**ATIS-0x0000x**

ATIS Standard on

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

**Proof-of-Possession of Telephone Numbers (TN-PoP)**

**Alliance for Telecommunications Industry Solutions**

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**Abstract**

This technical report defines mechanisms that enable a Service Provider to delegate STI authentication authority for a subset of its TNs to another entity. This delegation capability is needed to support STI for cases such as multi-homed SIP-PBXs, where the authorized owner of a TN does not provide originating call services for that TN.

**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:

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

**Revision History**

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# Scope, Purpose, & Application

## Scope

TN Proof-of-Possession (TN-PoP) is an extension to the base SHAKEN framework that enables an STI-authorized service provider to delegate authority for a subset of its telephone numbers to another non-STI entity. The non-STI entity can then use this “proof of possession” to provide cryptographic proof to STI verification services that it has authority to attest that the customer can legitimately originate calls from the delegated TNs.

This specification addresses all aspects of extending SHAKEN to support TN Proof-of-Possession, including:

* The TN-PoP certificate management procedures
* The TN-PoP authenticate and verification procedures during SIP call establishment

## Purpose

Users of legitimate telephone services should be able to receive the benefit of SHAKEN authentication with full attestation. To that end, the base SHAKEN specification describes three conditions that must exist in order for a SHAKEN authentication service to fully attest that an originating customer can legitimately use the calling TN:

1. The signing provider must be responsible for the origination of the call onto the IP based service provider voice network.
2. The signing provider must have a direct authenticated relationship with the customer and can identify the customer.
3. The signing provider must have established a verified association with the calling telephone number

Conditions 1 and 2 are relatively unambiguous; the originating provider is the signing provider, and the originating provider typically authenticates the calling user by some industry-accepted authentication mechanism such as SIP Digest.

The 3rd condition can be more complex. Obviously, condition 3 is easily satisfied for the case where the originating provider has authority over the calling TN, has assigned the calling TN to the originating customer, and has directly authenticated the customer before the call. However, there are a number of legitimate real-world call scenarios where this is not the case; i.e., where the originating SP does not have direct knowledge of the set of TNs the calling user is authorized to use, but it may still be legitimate for the customer to receive full attestation. Example scenarios include the following (note, list is not exhaustive):

* A SIP-PBX obtains originating call service from multiple providers (e.g., for redundancy or least cost routing). In this case, the PBX can legitimately originate a call via one provider from a calling TN that it obtained from a different provider.
* An enterprise wants to display a toll-free callback number for B2C calls, and the 800-number provider (RespOrg) and the originating provider are two separate entities.
* A “legitimate spoofing” service displays the subscriber’s work TN for calls originated by the user’s home phone.
* An outbound dialing service that automatically initiates calls on behalf of a business or other entity, and displays the business TN to the called users (e.g., school announces weather-related school closings to students, or airline sends flight information updates to its passengers).
* Wholesaled TNs used by reseller SPs, Cloud Communication Providers, and others when they originate calls
* A contact center serving multiple enterprises from various locations originates calls using the unique calling TN specified by each enterprise.

The SHAKEN specification provides guidance to originating SPs on how they can satisfy the TN-legitimacy condition in order to provide full attestation for call scenarios where the originating provider is not the TN provider. For example, the originating SP could establish the legitimacy of the calling TN as part of the service level agreement with the customer, or it could obtain the necessary TN assignment information from the TN provider using some “out-of-band” mechanism. However, these mechanisms often have shortcomings. The service level agreement approach may be unworkable in practice due to a low level of trust between originating provider and customer. Or the originating provider may have no relationship with or knowledge of the TN provider. And finally, the ad-hoc and non-automated nature of these mechanisms incurs a large administrative overhead for the participating parties (e.g., the overhead required to establish relationships between otherwise unrelated providers), and could make full attestation non-viable in the majority of enterprise scenarios.

The TN Proof-of-Possession mechanism defined in this specification addresses these shortcomings by providing an automated, protocol-based mechanism that enables an originating customer to provide cryptographic proof to the originating provider that the customer is authorized to use the calling TN. It does this in a way that is consistent with the foundational principles underlying SHAKEN. Specifically, a service provider only attests to “what it knows”. When a service provider makes an attestation, it is “putting its reputation on the line”. And finally, TN-PoP certificates provide an effective mechanism for authorities to “find and punish” service providers who abuse the system or fail to exercise due diligence.

Editor’s Note: for the scenarios where there is not a pre-existing relationship between the carrier that provides the TN and the originating carrier, local policy in the originating carrier’s network may dictate partial vs. full attestation. Further discussion and contributions to follow.

# 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).*

ATIS-1000080, *SHAKEN: Governance Model and Certificate Management,*

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

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

RFC 4122, *A Universally Unique IDentifier (UUID) URN Namespace.*1

RFC 4949, *Internet Security Glossary, Version 2.*1

RFC 5806, *Diversion Indication in SIP*. 1

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

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

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

draft-ietf-acme-authority-token, *ACME Challenges Using an Authority Token.* 1

draft-ietf-acme-authority-token-tnauthlist, *TNAuthList profile of ACME Authority Token.* 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

The following provides some key definitions used in this document.

**Caller ID:** The originating or calling party’s telephone number used to identify the caller carried either in the P-Asserted-Identity or From header fields in the Session Initiation Protocol (SIP) [RFC 3261] messages.

**(Digital) Certificate:** Binds a public key to a Subject (e.g., the end-entity). A certificate document in the form of a digital data object (a data object used by a computer) to which is appended a computed digital signature value that depends on the data object [RFC 4949]. See also STI Certificate.

**Certification Authority (CA):** An entity that issues digital certificates (especially X.509 certificates) and vouches for the binding between the data items in a certificate [RFC 4949].

**Certificate Chain:** See Certification Path.

**Certification Path:** A linked sequence of one or more public-key certificates, or one or more public-key certificates and one attribute certificate, that enables a certificate user to verify the signature on the last certificate in the path, and thus enables the user to obtain (from that last certificate) a certified public key, or certified attributes, of the system entity that is the subject of that last certificate. Synonym for Certificate Chain [RFC 4949].

**Certificate Revocation List (CRL):** A data structure that enumerates digital certificates that have been invalidated by their issuer prior to when they were scheduled to expire [RFC 4949].

**Certificate Signing Request (CSR):** A CSR is sent to a CA to request a certificate. A CSR contains a Public Key of the end-entity that is requesting the certificate.

**Chain of Trust:** Deprecated term referring to the chain of certificates to a Trust Anchor. Synonym for Certification Path or Certificate Chain [RFC 4949].

**Certificate Validation:** An act or process by which a certificate user established that the assertions made by a certificate can be trusted [RFC 4949].

**Company Code:** A unique four-character alphanumeric code (NXXX) assigned to all Service Providers [ATIS-0300251].

**End-Entity:** An entity that participates in the Public Key Infrastructure (PKI). Usually a Server, Service, Router, or a Person. In the context of SHAKEN, it is the Service Provider on behalf of the originating endpoint.

**Fingerprint:** A hash result ("key fingerprint") used to authenticate a public key or other data [RFC 4949].

**Identity:** Either a canonical Address-of-Record (AoR) SIP Uniform Resource Identifier (URI) employed to reach a user (such as ’sip:alice@atlanta.example.com’), or a telephone number, which commonly appears in either a TEL URI [RFC 3966] or as the user portion of a SIP URI. See also Caller ID [RFC 8224].

**National/Regional Regulatory Authority (NRRA):** A governmental entity responsible for the oversight/regulation of the telecommunication networks within a specific country or region.

NOTE: Region is not intended to be a region within a country (e.g., a region is not a state within the US).

**Online Certificate Status Protocol (OCSP):** An Internet protocol used by a client to obtain the revocation status of a certificate from a server.

**Private Key:** In asymmetric cryptography, the private key is kept secret by the end-entity. The private key can be used for both encryption and decryption [RFC 4949].

**Public Key:** The publicly disclosable component of a pair of cryptographic keys used for asymmetric cryptography [RFC 4949].

**Public Key Infrastructure (PKI):** The set of hardware, software, personnel, policy, and procedures used by a CA to issue and manage certificates [RFC 4949].

**Root CA:** A CA that is directly trusted by an end-entity. See also Trust Anchor CA and Trusted CA [RFC 4949].

**Secure Telephone Identity (STI) Certificate:** A public key certificate used by a service provider to sign and verify the PASSporT.

**Service Provider Code:** In the context of this document, this term refers to any unique identifier that is allocated by a Regulatory and/or administrative entity to a service provider. In the US and Canada this would be a Company Code as defined in [ATIS-0300251].

**Signature:** Created by signing the message using the private key. It ensures the identity of the sender and the integrity of the data [RFC 4949].

**Telephone Identity:** An identifier associated with an originator of a telephone call. In the context of the SHAKEN framework, this is a SIP identity (e.g., a SIP URI or a TEL URI) from which a telephone number can be derived.

**TN Proof-of-Possession (TN-PoP) Certificate:** An STI certificate whose scope of authority is expressed in terms of one or more telephone numbers.

**Trust Anchor:** An established point of trust (usually based on the authority of some person, office, or organization) from which a certificate user begins the validation of a certification path. The trust anchor is a combination of a trusted public key and the name of the entity to which the corresponding private key belongs [RFC 4949].

**Trust Anchor CA:** A CA that is the subject of a trust anchor certificate or otherwise establishes a trust anchor key. See also Root CA and Trusted CA [RFC 4949].

**Trusted CA:** A CA upon which a certificate user relies for issuing valid certificates; especially a CA that is used as a trust anchor CA [RFC 4949].

**Trust Model:** Describes how trust is distributed from Trust Anchors.

## Acronyms & Abbreviations

|  |  |
| --- | --- |
| 3GPP | 3rd Generation Partnership Project |
| ATIS | Alliance for Telecommunications Industry Solutions |
| B2BUA | Back-to-Back User Agent |
| CRL | Certificate Revocation List |
| CSCF | Call Session Control Function |
| CVT | Call Validation Treatment |
| 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 | Persona 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 |
| TN-PoP | TN Proof-of-Possession |
| TrGW | Transition Gateway |
| UA | User Agent |
| URI | Uniform Resource Identifier |
| UUID | Universally Unique Identifier |
| VoIP | Voice over Internet Protocol |

# Overview

This document describes a mechanism called TN Proof-of-Possession (TN-PoP) that extends the base Secure Telephone Identity procedures defined by IETF STIR to enable a calling TN to be authenticated with full attestation when TN ownership and originating call processing are split between two different providers.

TN Proof-of-Possession defines two new entities:

1. Telephone Number Provider (TN Provider):
   * An entity that is authoritative over a set of telephone numbers, and that can delegate a subset of those telephone numbers to another entity to attest for signing. In the context of this document, a TN Provider is an STI Service Provider as defined in the base SHAKEN specification (i.e., a TN Provider is authorized by the STI-PA to obtain end-user certificates from an STI-CA).
   * Ultimately the entities entitled to obtain STI Certificates will be defined by the STI-GA, but the initial definition is “Service Providers with an OCN (Operating Carrier Number) and eligible to directly obtain TNs.
2. Customer Application Function (Customer AF):
   * A non-STI-authorized entity that purchases (or otherwise obtains) delegated telephone numbers from a Telephone Number Provider.
   * Examples include an Enterprise PBX, Contact Center, Cloud Communication Provider, a legitimate spoofing application, or an automated outbound dialing service.

The TN-PoP framework provides a way for the Customer AF to obtain a TN-PoP certificate from the TN Provider, that the Customer AF can then use to attest to remote verification services that the calling TNs is being used legitimately.

### TN-PoP Certificate

The base SHAKEN Governance Model and Certificate Management specification [ATIS-1000080] mandates support for STI certificates that have a scope of authority expressed in terms of the identity of the certificate holder. Specifically, the TN Authorization List of the SHAKEN STI certificate must contain a ServiceProviderCode data item that identifies the SP holding the certificate. The assumption is that a terminating network performing STI verification trusts that an originating SP will sign "shaken" PASSporTs with full attestation only when it has established a verified association with the TN used for the call. This is a reasonable assumption, given that the STI-VS can verify that the originating SP has been authorized by the STI-PA to perform SHAKEN authentication.

Since a Customer AF is not an STI-authorized entity, it would not be appropriate to have verification services blindly trust that an originating Customer AF holding a valid STI certificate with SPC-level granularity is authorized to attest to the calling TN. The scope of a certificate obtained by the Customer AF must therefore be expressed in more granular terms that explicitly identify the TN or set of TNs that have been delegated by the TN Provider to the Customer AF. In this way, a verifier can check that the calling TN is on the list of TNs identified by the certificate. This more granular scope for is achieved using the TelephoneNumber, and TelephoneNumberRange data types of the TN Authorization List identifier defined by RFC [8226]. This document refers to certificates having TN-level granularity as TN-PoP certificates.

### PASSporT "tn-pop" Extension

TN-PoP utilizes the PASSporT extension "tn-pop" defined in [future reference]. This PASSporT extension serves two purposes. First, it enables a specific set of claims to be defined for TN-PoP authentication. Second, the presence of the “tn-pop” extension can serve as a trigger to inform a remote verification service that it must perform additional TN-PoP verification procedures; specifically, it must verify that the calling TN belongs to the set of TNs identified in the TN Authorization List of the TN-PoP certificate referenced by the PASSporT "x5u” parameter.

### TN-PoP Requirements

This section describes the overall requirements that apply to the TN-PoP solution.

1. When a TN provider delegates a subset of its TNs to a Customer AF, it may optionally provide a TN-PoP certificate for the delegated TNs to the Customer AF. A TN-PoP certificate is required if the customer wants to receive the benefit of SHAKEN authentication with full attestation for calls originated from the delegated TNs when the TN provider is not the originating provider.
2. A TN provider shall ensure that the scope of a TN-PoP certificate provided to a Customer AF covers only the TNs that it has delegated to the Customer AF.
3. When originating a call from a delegated TN that is in-scope for one of its TN-PoP certificates, the Customer AF shall use the certificate to perform TN-PoP authentication service (i.e., build an Identity header containing a "tn-pop" PASSporT that claims the legitimacy of the calling TN and that is signed with the certificate’s private key).
4. An originating SP serving the Customer AF shall verify any TN-PoP Identity header field received from the Customer AF, as specified in this document. The originating SP shall then replace the received TN-PoP Identity header with a SHAKEN Identity header. If the received TN-PoP Identity header is valid, then the SP shall assert Full attestation in the SHAKEN Identity header.

### TN-PoP Procedures

This section describes the information flow associated with the TN-PoP procedures for managing TN-PoP certificates, and for using TN-PoP certificates to authenticate and verify delegated TNs during call establishment.

#### PoP Certificate Management

Figure 1 shows the high-level overview of the procedure to provide TN Proof-of-Possession to the Customer AF.



Figure 1. Obtaining a TN-PoP Certificate

At 0) in Figure 1, the TN Provider delegates a subset of its TNs to the Customer AF. This is typically done at service turn-up time via a web-portal or API hosted by the TN Provider. Once it knows the set of TNs that it has been allocated, the Customer AF initiates the procedure to obtain a TN-PoP certificate that it can use as proof that it has authority for those delegated TNs:

1. The Customer AF first generates a public/private key pair, and stores the private key in a private key store. The public key will be carried in the TN-PoP certificate. The Customer AF will use the private key later, during origination call processing, to digitally sign calling TNs.

The remaining steps in the procedure are supported by the ACME protocol.

1. The Customer AF asks the TN Provider for a TN-PoP certificate that has a scope of authority covering the delegated TNs, and that contains the public key generated in (1).
2. The TN Provider verifies that the Customer AF is authorized to obtain TN-PoP certificates for the requested scope (see section 4.1.4.2 for details). If the requested scope does not exceed set of TNs delegated to the customer, then the TN Provider requests a TN-PoP certificate from the STI-CA, following the normal procedures defined by SHAKEN Certificate Management.
3. The STI-CA generates a TN-PoP certificate that is linked via a certification path through a sequence of zero or more intermediate certificates to one of the CA’s root certificates. The STI-CA returns all of the certificates in the certification path, including the TN-PoP certificate, to the TN Provider at (4).
4. The TN Provider stores the TN-PoP certificate in the STI-CR in order to make it available to remote verification services.
5. The TN Provider delivers the TN-PoP certificate to the Customer AF.

#### TN-PoP Certificate Authorization

##### Authorization at the TN Provider

The SHAKEN Governance and Certificate Management specification [ATIS-1000080] defines a token-based authorization mechanism whereby an SP obtains an SPC Token from the STI-PA that it can then use to prove authority over a TNAuthList Identifier when ordering an STI certificate from an STI-CA. While the SPC Token and TNAuthList that it authorizes can support a scope at both SPC-level and TN-level granularity, SHAKEN mandates support only for SPC-level scope.

This specification mandates that a TN Provider will reuse the SHAKEN-defined SPC Token mechanism to prove authority over the TNAuthList identifiers of TN-PoP certificates; i.e., a SHAKEN SPC Token (with SPC-level scope) will be used to prove authority over a TN-PoP TNAuthList containing both a Service Provider Code value of the requesting TN Provider and a set of delegated TN(s). In this case, the STI-CA issuing a TN-PoP certificate assumes that the requesting TN Provider is authoritative for the TNs identified by the TNAuthList in the CSR of the request.

The IETF ACME working group is defining a standard ACME extension for token-based authorization of TNAuthList identifiers that will eventually replace the SHAKEN-defined SPC Token. This work is being defined in the two drafts:

* [draft-ietf-acme-authority-token] defines a generic token-based authorization mechanism for ACME,
* [draft-ietf-acme-authority-token-tnauthlist] extends the generic token mechanism to define a specific authorization token type for the TNAuthList identifier called “TNAuthList Authorization Token”.

[draft-ietf-acme-authority-token-tnauthlist] defines the ACME authorization procedures for both SPC-level and TN-level TNAuthList Authorization tokens. Therefore, once SHAKEN has adopted this ACME token extension, it can choose to mandate support for TN-level TNAuthList Authorization Tokens for TN Providers that want to obtain TN-PoP certificates. In this case, the STI-PA would acquire the added responsibility of ensuring that the TNs authorized by a TNAuthList Authorization Token are in fact assigned to the TN Provider requesting the token (e.g., by checking LERG, NPAC, and other TN assignment databases). A TN Provider could then use its TN-level TNAuthList Authorization Token to explicitly demonstrate to an STI-CA that it has authority over the set of delegated TNs identified by the TNAuthList identifier when ordering a TN-PoP certificate.

##### Authorization at the Customer AF

ACME supports a mechanism called External Account Binding that enables the TN Provider to pre-authorize the customer’s ACME account to issue TN-PoP certificates with the proper scope. This simplifies the certificate authorization process for the Customer AF, since it eliminates the need to support the ACME identifier authorization procedures each time a certificate is issued.

An overview of the External Account Binding procedure is shown in Figure 2.



Figure 2. Pre-authorizing ACME Account via External Account Binding

External Account Binding enables the TN Provider to bind a newly created ACME Account to the customer’s already-established Customer Account, so that it can leverage the TN scope of authority of the Customer Account to pre-authorize the ACME Account.

1. At service activation time, the TN Provider and Customer AF perform some form of mutual authentication. The TN Provider creates a Customer Account, and provides the customer with its configuration data, including account ID and credentials, and the set of TNs delegated to the customer. The TN Provider also configures the Customer AF with the External Account Binding information that uniquely identifies the Customer Account.
2. The Customer AF includes the External Account Binding information in the ACME new-account request.
3. On receiving the request to create a new ACME Account, the TN Provider uses the received External Account Binding information to identify the Customer Account associated with this ACME Account.
4. The TN Provider pre-authorizes the ACME account to issue TN-PoP certificates for the set of TNs that have been delegated to the customer.

#### TN-PoP Authentication and Verification

Figure 2 shows the high-level overview of TN-PoP authentications and verification procedures used during call establishment.



Figure 3. TN-PoP Certificate support of STI Authentication & Verification during Call Setup

Figure 2 assumes that the Customer AF and TN Provider have already complete the procedure to obtain a TN-PoP certificate described in Figure 1. The call establishment procedure in Figure 2 is kicked off when the Customer AF receives an origination request to called TN-x from one of its delegated TNs (TN-a in this example).

1. The Customer AF Call Control function invokes the PoP-AS to perform authentication services for calling TN-a. The PoP-AS constructs a "tn-pop" PASSporT containing the calling TN-a, and signs it using the private key associated with the TN-PoP certificate. The PoP-AS then includes the "tn-pop" PASSporT and the TN-PoP certificate URL in a new Identity header.
2. The Customer AF Call Control includes the newly created Identity header containing the "tn-pop" PASSport in the originating INVITE to the originating SP.
3. The originating SP Call Control invokes the PoP-VS to verify the received Identity header.
4. The PoP-VS fetches the referenced TN-PoP certificate from the STI-CR, and verifies the received Identity header; e.g., checks that the TN-PoP certificate chains to an authorized STI-CA, verifies that the "tn-pop" PASSporT signature using the public key of the TN-PoP certificate, and verifies that the calling TN is within the scope of authority of the TN-PoP certificate.
5. The originating SP Call Control invokes the STI-AS to perform SHAKEN authentication. If TN-PoP verification in step-4 passed, and the originating SP has a direct authenticated relationship with the customer, then the STI-AS asserts an attestation level of Full. If TN-PoP verification in step-4 failed, then the STI-AS asserts an attestation level per [ATIS-1000074], and based on local policy (e.g., Partial or Gateway attestation).
6. The originating SP Call Control replaces the TN-PoP Identity header with the SHAKEN Identity header, and sends the INVITE toward the terminating SP. (The "tn-pop" Passport is saved to support later trace-back activity.)
7. The Terminating SP Call Control invokes the STI-VS to validate the received Identity header.
8. The STI-VS fetches the SHAKEN certificate from the STI-CR, and performs the SHAKEN verification procedure.
9. The terminating SP Call Control sets the INVITE Verstat parameter based on the verification results (in this case verification passed), and sends the INVITE to the phone registered for TN-x. ,

Open issues:

1) An issue that may arise during call set-up is if a TN has been ported from a Service Provider and the TN-PoP certificates has been cached by the terminating SP to reflect the “recipient” SP. This would result in an unverified call. This issue is contingent on the following factors:

* The time to live for TN-PoP certificates, or
* The amount of time the TN-PoP certificates are cached

Consequently, short time to live certificates might minimize this problem, but if longer time to live certificates are used by SPs or the amount of time allowed for caching could result in an indeterminate number of unverified calls.

Discussion: If AF uses the proper new certificate and the verifier is cached, perhaps the verifier should check for a recent port change and refresh the cache by exception?

Proposed resolution: Add section to this document (or separate use-case doc?) that describes how the different number portability use cases are handled by TN-PoP. Analysis done to-date hasn’t uncovered any issues, but we probably should complete a more comprehensive analysis sooner rather than later in case the exercise identifies impacts to the TN-PoP mechanism.

In general, NP and TN-PoP should work as follows: When delegated number(s) covered by a TN-PoP cert is/are ported to a new TN Provider, the customer should obtain a new TN-PoP certificate from the recipient provider, and start using it to provide valid and up-to-date "tn-pop" PASSporTs. The new TN-PoP cert will be referenced by a new “x5u” URL, and since the URL forms part of the key into the HTTP cache, there shouldn’t be a problem where a PoP-VS inadvertently retrieves the old TN-PoP certificate from the cache.

Editor’s note: does the final “In general…” paragraph satisfactorily address this issue?

# TN Proof-of-Possession Solution Description

This section describes the TN Proof-of-Possession architecture, and the procedures that support TN-PoP certificate management, and authentication and verification services.

## TN Proof-of-Possession Architecture

Figure 3 shows how the SHAKEN certificate management architecture can be extended to support TN Proof-of-Possession certificates. TN-PoP reuses many of the same concepts and mechanisms defined by the base SHAKEN architecture. The Customer Application Function (Customer AF) plays a role similar to the Service Provider defined by SHAKEN, using the ACME protocol to obtain certificates from the STI CA. Since the Customer AF is not an STI-authorized entity however, it cannot access the STI-CA directly, but must work through the TN Provider that provided it with its set of TNs. The TN Provider therefore acts as a proxy between the Customer AF and the STI-CA to ensure that the scope of the TN-PoP certificates issued to the Customer AF do not exceed the set of TNs delegated to that customer.



Figure 4. SHAKEN Architecture to support Management of TN-PoP Certificate

### TN-PoP Functional Elements

As shown in Figure 3, the following functional elements are added to the SHAKEN architecture to support TN-PoP certificates:

Customer Application Functional Entities:

* SKS – a Secure Key Store to store the private keys associated with TN-PoP certificates.
* TN-PoP-AS – the function that authenticates the calling TN using a TN-PoP certificate and its private key
* CAF-KMS – plays a role similar to the SP-KMS

Telephone Number Provider Functional Entities:

* ACME Proxy – acts as an interworking function between the CAF-KMS and the STI-CA. The ACME proxy appears as a Certificate Authority to the CAF-KMS, and as an SP-KMS to the STI-PA and STI-CA. The ACME Proxy acts as the enforcement point to ensure that issued TN-PoP certificates do not exceed the authority of the receiving Customer AF.

### TN-PoP Interfaces

The interfaces supporting the management of TN-PoP certificates are described in Table-1.

Table 1. TN-PoP Certificate Management Interfaces

|  |  |  |
| --- | --- | --- |
| **Interface** | **Definition** | **Description** |
| 1) Store Private Key | Proprietary – defined by SKS vendor | The CAF-KMS uses this interface to store the private key of a TN-PoP certificate in the SKS. |
| 2) ACME (PoP) | ACME profile defined in this specification | The CAF-KMS uses this interface to order a new TN-PoP certificate from the ACME Proxy. The ACME Proxy uses this interface to deliver the URL of the STI-CR file containing the newly issued TN-PoP certificate to the CAF-KMS. |
| 3) ACME (SHAKEN) | ACME profile defined in [ATIS-1000080] | The ACME Proxy uses this interface to order a new TN-PoP certificate from the STI-CA. |
| 4) Store TN-PoP certificate | HTTPS POST, Content-Type: application/pem-certificate-chain | The SP-KMS uses this interface to store a newly issued TN-PoP certificate in the STI-CR. |
| 5) Retrieve TN-PoP certificate URL | Proprietary – defined by Customer AF | The TN-PoP-AS uses this interface to fetch the URL of the STI-CR file containing the newly issued TN-PoP certificate from the CAF-KMS. |
| 6) Retrieve Private Key | Proprietary – defined by SKS vendor | The PoP-AS uses this interface to fetch the private key associated with a newly issued TN-PoP certificate from the SKS. |

## TN-PoP Certificate Management Procedures

This section describes the procedures that are used to issue TN-PoP certificates to the Customer AF.

### ACME External Account Binding

To simplify the TN-PoP certificate authorization process for the Customer AF, the ACME interface between the Customer AF and TN Provider will utilize the External Account Binding mechanism to pre-authorize the ACME Account. A protocol-level description of the External Account Binding procedure is provided in Figure 5.



Figure 5. Pre-authorizing ACME Account using External Account Binding

1. During service activation, the TN Provider configures the Customer AF with external account binding information in the form of two data items; a key-id that identifies the Customer account, and a MAC-key that serves as a shared secret between the TN provider and Customer AF.
2. At ACME account creation time, the Customer AF builds a JWS that contains the key-id and the ACME account public key, and is signed using the MAC-key. This JWS is included in an externalAccountBinding field in the JWS of the new-account request.
3. On receiving the new-account request, the ACME Proxy verifies the externalAccountBinding field as described in [draft-ietf-acme-acme], and if valid, binds the newly created ACME account to the Customer account identified by the key-id. The ACME Proxy pre-authorizes the ACME account to issue TN-PoP certificates for the set of TNs delegated to the customer.
4. and 5) The Customer AF orders a new TN-PoP certificate via 4). The ACME Proxy provides the interworking functionality between 4) and 5) to fulfill the order. If the set of TNs identified in the order falls within the scope pre-authorized for this ACME account, then the ACME proxy issues the certificate via 4) without challenging the Customer AF to prove it has authority for the set of TNs. The TN-PoP certificate itself is ordered and issued via 5), following the procedures specified in [SHAKEN spec].

### TN-PoP Certificate Management Message Flow

Figure 6 shows the certificate management procedures that enables a Customer Application Function to obtain TN-PoP certificates.



Figure 6. Procedure to obtain TN-PoP certificate

This procedure assumes the following initial conditions have been met:

* The TN Provider has obtained a valid SPC token from the STI-PA, and has created an ACME account with the STI-CA, as defined by the SHAKEN Governance Model and Certificate Management specification [ATIS-1000080].
* The Customer AF has obtained the SPC value and its set of delegated TNs from the TN Provider, plus the information it needs to obtain a TN-PoP certificate covering those TNs, including External Account Binding data, and the URL of the ACME Proxy’s directory resource.
* The Customer AF has queried the ACME directory resource to obtain the other ACME URLs it will need to obtain a certificate, including the new-account and new-order URLs. (Note that in the case of TN-PoP certificates, both the new-account and new order URLs will resolve to the TN Provider’s ACME Proxy.) Once it has this information, the Customer AF initiates the following procedure to obtain a TN-PoP certificate:

1. The CAF-KMS generates a public/private key pair for the TN-PoP certificate, and stores the private key in the SKS.
2. The CAF-KMS generates a 2nd public/private key pair for the ACME account, and requests creation of a new ACME account using the new-account URL. The new-account request contains the externalAccountBinding information that was provided by the TN Provider. The ACME Proxy creates its local instance of the account, pre-authorizes the account using the received externalAccountBinding information, and returns an ACME “201 Created” response to the CAF-KMS.
3. The CAF-KMS orders a new TN-PoP certificate using the new-order URL identified by the directory resource. The new-order request includes the Identifier of the certificate to be issued in the form of a TNAuthList containing the SPC of the TN Provider, plus the set (or a subset) of TNs that the TN Provider previously delegated to the Customer AF. The ACME Proxy verifies that the ACME Account is pre-authorized to issue certificates for the listed TNs, and returns a "201 Created" response containing the URL to finalize the order.
4. The CAF-KMS assumes that the authorization for this order have been satisfied (i.e., it assumes that the ACME account has been pre-authorized to issue certificates for the requested identifier). Therefore, it constructs a CSR describing the certificate, and posts it to the finalize URL received in step-3. The Identifier field in the CSR is identical to the Identifier field sent with the new-order request in step-3.
5. The ACME Proxy sends a request for a new TN-PoP certificate to the STI-CA. The request includes the identifier contained in the CSR received from the CAF-KMS in step-4. The STI-CA returns an authorization challenge, along with a finalize URL, to the ACME Proxy.
6. The ACME Proxy responds to the challenge received in setp-5 with a valid SPC token.
7. The STI-CA validates the challenge response SPC token with the STI-PA as specified by SHAKEN.
8. The ACME Proxy posts the CSR received from the CAF-KMS in step-4 to the finalize URL received from the STI-CA in step-5.
9. The ACME Proxy starts polling the STI-CA to determine when the TN-PoP certificate has been issued, as specified by SHAKEN. When the TN-PoP certificate is issued by the STI-CA, the ACME Proxy downloads the certificate.
10. The ACME Proxy stores the TN-PoP certificate in the STI-CR.
11. In parallel with step-5, the CAF-KMS starts polling the ACME Proxy to determine when the certificate has been issued. After the ACME Proxy stores the TN-PoP certificate in the STI-CR in step-10, it responds to the poll with the certificate URL identifying the STI-CR file where it has stored the TN-PoP certificate. This URL will be used by the TN-PoP-AS to populate the certificate reference in the "tn-pop" PASSporT during TN-PoP authentication.

### ACME Certificate Management Procedures

This section defines the profile of the of the ACME protocol that shall be supported by the TN Provider and Customer AF for the management of TN Proof-of-Possession certificates. In this context, the CAF-KMS plays the role of ACME client, while the ACME Proxy plays the role of ACME Server.

#### Initial Conditions

The TN Provider shall configure the Customer AF with the following data items, as a pre-requisite to issuing TN-PoP certificates using the AME protocol:

* The set of telephone numbers that it is delegating to the Customer AF,
* The SPC of the TN Provider,
* The URL of the ACME directory resource,
* A MAC key and key identity to be used to bind the ACME accounts created by his customer to the already-established customer account.

#### Creating the ACME Proxy Account

The CAF-KMS and ACME Proxy shall support the ACME account creation process defined in [draft-ietf-acme-acme]. The ACME Proxy shall set the “externalAccountRequired” subfield of the “meta” field of the directory object to “true”. The CAF-KMS shall generate a public/private key pair using the ES256 algorithm, to serve as credentials for the account. The CAF-KMS shall include an “externalAccountBinding” field in the HTTP POST request that it sends to the “newAccount” resource to create the ACME account, as shown in the following example:

POST /acme/new-account HTTP/1.1

Host: acme-proxy.tn-provider.com

Content-Type: application/jose+json

{

"protected": base64url({

"alg": "ES256",

"jwk": /\* ACME account public key \*/,

"nonce": "6S8IqOGY7eL2lsGoTZYifg",

"url": "https:/acme-proxy.tn-provider.com/acme/new-account"

})

"payload": base64url({

"contact": [

"mailto:cert-admin-caf-kms01@caf.com",

"tel:+12155551212"

]

"externalAccountBinding": {

"protected": base64url({

"alg": "HS256",

"kid": /\* key-id from TN Provider \*/,

"url": "https:// acme-proxy.tn-provider.com/acme/new-account"

}),

"payload": base64url(/\* ACME acct public key (same as in "jwk" above \*/),

"signature": /\* MAC using MAC-key from TN Provider \*/

}

}),

"signature": /\* signed using ACME account private key \*/

}

If the account already exists for the specified account key, then the ACME Proxy shall send a “200 OK” response to the POST request. Otherwise, the ACME Proxy shall create an account object and send a “201 Created” response, as shown in the following example:

HTTP/1.1 201 Created

Content-Type: application/json

Replay-Nonce: D8s4D2mLs8Vn-goWuPQeKA

Location: https://acme-proxy.tn-provider.com/acme/acct/1

Link: <https://acme-proxy.tn-provider.com/acme/some-directory>;rel="index"

{

"status": "valid",

"contact": [

"mailto:cert-admin-caf-kms01@caf.com",

"tel:+12155551212"

]

}

#### Pre-authorizing the ACME Account

In order to pre-authorize the newly created ACME account, the ACME Proxy shall provision an authorization object with a “status” of “valid”, and containing an “identifier” field of type “TNAuthList” with the following values:

* The SPC of the TN Provider,
* The full set of TNs delegated by the TN Provider to the Customer AF.

TN Provider shall advertise the URL of the authorization object in the “newAuthz” field of the directory object.

An example of the authorization object is as follows:

{

"status": "valid",

"expires": "2018-03-01T14:09:00Z",

"identifier": {

"type":"TNAuthList",

"value": [

"spc":"1234",

"tn-range":{"start":"12155551212", "count":"50"}

]

},

"challenges": []

}

#### Obtaining a TN-PoP Certificate

The CAF-KMS and ACME Proxy shall support the pre-authorization certificate ordering and issuance process defined in [draft-ietf-acme-acme].

**1) Ordering the Certificate**

As the first step in applying for a new certificate, the CAF-KMS shall provide an “identifiers” field in the new-order POST request of “type” of “TNAuthList. The “value” of the “identifiers” field shall identify the Service Provider Code of the TN Provider, and shall identify one or more of the TNs that have been delegated by the TN Provider to the Customer AF, as shown in the following example:

POST /acme/new-order HTTP/1.1

Host: acme-proxy.tn-provider.com

Content-Type: application/jose+json

{

"protected": base64url({

"alg": "ES256",

"kid": " https://acme-proxy.tn-provider.com/acme/acct/1",

"nonce": "5XJ1L3lEkMG7tR6pA00clA",

"url": " https://acme-proxy.tn-provider.com/acme/new-order"

})

"payload": base64url({

"identifiers": {

"type":"TNAuthList",

"value": [

"spc":"1234",

"tn-range":{"start":"12155551212", "count":"50"}

]

},

"notBefore": "2018-01-01T00:00:00Z",

"notAfter": "2018-01-08T00:00:00Z"

}),

"signature": /\* signed using ACME account private key \*/

}

**2) Verifying the order**

The ACME Proxy shall verify that the “Identifiers” field in the new-order request matches the “identifier” field of the pre-provisioned authorization object described in step-2. As an option, and based on local policy, the ACME Proxy may choose to issue certificates when the request “identifiers” field contains a subset of the TNs identified by the “identifier” field in the authorization object.

If the request is valid, then the ACME Proxy shall send a “201 Created” response containing the newly created order object, as shown in the following example:

HTTP/1.1 201 Created

Replay-Nonce: MYAuvOpaoIiywTezizk5vw

Location: https://acme-proxy.tn-provider.com/acme/order/asdf

{

"status": "pending",

"expires": "2016-01-01T00:00:00Z",

"notBefore": "2016-01-01T00:00:00Z",

"notAfter": "2016-01-08T00:00:00Z",

"identifiers": {

"type":"TNAuthList",

"value": [

"spc":"1234",

"tn-range":{"start":"12155551212", "count":"50"}

]

},

"authorizations": [

"https://sti-ca.com/acme/authz/1234"

],

"finalize": "https://example.com/acme/order/asdf/finalize"

}

The “authorizations” field contains the URL to the pre-provisioned authorization object described in section 5.2.3.3. The “finalize” field contains the URL that the CAF-URL will use to finalize the order.

**3) Finalizing the order**

The CAF-KMS assumes that the account is pre-authorized to issue the requested certificate, and therefore shall proceed to finalize the order. (As an option, the CAF-KMS may verify that the ACME account has been pre-authorized by sending a POST-as-GET request to the URL contained in the “authorizations” field in step-2, and verify that the returned authorization object has a status of “valid”.)

To finalize the order, the CAF-KMS shall create a CSR as specified in [shaken spec], but containing an “identifier” field identical to the “identifiers” field of the new-order request in step-1. The CAF-KMS shall then finalize the order by sending an HTTP POST request containing the CSR to the “finalize” URL received in step-2, as shown in the following example:

POST /acme/order/asdf/finalize HTTP/1.1

Host: acme-proxy.tn-provider.com

Content-Type: application/jose+json

{

"protected": base64url({

"alg": "ES256",

"kid": "https://acme-proxy.tn-provider.com/acme/acct/1",

"nonce": "MSF2j2nawWHPxxkE3ZJtKQ",

"url": "https://acme-proxy.tn-provider.com/acme/order/asdf/finalize"

}),

"payload": base64url({

"csr": "5jNudRx6Ye4HzKEqT5...FS6aKdZeGsysoCo4H9P",

}),

"signature": /\* signed using ACME account private key \*/

}

The ACME Proxy shall respond to the finalize request with a “200 OK” response containing the order object, as shown in the following example:

HTTP/1.1 200 OK

Replay-Nonce: MYAuvOpaoIiywTezizk5vw

Location: https://acme-proxy.tn-provider.com/acme/order/asdf

{

"status": "processing",

"expires": "2018-01-01T00:00:00Z",

"notBefore": "2018-01-01T00:00:00Z",

"notAfter": "2018-01-08T00:00:00Z",

"identifiers": {

"type":"TNAuthList",

"value": [

"spc":"1234",

"tn-range":{"start":"12155551212", "count":"50"}

]

},

"authorizations": [

"https://acme-proxy.tn-provider.com/acme/authz/1234"

],

"finalize": "https://acme-proxy.tn-provider.com/acme/order/asdf/finalize"

}

At this point in the process, the ACME Proxy shall apply for a TN-PoP certificate of the requested scope with an STI-CA, as specified in [ATIS-1000080]. While the STI-CA is filling the ACME Proxy’s order, the ACME Proxy shall maintain a value of “processing” for the CAF-KMS order.

**4) Polling for the certificate**

Once it has finalized the certificate order with the STI-CA, the ACME Proxy shall periodically poll the STI-CA order as specified in [draft-ietf-acme-acme]. When the STI-CA indicates that the order has been filled, the ACME Proxy shall download the certificate from the STI-CA and store it in the STI-CR as specified in [shaken spec]

Likewise, once it has finalized the certificate order with the ACME Proxy, the CAF-KMS shall periodically poll the ACME Proxy’s order resource as specified in [draft-ietf-acme-acme]. When the order has been filled and the certificate has been stored in the STI-CR, the ACME proxy shall indicate to the CAF-KMS that the certificate is available by responding to the next poll as shown in the following example:

POST /acme/order/asdf HTTP/1.1

Host: acme-proxy.tn-provider.com

Content-Type: application/jose+json

Accept: application/pkix-cert

{

"protected": base64url({

"alg": "ES256",

"kid": " https://acme-proxy.tn-provider.com/acme/acct/1",

"nonce": "uQpSjlRb4vQVCjVYAyyUWg",

"url": "https://acme-proxy.tn-provider.com/acme/acme/order/asdf",

}),

"payload": "",

"signature": /\* signed using ACME account private key \*/

}

HTTP/1.1 200 OK

Replay-Nonce: MYAuvOpaoIiywTezizk5vw

Location: https://acme-proxy.tn-provider.com/acme/order/asdf

{

"status": "valid",

"expires": "2018-01-01T00:00:00Z",

"notBefore": "2018-01-01T00:00:00Z",

"notAfter": "2018-01-08T00:00:00Z",

"identifiers": {

"type":"TNAuthList",

"value": [

"spc":"1234",

"tn-range":{"start":"12155551212", "count":"50"}

]

},

"authorizations": [

"https://acme-proxy.tn-provider.com/acme/authz/1234"

],

"finalize": <https://acme-proxy.tn-provider.com/acme/order/asdf/finalize>

"certificate": "https://sti-cr.tn-provider.com/cert-1"

}

Note that the Customer AF does not need to download the actual certificate. It will use the URL identified in the “certificate” field of the response to populate the “x5u” field in the "tn-pop" PASSporT created during TN-PoP authentication.

## TN-PoP Authentication and Verification Procedures

### PASSporT "tn-pop" Extension Definition

This specification defines the “tn-pop” extension to the base PASSporT defined in [RFC 8225].

The "tn-pop" PASSporT Protected Header shall include a “ppt” parameter containing the value “tn-pop”. The "tn-pop" PASSporT Payload shall contain an “origid” claim defined in [ATIS-1000074].

An example of the"tn-pop" PASSporT Protected Header and Payload is as follows:

*Protected Header*

{

"alg":"ES256",

"typ":"passport",

"ppt":"tn-pop",

"x5u":"https://cert.example.org/passport.crt"

}

*Payload*

{

"dest":{"tn":["12125551213 "]},

"iat":"1443208345",

"orig":{"tn":"12155551212"},

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

}

### TN-PoP Authentication Procedures

The TN-PoP Authentication service shall construct an Identity header field as described in [ATIS-1000074], except as specified in this section.

The TN-PoP Authentication service shall populate the Identify header field with a "tn-pop" PASSporT. The value of the “x5u” parameter in the Protected Header shall be set to a URI that references a valid TN-PoP certificate whose scope includes the TN identified in the Payload “orig” parameter.

The value of the “origid” parameter shall be set to a globally unique string corresponding to a Universally Unique Identifier (UUID) [RFC 4122]. Based on local policy, the Customer AF can set the “origid” to differentiate geographic regions, organizational departments, or other unique aspects of the originating user.

The "tn-pop" PASSporT shall be signed using the private key of the TN-PoP certificate identified in the “x5u” parameter of the Protected Header.

### TN-PoP Verification Procedures

The TN-PoP Verification service shall perform the verification procedures described in [ATIS-1000074], with the exceptions specified in this section.

The TN-PoP Verification service shall verify that the Identity header field contains a PASSporT supporting the “tn-pop” extension. In addition, the TN-PoP Verification service shall verify that the telephone number contained in the “orig” claim is listed in the TN Authorization List of the TN-PoP certificate referenced by the "x5u" parameter. If the telephone number identified by the "tn-pop" PASSport “orig” claim is not listed in the TN Authorization List of the TN-PoP certificate, then the TN-PoP Verification service shall return the error response code 437 – ‘Unsupported credential’.

### TN-PoP SIP Procedures

During originating call processing, the Customer AF shall invoke its PoP-AS function to perform the TN-PoP Authentication procedures described in section 5.3.2, and shall include the resulting Identity header field in the SIP INVITE request sent to the originating Service Provider.

On receiving a SIP INVITE request containing an Identity header field with a "tn-pop" PASSporT from a Customer AF, the originating SP shall invoke its STI-VS function to perform the TN-PoP Verification procedures described in section 5.3.3. Following TN-PoP Verification, the originating SP shall invoke its STI-AS function to perform SHAKEN authentication as specified in [ATIS-1000074], except as noted in this section. The STI-AS shall set the attestation level in the "shaken" PASSporT based on the output of the TN-PoP Verification procedure, and on the authentication relationship between the originating SP and the customer, as follows:

1. **Full Attestation:**

* The TN-PoP Verification procedure indicates that the received Identity header contains a valid "tn-pop" PASSporT, and
* The originating SP has a direct authenticated relationship with the customer and can identify the customer, as specified in [ATIS-1000074].

1. **Partial Attestation:**

* The TN-PoP Verification procedure indicates that the received Identity header contains an invalid "tn-pop" PASSporT, and
* The originating SP has a direct authenticated relationship with the customer and can identify the customer, as specified in [ATIS-1000074].

1. **Gateway Attestation:**

* As specified in [ATIS-1000074]

The values of the SHAKEN attestation levels set by the originating SP when TN-PoP is supported are summarized in Table 2.

Table 2. SHAKEN Attestation Level following TN-PoP Verification

|  |  |  |
| --- | --- | --- |
| **Input to Attestation Level Determination** | | **Output Attestation Level1** |
| **Originating SP 🡨🡪 Customer AF Authentication Relationship** | **TN-PoP Verification Results** |
| Direct authenticated relationship | Passed | Full |
| Fail | Partial |
| No authenticated relationship | Passed | Gateway |
| Fail | Gateway |

The originating SP shall replace the TN-PoP Identity header field in the received INVITE request with a new Identity header field containing the newly constructed "shaken" PASSporT, and send the INVITE to the terminating SP. The terminating SP shall perform SHAKEN verification as specified in [ATIS-1000074].

# A Annex Title

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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)