in an INVITE request received from an end-user device indicates that the request has been retargeted, and the retargeting entity indicates a TN that the end-user device is not authorized to use, then the STI-AS shall not perform a “div” authentication. Instead, the STI-AS shall remove any received Identity headers, and perform base SHAKEN authentication as defined in [ATIS-1000074].

1. **Authentication of End-user Device Retargeted Calls**

Implementation of the normative procedures for authentication of in-network INVITE retargeting cases (section 5.5) is relatively straightforward, since the STI-AS of the retargeting network has direct access to the information it needs to perform “div” authentication for the retargeted leg of the call. The situation for end-user device INVITE retargeting (section 5.6.2) is somewhat more complex, since variations in SIP-PBX implementations mean that the STI-AS has to support a wider range of use cases in terms of the varying levels of information made available to the authentication service in the retargeted INVITE request. Therefore, this appendix provides information that shows how the generic requirements in section 5.6.2 can be applied to different end-user device retargeting use cases.

The information in this appendix is not normative. Also, this section does not address the entire set of end-user device retargeting scenarios that could be encountered in real-world deployments, but is meant to serve as an example of how a service provider can support SHAKEN within the limits of operator policies and end-user device capabilities.

* 1. ***STI-AS Procedures***

As shown in Figure 2, the procedures performed by the STI-AS to authenticate an INVITE retargeting event depend on the capabilities of the retargeting entity, and specifically on the information provided by the retargeting entity to the STI-AS in the retargeted INVITE. Figure 2 illustrates the type of scenarios that the STI-AS is required to support, where an originating [1] INVITE request could be retargeted by one of three different retargeting entities; an in-network Application Server or end-user device-1 that convey the received Identity header in the retargeted [2] INVITE, or an end-user device-2 that does not convey the received Identity header in the retargeted [4] INVITE.

On receiving [2] INVITE from the in-network AS, or from end-user device-1, the STI-AS uses information such as the presence and contents of the Diversion, From, and Identity headers, and the contents of the Request-URI, to determine that an INVITE from TN-a to TN-b has been legitimately retargeted to TN-c. Since the retargeted INVITE contains a "shaken" PASSporT, the STI-AS performs “div” authentication for the TB-b🡪TN-c leg of the call, and replaces the received Identity header with a new Identity header containing the “div” PASSporT (that in turn contains the nested "shaken" PASSporT) in [3] INVITE sent to SP-c).

However, for the case where the STI-AS receives [4] INVITE from end-user device-2, the STI-AS knows that the INVITE has been retargeted, but it cannot simply perform “div” authentication because [4] INVITE does not contain a SHAKEN Identity header. Therefore, the STI-AS first performs SHAKEN authentication based on the information that it does have; i.e., that TN-a called TN-b, and TN-b retargeted the call to TN-c. In this example, since SP-b has no relationship with the originator of the call, it asserts an attestation level of Gateway in the “shaken” PASSporT. If SP-b is authoritative for the TN of the retargeting entity (TN-b), then it shall perform "div" authentication. The STI-AS includes an Identity header containing the "div" PASSporT with the nested "shaken" PASSporT in [5] INVITE to SP-c.



Figure 2. STI-AS Authentication Examples

Figure 3 provides an overview of the logic applied by the STI-AS to determine whether “shaken” or “div” authentication is performed for an INVITE request received from an end-user device (CPE).

1. If the CPE device is not able or allowed to retarget INVITE requests, then the STI-AS performs “shaken” authentication (else continue).
2. A CPE that is allowed to retarget calls may provide sufficient information in INVITE requests to enable the STI-AS to distinguish between originating and retargeted requests; e.g., the CPE includes a Diversion header identifying the TN of the retargeting entity if and only if the INVITE is retargeted. Therefore, if the STI-AS is able to explicitly identify that the INVITE is “originating”, or if the STI-AS cannot distinguish between originating and retargeted INVITEs from this CPE, then it performs “shaken” authentication (else continue).
3. If the CPE is not able or allowed to convey Identity header(s) in retargeted INVITE requests, then the STI-AS performs “shaken” authentication followed by "div" authentication (else continue).
4. If the retargeted INVITE request contains an Identity header with a "shaken" PASSporT, or with a "div" PASSporT containing a nested "shaken" PASSporT, then the STI-AS performs “div” authentication; otherwise it performs “shaken” authentication followed by "div" authentication.



Figure 3. STI-AS logic to determine authentication procedures for INVITE from CPE

* 1. ***End-user Device Retargeting Examples***

The message sequence diagrams in this section use the template shown in Figure 4, where an inbound call from TN-a to TN-b is forwarded to TN-c. TN-a, TN-b, and TN-c are hosted by SP-a, SP-b, and SP-c respectively. SP-b has delegated TN-b to SIP-PBX-1. SIP-PBX-1 supports call forwarding by INVITE retargeting, where inbound [2] INVITE to TN-b is retargeted to [3] INVITE to forward-to TN-c.



Figure 4. Message sequence diagram template

This section describes the SHAKEN procedures for four different SIP-PBX use cases that vary based on the PBX’s ability to convey SHAKEN authentication information from inbound [2] INVITE to retargeted [3] INVITE. These four SIP-PBX cases are summarized in Table-1.

Table 1 – SIP-PBX cases



Three different scenarios are documented for each SIP-PBX case. The scenarios differ based on the SHAKEN authentication information added by SP-a to [1] INVITE, as follows:

1. INVITE contains a valid SHAKEN Identity header
2. INVITE contains no Identity header
3. INVITE contains an invalid Identity header

Note, the following sub-sections use the term "PAID" to refer to the P-Asserted-Identity header, and "PPI" to refer to the P-Preferred-Identity header. Also, in the following message sequence diagrams, the presence of the Diversion header in an INVITE request indicates that the INVITE has been retargeted by the SIP-PBX. Retargeting could also be indicated by the presence of the History-Info header, or the Referred-By header.

* + 1. ***Case-1: Identity/PAID/From conveyed in retargeted INVITE***

**SP-b policy**:

* Include received Identity headers in inbound [2] INVITE requests sent to SIP-PBX-1
* Trust P-Asserted-Identity header received in retargeted [3] INVITE requests from SIP-PBX-1

**SIP-PBX-1 capabilities:**

* When inbound [2] INVITE is retargeted, SIP-PBX-1 populates retargeted [3] INVITE with Identity, P-Asserted-Identity and From headers from [2] INVITE, and with a Diversion header identifying the retargeting entity

**Case-1a: Originating [1] INVITE contains valid SHAKEN Identity header**

On receiving [1] INVITE in Figure 5, SP-b STI-VS verifies that the received SHAKEN Identity header is valid. SP-b includes the Identity header and a “TN-Verification-Passed” indication in [2] INVITE to SIP-PBX-1. On receiving [3] INVITE from SIP-PBX-1, SP-b detects that a previous inbound INVITE to SIP-PBX-1 has been retargeted by the presence of the Diversion header. Since [3] INVITE contains an Identity header, the STI-AS performs normal “div” authentication, and replaces the received Identity header with an Identity header containing the newly created “div” PASSporT, which in turn contains the nested “shaken” PASSporT, and routes [4] INVITE to SP-c.



Figure 5. Case-1a – [1] INVITE contains valid Identity header

**Case-1b: Originating [1] INVITE contains no Identity header**

On receiving [1] INVITE in Figure 6, SP-b STI-VS skips verification since there is no Identity header. Based on local policy, SP-b STI-AS performs authentication for calling TN-a, and adds a SHAKEN Identity header with an attestation level of "Gateway" to [2] INVITE. On receiving [3] INVITE from SIP-PBX-1, SP-b STI-AS performs normal “div” authentication, and replaces the received Identity header with an Identity header containing the “div” PASSporT, and routes [4] INVITE to SP-c.

As an alternative, SP-b could choose not perform SHAKEN authentication on [1] INVITE, in which case [2] INVITE to SIP-PBX-1 would not contain an Identity header. In this case, SP-b would perform SHAKEN authentication on [3] INVITE (since it doesn’t contain a SHAKEN Identity header), and include a single SHAKEN Identity header for calling TN-a with "Gateway" attestation in [4] INVITE to SP-c.

The first option, where SP-b authenticates [1] INVITE, has a slight advantage in that SP-b assigns a "shaken" PASSporT "origid" claim that could be used during subsequent trace-back activity to identify the ingress gateway that received [1] INVITE, and possibly identify originating SP-a. Ultimately, the option selected is a policy decision for SP-b.



Figure 6. Case-1b – [1] INVITE contains no Identity header

**Case-1c: Originating [1] INVITE contains invalid Identity header**

On receiving [1] INVITE in Figure 7, SP-b STI-VS verification service produces a failure result (PASSporT signature validation fails since "orig" claim does not match the calling TN in the P-Asserted-Identity header). SP-b sends the invalid Identity header in [2] INVITE to SIP-PBX-1. On receiving retargeted [3] INVITE from SIP-PBX-1, SP-b STI-AS performs “div” authentication, and replaces the received Identity header with an Identity header containing a “div” PASSporT to [4] INVITE. Verification fails at SP-c, and a “TN-Validation-Failed” indication is delivered to UE-c in [5] INVITE.



Figure 7. Case-1c – [1] INVITE contains invalid Identity header

* + 1. ***Case-2: Identity conveyed in retargeted INVITE, but not PAID/From***

**SP-b policy**:

* Include received Identity headers in inbound [2] INVITE requests sent to SIP-PBX-1

**SIP-PBX-1 capabilities:**

* SIP-PBX-1 populates retargeted [3] INVITE with Identity header from [2] INVITE, and with P-Preferred-Identity/From headers containing retargeting TN-b. P-Asserted-Identity from [2] INVITE is discarded.
* SIP-PBX does not include Diversion header in retargeted INVITE requests.

**Case-2a: Originating [1] INVITE contains valid SHAKEN Identity header**

On receiving [1] INVITE in Figure 8, SP-b STI-VS verifies that the received SHAKEN Identity header is valid, and includes the Identity header and a “TN-Validation-Passed” indication in [2] INVITE to SIP-PBX-1. The SIP-PBX populates the P-Preferred-Identity header of [3] INVITE with the calling user identity (TN-b) that the SIP-PBX would like to deliver to the called user TN-c for this call leg. On receiving [3] INVITE, SP-b detects that the received “shaken” PASSporT is not valid since the “orig” claim TN (TN-a) does not match the actual calling TN (TN-b). Therefore, the STI-AS removes the received SHAKEN Identity header, performs “shaken” authentication for calling TN-b, and includes the resulting SHAKEN Identity header in [4] INVITE to SP-c.



Figure 8. Case-2a – [1] INVITE contains valid Identity header

Case-2a demonstrates the fact that a SIP-PBX cannot deliver end-to-end SHAKEN by simply relaying the received Identity header in a retargeted INVITE. For call retargeting scenarios where the customer wants to deliver the original calling TN-a to the forward-to user, the SIP-PBX must convey calling TN-a in the P-Preferred-Identity or P-Asserted-Identity header of the retargeted INVITE, and explicitly indicate that the INVITE is being retargeted with a Diversion or History-Info header, similar to the Case-1 procedures shown in Appendix A.2.1.

**Case-2b/2c: Originating [1] INVITE contains no/invalid Identity header**

The procedures for Case-2b/2c are generally the same as Case-2a. Independent of the SHAKEN authentication information received from SP-a in [1] INVITE, SP-b delivers a SHAKEN Identity header authenticating TN-b in [4] INVITE to SP-c.

* + 1. ***Case-3: PAID/From conveyed in retargeted INVITE, but not Identity***

**SP-b policy**:

* Do not include received Identity headers in inbound [2] INVITE requests sent to SIP-PBX-1.

**SIP-PBX-1 capabilities:**

* SIP-PBX-1 does not populate [3] INVITE with an Identity header, either because it did not receive one from host SP, or because it doesn’t convey Identity headers in retargeted INVITE requests.
* SIP-PBX-1 populates [3] INVITE with the P-Asserted-Identity and From headers received in [2] INVITE, and with a Diversion header identifying the retargeting entity.

**Case-3a: Originating [1] INVITE contains valid SHAKEN Identity header**

On receiving [1] INVITE in Figure 9, SP-b STI-VS verifies that the received SHAKEN Identity header is valid, and therefore includes a “TN-Validation-Passed” indication in [2] INVITE to SIP-PBX-1. Per local policy, SP-b does not include the received Identity header in [2] INVITE to the SIP-PBX. On receiving [3] INVITE from SIP-PBX-1, SP-b STI-AS performs SHAKEN authentication for calling TN-a with Gateway attestation followed by "div" authentication for retargeting TN-b, and adds the resulting Identity header containing the "div" PASSporT with nested "shaken" PASSporT to [4] INVITE to SP-c. On receiving [4] INVITE, SP-c STI-VS verifies the received Identity header (result is valid with Gateway attestation), and sends an indication of “No-TN-Validation” to UE-c.

****

Figure 9. Case-3a – [1] INVITE contains valid Identity header

**Case-3b/3c: Originating [1] INVITE contains no/invalid Identity header**

The procedure for Case-3b/3c is the same as Case-3a, except that for Case-3b, SP-b skips verification of [1] INVITE and sets the verification result indication in [2] INVITE to “No-TN-Validation”, while for Case-3c, verification of [1] INVITE fails and SP-b sets verification result indication in [2] INVITE to “TN-Validation-Failed”. In both cases, SP-b provides a SHAKEN Identity header authenticating TN-a in [4] INVITE to SP-c.

* + 1. ***Case-4: Retargeted INVITE does not convey Identity/PAID/From***

**SP-b policy**:

* Do not include received Identity headers in inbound [2] INVITE requests sent to SIP-PBX-1

**SIP-PBX-1 capabilities:**

* SIP-PBX-1 does not populate [3] INVITE with an Identity header, either because it did not receive one from host SP, or because it doesn’t convey Identity headers in retargeted INVITE requests.
* SIP-PBX-1 populates retargeted [3] INVITE with P-Preferred-Identity and From headers containing TN of retargeting entity. SIP-PBX-1 does not include the P-Asserted-Identity header from [2] INVITE in the [3] INVITE request.
* SIP-PBX does not include Diversion header in retargeted INVITE requests.

**Case-4a: Originating [1] INVITE contains valid SHAKEN Identity header**

On receiving [1] INVITE in Figure 10, SP-b STI-VS verifies that the received SHAKEN Identity header is valid, and includes a “TN-Validation-Passed” indication in [2] INVITE to SIP-PBX-1. Per local policy, SP-b does not include the received Identity header in [2] INVITE to the SIP-PBX. On receiving [3] INVITE from SIP-PBX-1, SP-b STI-AS performs SHAKEN authentication for calling TN-b with Full attestation, and adds the resulting Identity header to [4] INVITE to SP-c. On receiving [4] INVITE, SP-c STI-VS verifies the received Identity header (result is valid with Full attestation), and sends an indication of “TN-Validation-Passed” to UE-c.

****

Figure 10. Case-4a – [1] INVITE contains valid Identity header

**Case-4b: Originating [1] INVITE contains no Identity header**

As shown in Figure 11, the procedure for Case-4b is the same as Case-4a, except that SP-b sets the verification result indication in [2] INVITE to “No-TN-Validation”.



Figure 11. Case-4b – [1] INVITE contains no Identity header

**Case-4c: Originating [1] INVITE contains invalid Identity header**

As shown in Figure 12, the procedure for Case-4c is the same as Case-4a, except that SP-b sets the verification result indication in [2] INVITE to “TN-Validation-Failed”.



Figure 12. Case-4c – [1] INVITE contains invalid Identity header

1. **SIP Identity Header Example for "div" PASSporT**

This appendix shows an example of a SIP Identity header containing a "div" PASSporT for the INVITE retargeting case where a call from TN-a to TN-b is forwarded to TN-c. The TN assignments used in the example are as follows:

* TN-a is 212-555-1212
* TN-b is 424-666-2323
* TN-c is 646-777-3434

TN-a, TN-b, and TN-c are hosted by SP-a (example-1.net), SP-b (example2.net), and SP-c (example3.net) respectively.

During origination call processing, SP-a provides authentication services for calling TN-a by creating a “shaken” PASSporT containing a Protected header and Payload as specified in [ATIS-1000074]:

Protected Header

{

"alg":"ES256",

"ppt":"shaken",

"typ":"passport",

"x5u":"https://cert.example1.net/passport.cer"

}

Payload

{

"attest":"A",

"dest":{"tn":["14246662323"]},

"iat":1538519401,

"orig":{"tn":"12125551212"},

"origid":"123e4567-e89b-12d3-a456-426655440000"

}

Per normal SHAKEN authentication procedures, SP-a adds an Identity header containing the resulting “shaken” PASSporT to the INVITE request sent to SP-b, as follows:

INVITE sip:+14246662323@tel.example2.net SIP/2.0  
Via: SIP/2.0/UDP 10.36.78.177:60012;branch=z9hG4bK-524287-1---77ba17085d60f141;rport  
Max-Forwards: 69  
Contact: <sip:+12125551212@69.241.19.12:50207;rinstance=9da3088f36cc528e>  
To: <sip:+14246662323@tel.example2.net>  
From: "Alice"<sip:+12125551212@tel.example1.net>;tag=614bdb40  
Call-ID: 79048YzkxNDA5NTI1MzA0OWFjOTFkMmFlODhiNTI2OWQ1ZTI

P-Asserted-Identity: "Alice"<sip:+12125551212@tel.example1.net>,<tel:+12125551212>  
CSeq: 2 INVITE  
Allow: SUBSCRIBE, NOTIFY, INVITE, ACK, CANCEL, BYE, REFER, INFO, MESSAGE, OPTIONS  
Content-Type: application/sdp  
Date: Tue, 02 Oct 2018 16:30:01 GMT

Identity: eyJhbGciOiJFUzI1NiIsInBwdCI6InNoYWtlbiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUxLm5ldC9wYXNzcG9ydC5jZXIifQo=.eyJhdHRlc3QiOiJBIiwiZGVzdCI6eyJ0biI6WyIxNDI0NjY2MjMyMyJdfSwiaWF0IjoxNTM4NTE5NDAxLCJvcmlnIjp7InRuIjoiMTIxMjU1NTEyMTIifSwib3JpZ2lkIjoiMTIzZTQ1NjctZTg5Yi0xMmQzLWE0NTYtNDI2NjU1NDQwMDAwIn0K.\_28kAwRWnheXyA6nY4MvmK5JKHZH9hSYkWI4g75mnq9Tj2lW4WPm0PlvudoGaj7wM5XujZUTb\_3MA4modoDtCA;info=<https://cert.example1.net/passport.cer>;alg=ES256;ppt="shaken"

Content-Length: 153  
v=0  
o=- 13103070023943130 1 IN IP4 10.36.78.177  
s=-

c=IN IP4 10.36.78.177  
t=0 0  
m=audio 54242 RTP/AVP 0  
a=sendrecv

On receiving the above INVITE request, SP-b forwards the call to SP-c by retargeting the INVITE to forward-to TN TN-c. SP-b authenticates forwarding TN-b by creating a “div” PASSporT containing a Protected header and Payload as shown below. The Protected header “ppt” field is set to “div” to indicate that this PASSporT complies with [draft-ietf-stir-passport-divert]. The “x5u” field references the SHAKEN certificate containing the public key that a remote terminating service can use to verify the "div" PASSporT signature.

Protected Header

{

"alg":"ES256",

"ppt":"div",

"typ":"passport",

"x5u":"https://cert.example2.net/passport.cer"

}

The PASSporT Payload “orig” claim is set to the “orig” claim of the received “shaken” PASSporT (TN-a), the “dest” claim is set to the new forward-to TN (TN-c), and the "div" claim is set to the forwarding TN (TN-b). The "opt" claim value is populated with the "shaken" PASSporT contained in the Identity header received from SP-a.

Payload

{

"dest":{"tn":["16467773434"]},

"div":{"tn":"14246662323"},

"iat":1538519403,

"orig":{"tn":"12125551212"},

"opt":"eyJhbGciOiJFUzI1NiIsInBwdCI6InNoYWtlbiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUxLm5ldC9wYXNzcG9ydC5jZXIifQo=.eyJhdHRlc3QiOiJBIiwiZGVzdCI6eyJ0biI6WyIxNDI0NjY2MjMyMyJdfSwiaWF0IjoxNTM4NTE5NDAxLCJvcmlnIjp7InRuIjoiMTIxMjU1NTEyMTIifSwib3JpZ2lkIjoiMTIzZTQ1NjctZTg5Yi0xMmQzLWE0NTYtNDI2NjU1NDQwMDAwIn0K.\_28kAwRWnheXyA6nY4MvmK5JKHZH9hSYkWI4g75mnq9Tj2lW4WPm0PlvudoGaj7wM5XujZUTb\_3MA4modoDtCA"

}

SP-b replaces the SHAKEN Identity header in the retargeted INVITE with a new Identity header containing the "div" PASSporT. The retargeted INVITE request sent to SP-c is shown in the following example:

INVITE sip:+ 16467773434@tel.example3.net SIP/2.0  
Via: SIP/2.0/UDP 10.36.78.177:60012;branch=z9hG4bK-524287-1---77ba17085d60f141;rport  
Max-Forwards: 68  
Contact: <sip:+12125551212@69.241.19.12:50207;rinstance=9da3088f36cc528e>  
To: <sip:+14246662323@tel.example2.net>  
From: "Alice"<sip:+12125551212@tel.example1.net>;tag=614bdb40  
Call-ID: 79048YzkxNDA5NTI1MzA0OWFjOTFkMmFlODhiNTI2OWQ1ZTI

P-Asserted-Identity: "Alice"<sip:+12125551212@tel.example1.net>,<tel:+12125551212>  
CSeq: 2 INVITE  
Allow: SUBSCRIBE, NOTIFY, INVITE, ACK, CANCEL, BYE, REFER, INFO, MESSAGE, OPTIONS  
Content-Type: application/sdp  
Date: Tue, 02 Oct 2018 16:30:03 GMT

Diversion: <sip:+14246662323@tel.example2.net>;reason=unconditional

Identity: eyJhbGciOiJFUzI1NiIsInBwdCI6ImRpdiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUyLm5ldC9wYXNzcG9ydC5jZXIifQo=..rq3pjT1hoRwakEGjHCnWSwUnshd09zJ6F1VOgFWSjHBr8QjpjlkpcpFYpFYsojNCpTzO3QfPOlckGaS6hEck7w;info=<https://cert.example2.net/passport.cer>;alg=ES256;ppt="div"

Content-Length: 153  
v=0  
o=- 13103070023943130 1 IN IP4 10.36.78.177  
s=-

c=IN IP4 10.36.78.177  
t=0 0  
m=audio 54242 RTP/AVP 0  
a=sendrecv

On receiving the retargeted INVITE request, SP-c verifies the received "shaken" and “div” PASSporTs as specified in [ATIS-1000074] and in this specification, including verification that the “div” PASSporT provides an unbroken chain of authority between the Request-URI TN and the "shaken" PASSporT "dest" claim.

1. Available from the Internet Engineering Task Force (IETF) at: < <https://www.ietf.org/> >. [↑](#footnote-ref-1)
2. Available from 3rd Generation Partnership Project (3GPP) at: < [https://www.3gpp.org](http://www.3gpp.org) > [↑](#footnote-ref-2)