       Enhancements for Authenticated Identity Management in the
                  Session Initiation Protocol (SIP)

Status of This Memo

   This document specifies an Internet standards track protocol for the
   Internet community, and requests discussion and suggestions for
   improvements. Please refer to the current edition of the "Internet
   Official Protocol Standards" (STD 1) for the standardization state
   and status of this protocol. Distribution of this memo is unlimited.

Abstract

   The existing security mechanisms in the Session Initiation Protocol
   (SIP) are inadequate for cryptographically assuring the identity of
   the end users that originate SIP requests, especially in an
   interdomain context. This document defines a mechanism for securely
   identifying originators of SIP messages. It does so by defining two
   new SIP header fields, Identity, for conveying a signature used for
   validating the identity, and Identity-Info, for conveying a reference
   to the certificate of the signer.

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1. Introduction

   This document provides enhancements to the existing mechanisms for
   authenticated identity management in the Session Initiation Protocol
   (SIP, RFC 3261 [1]). An identity, for the purposes of this document,
   is defined as a SIP URI, commonly a canonical address-of-record (AoR)
   employed to reach a user (such as 'sip:alice@atlanta.example.com').

   RFC 3261 stipulates several places within a SIP request where a user
   can express an identity for themselves, notably the user-populated
   From header field. However, the recipient of a SIP request has no
   way to verify that the From header field has been populated
   appropriately, in the absence of some sort of cryptographic
   authentication mechanism.

   RFC 3261 specifies a number of security mechanisms that can be
   employed by SIP user agents (UAs), including Digest, Transport Layer
   Security (TLS), and S/MIME (implementations may support other
   security schemes as well). However, few SIP user agents today
   support the end-user certificates necessary to authenticate
   themselves (via S/MIME, for example), and furthermore Digest
   authentication is limited by the fact that the originator and
   destination must share a prearranged secret. It is desirable for SIP
   user agents to be able to send requests to destinations with which
   they have no previous association -- just as in the telephone network
   today, one can receive a call from someone with whom one has no
   previous association, and still have a reasonable assurance that the
   person's displayed Caller-ID is accurate. A cryptographic approach,
   like the one described in this document, can probably provide a much
   stronger and less-spoofable assurance of identity than the telephone
   network provides today.

2. Terminology

   In this document, the key words "MUST", "MUST NOT", "REQUIRED",
   "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT
   RECOMMENDED", "MAY", and "OPTIONAL" are to be interpreted as
   described in RFC 2119 [2] and indicate requirement levels for
   compliant SIP implementations.

3. Background

   The usage of many SIP applications and services is governed by
   authorization policies. These policies may be automated, or they may
   be applied manually by humans. An example of the latter would be an
   Internet telephone application that displays the Caller-ID of a
   caller, which a human may review before answering a call. An example
   of the former would be a presence service that compares the identity

of potential subscribers to a whitelist before determining whether it
should accept or reject the subscription. In both of these cases,
attackers might attempt to circumvent these authorization policies
through impersonation. Since the primary identifier of the sender of
a SIP request, the From header field, can be populated arbitrarily by
the controller of a user agent, impersonation is very simple today.
The mechanism described in this document aspires to provide a strong
identity system for SIP in which authorization policies cannot be
circumvented by impersonation.

All RFC 3261-compliant user agents support Digest authentication,
which utilizes a shared secret, as a means for authenticating
themselves to a SIP registrar. Registration allows a user agent to
express that it is an appropriate entity to which requests should be
sent for a particular SIP AoR URI (e.g.,
'sip:alice@atlanta.example.com').

By the definition of identity used in this document, registration is
a proof of the identity of the user to a registrar. However, the
credentials with which a user agent proves its identity to a
registrar cannot be validated by just any user agent or proxy server
-- these credentials are only shared between the user agent and their
domain administrator. So this shared secret does not immediately
help a user to authenticate to a wide range of recipients.
Recipients require a means of determining whether or not the 'return
address' identity of a non-REGISTER request (i.e., the From header
field value) has legitimately been asserted.

The AoR URI used for registration is also the URI with which a UA
commonly populates the From header field of requests in order to
provide a 'return address' identity to recipients. From an
authorization perspective, if you can prove you are eligible to
register in a domain under a particular AoR, you can prove you can
legitimately receive requests for that AoR, and accordingly, when you
place that AoR in the From header field of a SIP request other than a
registration (like an INVITE), you are providing a 'return address'
where you can legitimately be reached. In other words, if you are
authorized to receive requests for that 'return address', logically,
it follows that you are also authorized to assert that 'return
address' in your From header field. This is of course only one
manner in which a domain might determine how a particular user is
authorized to populate the From header field; as an aside, for other
sorts of URIs in the From (like anonymous URIs), other authorization
policies would apply.

Ideally, then, SIP user agents should have some way of proving to
recipients of SIP requests that their local domain has authenticated
them and authorized the population of the From header field. This

document proposes a mediated authentication architecture for SIP in
which requests are sent to a server in the user's local domain, which
authenticates such requests (using the same practices by which the
domain would authenticate REGISTER requests). Once a message has
been authenticated, the local domain then needs some way to
communicate to other SIP entities that the sending user has been
authenticated and its use of the From header field has been
authorized. This document addresses how that imprimatur of
authentication can be shared.

RFC 3261 already describes an architecture very similar to this in
Section 26.3.2.2, in which a user agent authenticates itself to a
local proxy server, which in turn authenticates itself to a remote
proxy server via mutual TLS, creating a two-link chain of transitive
authentication between the originator and the remote domain. While
this works well in some architectures, there are a few respects in
which this is impractical. For one, transitive trust is inherently
weaker than an assertion that can be validated end-to-end. It is
possible for SIP requests to cross multiple intermediaries in
separate administrative domains, in which case transitive trust
becomes even less compelling.

One solution to this problem is to use 'trusted' SIP intermediaries
that assert an identity for users in the form of a privileged SIP
header. A mechanism for doing so (with the P-Asserted-Identity
header) is given in [12]. However, this solution allows only hop-
by-hop trust between intermediaries, not end-to-end cryptographic
authentication, and it assumes a managed network of nodes with strict
mutual trust relationships, an assumption that is incompatible with
widespread Internet deployment.

Accordingly, this document specifies a means of sharing a
cryptographic assurance of end-user SIP identity in an interdomain or
intradomain context that is based on the concept of an
'authentication service' and a new SIP header, the Identity header.
Note that the scope of this document is limited to providing this
identity assurance for SIP requests; solving this problem for SIP
responses is more complicated and is a subject for future work.

This specification allows either a user agent or a proxy server to
provide identity services and to verify identities. To maximize
end-to-end security, it is obviously preferable for end-users to
acquire their own certificates and corresponding private keys; if
they do, they can act as an authentication service. However, end-
user certificates may be neither practical nor affordable, given the
difficulties of establishing a Public Key Infrastructure (PKI) that
extends to end-users, and moreover, given the potentially large
number of SIP user agents (phones, PCs, laptops, PDAs, gaming

devices) that may be employed by a single user. In such
environments, synchronizing keying material across multiple devices
may be very complex and requires quite a good deal of additional
endpoint behavior. Managing several certificates for the various
devices is also quite problematic and unpopular with users.
Accordingly, in the initial use of this mechanism, it is likely that
intermediaries will instantiate the authentication service role.

4. Overview of Operations

   This section provides an informative (non-normative) high-level
   overview of the mechanisms described in this document.

   Imagine the case where Alice, who has the home proxy of example.com
   and the address-of-record sip:alice@example.com, wants to communicate
   with sip:bob@example.org.

   Alice generates an INVITE and places her identity in the From header
   field of the request. She then sends an INVITE over TLS to an
   authentication service proxy for her domain.

   The authentication service authenticates Alice (possibly by sending a
   Digest authentication challenge) and validates that she is authorized
   to assert the identity that is populated in the From header field.
   This value may be Alice's AoR, or it may be some other value that the
   policy of the proxy server permits her to use. It then computes a
   hash over some particular headers, including the From header field
   and the bodies in the message. This hash is signed with the
   certificate for the domain (example.com, in Alice's case) and
   inserted in a new header field in the SIP message, the 'Identity'
   header.

   The proxy, as the holder of the private key of its domain, is
   asserting that the originator of this request has been authenticated
   and that she is authorized to claim the identity (the SIP address-
   of-record) that appears in the From header field. The proxy also
   inserts a companion header field, Identity-Info, that tells Bob how
   to acquire its certificate, if he doesn't already have it.

   When Bob's domain receives the request, it verifies the signature
   provided in the Identity header, and thus can validate that the
   domain indicated by the host portion of the AoR in the From header
   field authenticated the user, and permitted the user to assert that
   From header field value. This same validation operation may be
   performed by Bob's user agent server (UAS).

5. Authentication Service Behavior

   This document defines a new role for SIP entities called an
   authentication service. The authentication service role can be
   instantiated by a proxy server or a user agent. Any entity that
   instantiates the authentication service role MUST possess the private
   key of a domain certificate. Intermediaries that instantiate this
   role MUST be capable of authenticating one or more SIP users that can
   register in that domain. Commonly, this role will be instantiated by
   a proxy server, since these entities are more likely to have a static
   hostname, hold a corresponding certificate, and have access to SIP
   registrar capabilities that allow them to authenticate users in their
   domain. It is also possible that the authentication service role
   might be instantiated by an entity that acts as a redirect server,
   but that is left as a topic for future work.

   SIP entities that act as an authentication service MUST add a Date
   header field to SIP requests if one is not already present (see
   Section 9 for information on how the Date header field assists
   verifiers). Similarly, authentication services MUST add a Content-
   Length header field to SIP requests if one is not already present;
   this can help verifiers to double-check that they are hashing exactly
   as many bytes of message-body as the authentication service when they
   verify the message.

   Entities instantiating the authentication service role perform the
   following steps, in order, to generate an Identity header for a SIP
   request:

   Step 1:

   The authentication service MUST extract the identity of the sender
   from the request. The authentication service takes this value from
   the From header field; this AoR will be referred to here as the
   'identity field'. If the identity field contains a SIP or SIP Secure
   (SIPS) URI, the authentication service MUST extract the hostname
   portion of the identity field and compare it to the domain(s) for
   which it is responsible (following the procedures in RFC 3261,
   Section 16.4, used by a proxy server to determine the domain(s) for
   which it is responsible). If the identity field uses the TEL URI
   scheme, the policy of the authentication service determines whether
   or not it is responsible for this identity; see Section 11 for more
   information. If the authentication service is not responsible for
   the identity in question, it SHOULD process and forward the request
   normally, but it MUST NOT add an Identity header; see below for more
   information on authentication service handling of an existing
   Identity header.

Step 2:

The authentication service MUST determine whether or not the sender
of the request is authorized to claim the identity given in the
identity field. In order to do so, the authentication service MUST
authenticate the sender of the message. Some possible ways in which
this authentication might be performed include:

    If the authentication service is instantiated by a SIP
    intermediary (proxy server), it may challenge the request with
    a 407 response code using the Digest authentication scheme (or
    viewing a Proxy-Authentication header sent in the request,
    which was sent in anticipation of a challenge using cached
    credentials, as described in RFC 3261, Section 22.3). Note
    that if that proxy server is maintaining a TLS connection with
    the client over which the client had previously authenticated
    itself using Digest authentication, the identity value obtained
    from that previous authentication step can be reused without an
    additional Digest challenge.

    If the authentication service is instantiated by a SIP user
    agent, a user agent can be said to authenticate its user on the
    grounds that the user can provision the user agent with the
    private key of the domain, or preferably by providing a
    password that unlocks said private key.

Authorization of the use of a particular username in the From header
field is a matter of local policy for the authentication service, one
that depends greatly on the manner in which authentication is
performed. For example, one policy might be as follows: the username
given in the 'username' parameter of the Proxy-Authorization header
MUST correspond exactly to the username in the From header field of
the SIP message. However, there are many cases in which this is too
limiting or inappropriate; a realm might use 'username' parameters in
Proxy-Authorization that do not correspond to the user-portion of SIP
From headers, or a user might manage multiple accounts in the same
administrative domain. In this latter case, a domain might maintain
a mapping between the values in the 'username' parameter of Proxy-
Authorization and a set of one or more SIP URIs that might
legitimately be asserted for that 'username'. For example, the
username can correspond to the 'private identity' as defined in Third
Generation Partnership Project (3GPP), in which case the From header
field can contain any one of the public identities associated with
this private identity. In this instance, another policy might be as
follows: the URI in the From header field MUST correspond exactly to
one of the mapped URIs associated with the 'username' given in the
Proxy-Authorization header. Various exceptions to such policies
might arise for cases like anonymity; if the AoR asserted in the From

header field uses a form like 'sip:anonymous@example.com', then the
'example.com' proxy should authenticate that the user is a valid user
in the domain and insert the signature over the From header field as
usual.

Note that this check is performed on the addr-spec in the From header
field (e.g., the URI of the sender, like
'sip:alice@atlanta.example.com'); it does not convert the display-
name portion of the From header field (e.g., 'Alice Atlanta').
Authentication services MAY check and validate the display-name as
well, and compare it to a list of acceptable display-names that may
be used by the sender; if the display-name does not meet policy
constraints, the authentication service MUST return a 403 response
code. The reason phrase should indicate the nature of the problem;
for example, "Inappropriate Display Name". However, the display-name
is not always present, and in many environments the requisite
operational procedures for display-name validation may not exist.
For more information, see Section 13.2.

Step 3:

The authentication service SHOULD ensure that any preexisting Date
header in the request is accurate. Local policy can dictate
precisely how accurate the Date must be; a RECOMMENDED maximum
discrepancy of ten minutes will ensure that the request is unlikely
to upset any verifiers. If the Date header contains a time different
by more than ten minutes from the current time noted by the
authentication service, the authentication service SHOULD reject the
request. This behavior is not mandatory because a user agent client
(UAC) could only exploit the Date header in order to cause a request
to fail verification; the Identity header is not intended to provide
a source of non-repudiation or a perfect record of when messages are
processed. Finally, the authentication service MUST verify that the
Date header falls within the validity period of its certificate. For
more information on the security properties associated with the Date
header field value, see Section 9.

Step 4:

The authentication service MUST form the identity signature and add
an Identity header to the request containing this signature. After
the Identity header has been added to the request, the authentication
service MUST also add an Identity-Info header. The Identity-Info
header contains a URI from which its certificate can be acquired.
Details on the generation of both of these headers are provided in
Section 9.

Finally, the authentication service MUST forward the message
normally.

5.1. Identity within a Dialog and Retargeting

Retargeting is broadly defined as the alteration of the Request-URI
by intermediaries. More specifically, retargeting supplants the
original target URI with one that corresponds to a different user, a
user that is not authorized to register under the original target
URI. By this definition, retargeting does not include translation of
the Request-URI to a contact address of an endpoint that has
registered under the original target URI, for example.

When a dialog-forming request is retargeted, this can cause a few
wrinkles for the Identity mechanism when it is applied to requests
sent in the backwards direction within a dialog. This section
provides some non-normative considerations related to this case.

When a request is retargeted, it may reach a SIP endpoint whose user
is not identified by the URI designated in the To header field value.
The value in the To header field of a dialog-forming request is used
as the From header field of requests sent in the backwards direction
during the dialog, and is accordingly the header that would be signed
by an authentication service for requests sent in the backwards
direction. In retargeting cases, if the URI in the From header does
not identify the sender of the request in the backwards direction,
then clearly it would be inappropriate to provide an Identity
signature over that From header. As specified above, if the
authentication service is not responsible for the domain in the From
header field of the request, it MUST NOT add an Identity header to
the request, and it should process/forward the request normally.

Any means of anticipating retargeting, and so on, is outside the
scope of this document, and likely to have equal applicability to
response identity as it does to requests in the backwards direction
within a dialog. Consequently, no special guidance is given for
implementers here regarding the 'connected party' problem;
authentication service behavior is unchanged if retargeting has
occurred for a dialog-forming request. Ultimately, the
authentication service provides an Identity header for requests in
the backwards dialog when the user is authorized to assert the
identity given in the From header field, and if they are not, an
Identity header is not provided.

For further information on the problems of response identity and the
potential solution spaces, see [15].

6. Verifier Behavior

   This document introduces a new logical role for SIP entities called a
   server. When a verifier receives a SIP message containing an
   Identity header, it may inspect the signature to verify the identity
   of the sender of the message. Typically, the results of a
   verification are provided as input to an authorization process that
   is outside the scope of this document. If an Identity header is not
   present in a request, and one is required by local policy (for
   example, based on a per-sending-domain policy, or a per-sending-user
   policy), then a 428 'Use Identity Header' response MUST be sent.

   In order to verify the identity of the sender of a message, an entity
   acting as a verifier MUST perform the following steps, in the order
   here specified.

   Step 1:

   The verifier MUST acquire the certificate for the signing domain.
   Implementations supporting this specification SHOULD have some means
   of retaining domain certificates (in accordance with normal practices
   for certificate lifetimes and revocation) in order to prevent
   themselves from needlessly downloading the same certificate every
   time a request from the same domain is received. Certificates cached
   in this manner should be indexed by the URI given in the Identity-
   Info header field value.

   Provided that the domain certificate used to sign this message is not
   previously known to the verifier, SIP entities SHOULD discover this
   certificate by dereferencing the Identity-Info header, unless they
   have some more efficient implementation-specific way of acquiring
   certificates for that domain. If the URI scheme in the Identity-Info
   header cannot be dereferenced, then a 436 'Bad Identity-Info'
   response MUST be returned. The verifier processes this certificate
   in the usual ways, including checking that it has not expired, that
   the chain is valid back to a trusted certification authority (CA),
   and that it does not appear on revocation lists. Once the
   certificate is acquired, it MUST be validated following the
   procedures in RFC 3280 [9]. If the certificate cannot be validated
   (it is self-signed and untrusted, or signed by an untrusted or
   unknown certificate authority, expired, or revoked), the verifier
   MUST send a 437 'Unsupported Certificate' response.

   Step 2:

   The verifier MUST follow the process described in Section 13.4 to
   determine if the signer is authoritative for the URI in the From
   header field.

Step 3:

The verifier MUST verify the signature in the Identity header field,
following the procedures for generating the hashed digest-string
described in Section 9. If a verifier determines that the signature
on the message does not correspond to the reconstructed digest-
string, then a 438 'Invalid Identity Header' response MUST be
returned.

Step 4:

The verifier MUST validate the Date, Contact, and Call-ID headers in
the manner described in Section 13.1; recipients that wish to verify
Identity signatures MUST support all of the operations described
there. It must furthermore ensure that the value of the Date header
falls within the validity period of the certificate whose
corresponding private key was used to sign the Identity header.

7. Considerations for User Agent

This mechanism can be applied opportunistically to existing SIP
deployments; accordingly, it requires no change to SIP user agent
behavior in order for it to be effective. However, because this
mechanism does not provide integrity protection between the UAC and
the authentication service, a UAC SHOULD implement some means of
providing this integrity. TLS would be one such mechanism, which is
attractive because it MUST be supported by SIP proxy servers, but is
potentially problematic because it is a hop-by-hop mechanism. See
Section 13.3 for more information about securing the channel between
the UAC and the authentication service.

When a UAC sends a request, it MUST accurately populate the From
header field with a value corresponding to an identity that it
believes it is authorized to claim. In a request, it MUST set the
URI portion of its From header to match a SIP, SIPS, or TEL URI AoR
that it is authorized to use in the domain (including anonymous URIs,
as described in RFC 3323 [3]). In general, UACs SHOULD NOT use the
TEL URI form in the From header field (see Section 11).

Note that this document defines a number of new 4xx response codes.
If user agents support these response codes, they will be able to
respond intelligently to Identity-based error conditions.

The UAC MUST also be capable of sending requests, including mid-call
requests, through an 'outbound' proxy (the authentication service).
The best way to accomplish this is using pre-loaded Route headers and
loose routing. For a given domain, if an entity that can instantiate
the authentication service role is not in the path of dialog-forming

requests, identity for mid-dialog requests in the backwards direction
cannot be provided.

As a recipient of a request, a user agent that can verify signed
identities should also support an appropriate user interface to
render the validity of identity to a user. User agent
implementations SHOULD differentiate signed From header field values
from unsigned From header field values when rendering to an end-user
the identity of the sender of a request.

8. Considerations for Proxy Servers

Domain policy may require proxy servers to inspect and verify the
identity provided in SIP requests. A proxy server may wish to
ascertain the identity of the sender of the message to provide spam
prevention or call control services. Even if a proxy server does not
act as an authentication service, it MAY validate the Identity header
before it makes a forwarding decision for a request. Proxy servers
MUST NOT remove or modify an existing Identity or Identity-Info
header in a request.

9. Header Syntax

This document specifies two new SIP headers: Identity and Identity-
Info. Each of these headers can appear only once in a SIP message.
The grammar for these two headers is (following the ABNF [6] in RFC
3261 [1]):

Identity = "Identity" HCOLON signed-identity-digest
signed-identity-digest = LDQUOT 32LHEX RDQUOT

Identity-Info = "Identity-Info" HCOLON ident-info
                *(SEMI ident-info-params)
ident-info = LAQUOT absoluteURI RAQUOT
ident-info-params = ident-info-alg / ident-info-extension
ident-info-alg = "alg" EQUAL token
ident-info-extension = generic-param

The signed-identity-digest is a signed hash of a canonical string
generated from certain components of a SIP request. To create the
contents of the signed-identity-digest, the following elements of a
SIP message MUST be placed in a bit-exact string in the order
specified here, separated by a vertical line, "|" or %x7C, character:

o The AoR of the UA sending the message, or addr-spec of the From
   header field (referred to occasionally here as the 'identity
   field').

o The addr-spec component of the To header field, which is the AoR
   to which the request is being sent.
o The callid from Call-Id header field.
o The digit (1*DIGIT) and method (method) portions from CSeq header
   field, separated by a single space (ABNF SP, or %x20). Note that
   the CSeq header field allows linear whitespace (LWS) rather than
   SP to separate the digit and method portions, and thus the CSeq
   header field may need to be transformed in order to be
   canonicalized. The authentication service MUST strip leading
   zeros from the 'digit' portion of the Cseq before generating the
   digest-string.
o The Date header field, with exactly one space each for each SP and
   the weekday and month items case set as shown in BNF in RFC 3261.
   RFC 3261 specifies that the BNF for weekday and month is a choice
   amongst a set of tokens. The RFC 2234 rules for the BNF specify
   that tokens are case sensitive. However, when used to construct
   the canonical string defined here, the first letter of each week
   and month MUST be capitalized, and the remaining two letters must
   be lowercase. This matches the capitalization provided in the
   definition of each token. All requests that use the Identity
   mechanism MUST contain a Date header.
o The addr-spec component of the Contact header field value. If the
   request does not contain a Contact header, this field MUST be
   empty (i.e., there will be no whitespace between the fourth and
   fifth "|" characters in the canonical string).
o The body content of the message with the bits exactly as they are
   in the Message (in the ABNF for SIP, the message-body). This
   includes all components of multipart message bodies. Note that
   the message-body does NOT include the CRLF separating the SIP
   headers from the message-body, but does include everything that
   follows that CRLF. If the message has no body, then message-body
   will be empty, and the final "|" will not be followed by any
   additional characters.

For more information on the security properties of these headers, and
why their inclusion mitigates replay attacks, see Section 13 and [5].
The precise formulation of this digest-string is, therefore
(following the ABNF [6] in RFC 3261 [1]):

digest-string = addr-spec "|" addr-spec "|" callid "|"
                1*DIGIT SP Method "|" SIP-date "|" [addr-spec] "|"
                message-body

Note again that the first addr-spec MUST be taken from the From
header field value, the second addr-spec MUST be taken from the To
header field value, and the third addr-spec MUST be taken from the
Contact header field value, provided the Contact header is present in
the request.

After the digest-string is formed, it MUST be hashed and signed with
the certificate for the domain. The hashing and signing algorithm is
specified by the 'alg' parameter of the Identity-Info header (see
below for more information on Identity-Info header parameters). This
document defines only one value for the 'alg' parameter: 'rsa-sha1';
further values MUST be defined in a Standards Track RFC, see Section
14.7 for more information. All implementations of this specification
MUST support 'rsa-sha1'. When the 'rsa-sha1' algorithm is specified
in the 'alg' parameter of Identity-Info, the hash and signature MUST
be generated as follows: compute the results of signing this string
with sha1WithRSAEncryption as described in RFC 3370 [7] and base64
encode the results as specified in RFC 3548 [8]. A 1024-bit or
longer RSA key MUST be used. The result is placed in the Identity
header field. For detailed examples of the usage of this algorithm,
see Section 10.

The 'absoluteURI' portion of the Identity-Info header MUST contain a
URI which dereferences to a resource containing the certificate of
the authentication service. All implementations of this
specification MUST support the use of HTTP and HTTPS URIs in the
Identity-Info header. Such HTTP and HTTPS URIs MUST follow the
conventions of RFC 2585 [10], and for those URIs the indicated
resource MUST be of the form 'application/pkix-cert' described in
that specification. Note that this introduces key lifecycle
management concerns; were a domain to change the key available at the
Identity-Info URI before a verifier evaluates a request signed by an
authentication service, this would cause obvious verifier failures.
When a rollover occurs, authentication services SHOULD thus provide
new Identity-Info URIs for each new certificate, and SHOULD continue
to make older key acquisition URIs available for a duration longer
than the plausible lifetime of a SIP message (an hour would most
likely suffice).

The Identity-Info header field MUST contain an 'alg' parameter. No
other parameters are defined for the Identity-Info header in this
document. Future Standards Track RFCs may define additional
Identity-Info header parameters.

This document adds the following entries to Table 2 of RFC 3261 [1]:

Header field	where	proxy	ACK	BYE	CAN	INV	OPT	REG
Identity	R	a	o	o	-	o	o	o

			SUB	NOT	REF	INF	UPD	PRA
			o	o	o	o	o	o

Header field	where	proxy	ACK	BYE	CAN	INV	OPT	REG
Identity-Info	R	a	o	o	-	o	o	o

			SUB	NOT	REF	INF	UPD	PRA
			o	o	o	o	o	o

   Note, in the table above, that this mechanism does not protect the
   CANCEL method. The CANCEL method cannot be challenged, because it is
   hop-by-hop, and accordingly authentication service behavior for
   CANCEL would be significantly limited. Note as well that the
   REGISTER method uses Contact header fields in very unusual ways that
   complicate its applicability to this mechanism, and the use of
   Identity with REGISTER is consequently a subject for future study,
   although it is left as optional here for forward-compatibility
   reasons. The Identity and Identity-Info header MUST NOT appear in
   CANCEL.

10. Compliance Tests and Examples

   The examples in this section illustrate the use of the Identity
   header in the context of a SIP transaction. Implementers are advised
   to verify their compliance with the specification against the
   following criteria:

   o Implementations of the authentication service role MUST generate
      identical base64 identity strings to the ones shown in the
      Identity headers in these examples when presented with the source
      message and utilizing the appropriate supplied private key for the
      domain in question.
   o Implementations of the verifier role MUST correctly validate the
      given messages containing the Identity header when utilizing the
      supplied certificates (with the caveat about self-signed
      certificates below).

Note that the following examples use self-signed certificates, rather
than certificates issued by a recognized certificate authority. The
use of self-signed certificates for this mechanism is NOT
RECOMMENDED, and it appears here only for illustrative purposes.
Therefore, in compliance testing, implementations of verifiers SHOULD
generate appropriate warnings about the use of self-signed
certificates. Also, the example certificates in this section have
placed their domain name subject in the subjectAltName field; in
practice, certificate authorities may place domain names in other
locations in the certificate (see Section 13.4 for more information).

Note that all examples in this section use the 'rsa-sha1' algorithm.

Bit-exact reference files for these messages and their various
transformations are supplied in Appendix B.

10.1. Identity-Info with a Singlepart MIME body

Consider the following private key and certificate pair assigned to
'atlanta.example.com' (rendered in OpenSSL format).

```
-----BEGIN RSA PRIVATE KEY-----
MIICXQIBAAKBgQDPPMBtHVoPkXV+Z6jq1LsgfTELVWpy2BVUffJMPH06LL0cJSQO
aIeVzIojzWtpauB7IylZKlAjB5f429tRuoUiedCwMLKblWAqZt6eHWpCNZJ7lONc
IEwnmh2nAccKk83Lp/VH3tgAS/43DQoX2sndnYh+g8522Pzwg7EGWspzzwIDAQAB
AoGBAK0W3tnEFD7AjVQAnJNXDtx59Aa1Vu2JEXe6oi+OrkFysJjbZJwsLmKtrgtt
PXOU8t2mZpi0wK4hX4tZhntiwGKkUPC3h9Bjp+GerifP341RMyMO+6fPgjqOzUDw
+rPjjMpwD7AkcEcqDgbTrZnWv/QnCSaaF3xkUGfFkLx5OKcRAkEA7UxnsE8XaT30
tP/UUc51gNk2KGKgxQQTHopBcew9yfeCRFhvdL7jpaGatEi5iZwGGQQDVOVHUN1H
0YLpHQjRowJBAN+R2bvA/Nimq464ZgnelEDPqaEAZWaD3kOfhS9+vL7oqES+u5E0
J7kXb7ZkiSVUg9XU/8PxMKx/DAz0dUmOL+UCQH8C9ETUMI2uEbqHbBdVUGNk364C
DFcndSxVh+34KqJdjiYSx6VPPv26X9m7S0OydTkSgs3/4ooPxo8HaMqXm80CQB+r
xbB3UlpOohcBwFK9mTrlMB6Cs9ql66KgwnlL9ukEhHHYozGatdXeoBCyhUsogdSU
6/aSAFcvWEGtj7/vyJECQQCS1lKgEXoNQPqONalvYhyyMZRXFLdD4gbwRPK1uXK
Ypk3CkfFzOyfjeLcGPxXzq2qzuHzGTDxZ9PAepwX4RSk
-----END RSA PRIVATE KEY-----
-----BEGIN CERTIFICATE-----
MIIC3TCCAkagAwIBAgIBADANBgkqhkiG9w0BAQUFADBzMQswCQYDVQQGEwJVUzEL
MAkGA1UECAwCR0ExEDAOBgNVBAcMB0F0bGFudGExDTALBgNVBAoMBElFVEYxHDAa
BgNVBAMME2F0bGFudGEuZXhhbXBsZS5jb20wHhcNMDUxMDI0MDYzNjA2WhcNMDYx
MDI0MDYzNjA2WjBzMQswCQYDVQQGEwJVUzELMAkGA1UECAwCR0ExEDAOBgNVBAcM
B0F0bGFudGExDTALBgNVBAoMBElFVEYxHDAaBgNVBAMME2F0bGFudGEuZXhhbXBs
ZS5jb20wgZ8wDQYJKoZIhvcNAQEBBQADgY0AMIGJAoGBAM88wG0dWg+RdX5nqOrU
uyB9MQtVanLYFVR98kw8fTosvRwlJA5oh5XMiiPNa2lq4HsjKVkqUCMHl/jb21G6
hSJ50LAwspuVYCpm3p4dakI1knuU41wgTCeaHacBxwqTzcun9Ufe2ABL/jcNChfa
yd2diH6DznbY/PCDsQZaynPPAgMBAAGjgbQwgbEwHQYDVR0OBBYEFNmU/MrbVYcE
KDr/20WISrG1j1rNMIGBBgNVHSMEejB4gBTZlPzK21WHBCg6/9tFiEqxtY9azaFd
pFswWTELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAkdBMRAwDgYDVQQHDAdBdGxhbnRh
```

        MQ0wCwYDVQQKDARJRVRGMRwwGgYDVQQDDBNhdGxhbnRhLmV4YW1wbGUuY29tggEA
        MAwGA1UdEwQFMAMBAf8wDQYJKoZIhvcNAQEFBQADgYEADdQYtswBDmTSTq0mt2ll
        7alm/XGFrb2zdbU0vorxRdOZ04qMyrIpXG1LEmnEOgcocyrXRBvq5p6WbZAcEQk0
        DsE3Ve0Nc8x9nmvljW7GsMGFCnCuo4ODTf/1lGdVr9DeCzcj10YUQ3MRemDMXhY2
        CtDisLWl7SXOORcZAi1oU9w=
        -----END CERTIFICATE-----

   A user of atlanta.example.com, Alice, wants to send an INVITE to
   bob@biloxi.example.org. She therefore creates the following INVITE
   request, which she forwards to the atlanta.example.org proxy server
   that instantiates the authentication service role:

```
        INVITE sip:bob@biloxi.example.org SIP/2.0
        Via: SIP/2.0/TLS pc33.atlanta.example.com;branch=z9hG4bKnashds8
        To: Bob <sip:bob@biloxi.example.org>
        From: Alice <sip:alice@atlanta.example.com>;tag=1928301774
        Call-ID: a84b4c76e66710
        CSeq: 314159 INVITE
        Max-Forwards: 70
        Date: Thu, 21 Feb 2002 13:02:03 GMT
        Contact: <sip:alice@pc33.atlanta.example.com>
        Content-Type: application/sdp
        Content-Length: 147

        v=0
        o=UserA 2890844526 2890844526 IN IP4 pc33.atlanta.example.com
        s=Session SDP
        c=IN IP4 pc33.atlanta.example.com
        t=0 0
        m=audio 49172 RTP/AVP 0
        a=rtpmap:0 PCMU/8000
```

   When the authentication service receives the INVITE, it authenticates
   Alice by sending a 407 response. As a result, Alice adds an
   Authorization header to her request, and resends to the
   atlanta.example.com authentication service. Now that the service is
   sure of Alice's identity, it calculates an Identity header for the
   request. The canonical string over which the identity signature will
   be generated is the following (note that the first line wraps because
   of RFC editorial conventions):

```
   sip:alice@atlanta.example.com|sip:bob@biloxi.example.org|
   a84b4c76e66710|314159 INVITE|Thu, 21 Feb 2002 13:02:03 GMT|
   sip:alice@pc33.atlanta.example.com|v=0
   o=UserA 2890844526 2890844526 IN IP4 pc33.atlanta.example.com
   s=Session SDP
   c=IN IP4 pc33.atlanta.example.com
   t=0 0
```

```
m=audio 49172 RTP/AVP 0
a=rtpmap:0 PCMU/8000
```

The resulting signature (sha1WithRsaEncryption) using the private RSA
key given above, with base64 encoding, is the following:

ZYNBbHC00VMZr2kZt6VmCvPonWJMGvQTBDqghoWeLxJfzB2a1pxAr3VgrB0SsSAa
ifsRdiOPoQZYOy2wrVghuhcsMbHWUSFxI6p6q5TOQXHMmz6uEo3svJsSH49thyGn
FVcnyaZ++yRlBYYQTLqWzJ+KVhPKbfU/pryhVn9Yc6U=

Accordingly, the atlanta.example.com authentication service will
create an Identity header containing that base64 signature string
(175 bytes). It will also add an HTTPS URL where its certificate is
made available. With those two headers added, the message looks like
the following:

```
INVITE sip:bob@biloxi.example.org SIP/2.0
Via: SIP/2.0/TLS pc33.atlanta.example.com;branch=z9hG4bKnashds8
To: Bob <sip:bob@biloxi.example.org>
From: Alice <sip:alice@atlanta.example.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Max-Forwards: 70
Date: Thu, 21 Feb 2002 13:02:03 GMT
Contact: <sip:alice@pc33.atlanta.example.com>
Identity:
  "ZYNBbHC00VMZr2kZt6VmCvPonWJMGvQTBDqghoWeLxJfzB2a1pxAr3VgrB0SsSAa
   ifsRdiOPoQZYOy2wrVghuhcsMbHWUSFxI6p6q5TOQXHMmz6uEo3svJsSH49thyGn
   FVcnyaZ++yRlBYYQTLqWzJ+KVhPKbfU/pryhVn9Yc6U="
Identity-Info: <https://atlanta.example.com/atlanta.cer>;alg=rsa-sha1
Content-Type: application/sdp
Content-Length: 147

v=0
o=UserA 2890844526 2890844526 IN IP4 pc33.atlanta.example.com
s=Session SDP
c=IN IP4 pc33.atlanta.example.com
t=0 0
m=audio 49172 RTP/AVP 0
a=rtpmap:0 PCMU/8000
```

atlanta.example.com then forwards the request normally. When Bob
receives the request, if he does not already know the certificate of
atlanta.example.com, he dereferences the URL in the Identity-Info
header to acquire the certificate. Bob then generates the same
canonical string given above, from the same headers of the SIP
request. Using this canonical string, the signed digest in the
Identity header, and the certificate discovered by dereferencing the

Identity-Info header, Bob can verify that the given set of headers
and the message body have not been modified.

10.2. Identity for a Request with No MIME Body or Contact

Consider the following private key and certificate pair assigned to
"biloxi.example.org".

```
-----BEGIN RSA PRIVATE KEY-----
MIICXgIBAAKBgQC/obBYLRMPjskrAqWOiGPAUxI3/m2ti7ix4caqCTAuFX5cLegQ
7nmquLOHfIhxVIqT2f06UA0lOo2NVofK9G7MTkVbVNiyAlLYUDEj7XWLDICf3ZHL
6Fr/+CF7wrQ9r4kv7XiJKxodVCCd/DhCT9Gp+VDoe8HymqOW/KsneriyIwIDAQAB
AoGBAJ7fsFIKXKkjWgj8ksGOthS3Sn19xPSCyEdBxfEm2Pj7/Nzzeli/PcOaic0k
JALBcnqN2fHEeIGK/9xUBxTufgQYVJqvyHERs6rXX/iT4Ynm9t1905EiQ9ZpHsrI
/AMMUYA1QrGgAIHvZLVLzq+9KLDEZ+HQbuCLJXF+6bl0Eb5BAkEA636oMANp0Qa3
mYWEQ2utmGsYxkXSfyBb18TCOwCty0ndBR24zyOJF2NbZS98Lz+Ga25hfIGw/JHK
nD9bOE88UwJBANBRSpd4bmS+m48R/13tRESAtHqydNinX0kS/RhwHr7mkHTU3k/M
FxQtx34I3GKzaZxMn0A66KS9v/SHdnF+ePECQQCGe7QshyZ8uitLPtZDclCWhEKH
qAQHmUEZvUF2VHLrbukLLOgHUrHNa24cILv4d3yaCVUetymNcuyTwhKj24wFAkAO
z/jx1EplN3hwL+NsllZoWI58uvu7/Aq2c3czqaVGBbb3l7sHCYgKk0bAG3kwO3mi
93/LXWT1cdiYVpmBcHDBAkEAmpgkFj+xZu5gWASY5ujv+FCMP0WwaH5hTnXu+tKe
PJ3d2IJZKxGnl6itKRN7GeRh9PSK0kZSqGFeVrvsJ4Nopg==
-----END RSA PRIVATE KEY-----
-----BEGIN CERTIFICATE-----
MIIC1jCCAj+gAwIBAgIBADANBgkqhkiG9w0BAQUFADBXMQswCQYDVQQGEwJVUzEL
MAkGA1UECAwCTVMxDzANBgNVBAcMBkJpbG94aTENMAsGA1UECgwESUVURjEbMBkG
A1UEAwwSYmlsb3hpLmV4YW1wbGUuY29tMB4XDTA1MTAyNDA2NDAyNloXDTA2MTAy
NDA2NDAyNlowVzELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAk1TMQ8wDQYDVQQHDAZC
aWxveGkxDTALBgNVBAoMBElFVEYxGzAZBgNVBAMMEmJpbG94aS5leGFtcGxlLmNv
bTCBnzANBgkqhkiG9w0BAQEFAAOBjQAwgYkCgYEAv6GwWC0TD47JKwKljohjwFMS
N/5trYu4seHGqgkwLhV+XC3oEO55qrizh3yIcVSKk9n9OlANJTqNjVaHyvRuzE5F
W1TYsgJS2FAxI+1liwyAn92Ry+ha//ghe8K0Pa+JL+14iSsaHVQgnfw4Qk/RqflQ
6HvB8pqjlvyrJ3q4siMCAwEAAaOBsTCBrjAdBgNVHQ4EFgQU0Z+RL47W/APDtc5B
fSoQXuEFE/wwfwYDVR0jBHgwdoAU0Z+RL47W/APDtc5BfSoQXuEFE/yhW6RZMFcx
CzAJBgNVBAYTAlVTMQswCQYDVQQIDAJNUzEPMA0GA1UEBwwGQmlsb3hpMQ0wCwYD
VQQKDARJRVRGMRswGQYDVQQDDBJiaWxveGkuZXhhbXBsZS5jb22CAQAwDAYDVR0T
BAUwAwEB/zANBgkqhkiG9w0BAQUFAAOBgQBiyKHIt8TXfGNfpnJXi5jCizOxmY8Y
gln8tyPFaeyq95TGcvTCWzdoBLVpBD+fpRWrX/II5sE6VHbbAPjjVmKbZwzQAtpp
P2Fauj28t94ZeDHN2vqzjfnHjCO24kG3Juf2T80ilp9YHcDwxjUFrt86UnlC+yid
yaTeusW5Gu7v1g==
-----END CERTIFICATE-----
```

Bob (bob@biloxi.example.org) now wants to send a BYE request to Alice
at the end of the dialog initiated in the previous example. He
therefore creates the following BYE request, which he forwards to the
'biloxi.example.org' proxy server that instantiates the
authentication service role:

```
BYE sip:alice@pc33.atlanta.example.com SIP/2.0
Via: SIP/2.0/TLS 192.0.2.4;branch=z9hG4bKnashds10
Max-Forwards: 70
From: Bob <sip:bob@biloxi.example.org>;tag=a6c85cf
To: Alice <sip:alice@atlanta.example.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 231 BYE
Content-Length: 0
```

When the authentication service receives the BYE, it authenticates
Bob by sending a 407 response. As a result, Bob adds an
Authorization header to his request, and resends to the
biloxi.example.org authentication service. Now that the service is
sure of Bob's identity, it prepares to calculate an Identity header
for the request. Note that this request does not have a Date header
field. Accordingly, the biloxi.example.org will add a Date header to
the request before calculating the identity signature. If the
Content-Length header were not present, the authentication service
would add it as well. The baseline message is thus:

```
BYE sip:alice@pc33.atlanta.example.com SIP/2.0
Via: SIP/2.0/TLS 192.0.2.4;branch=z9hG4bKnashds10
Max-Forwards: 70
From: Bob <sip:bob@biloxi.example.org>;tag=a6c85cf
To: Alice <sip:alice@atlanta.example.com>;tag=1928301774
Date: Thu, 21 Feb 2002 14:19:51 GMT
Call-ID: a84b4c76e66710
CSeq: 231 BYE
Content-Length: 0
```

Also note that this request contains no Contact header field.
Accordingly, biloxi.example.org will place no value in the canonical
string for the addr-spec of the Contact address. Also note that
there is no message body, and accordingly, the signature string will
terminate, in this case, with two vertical bars. The canonical
string over which the identity signature will be generated is the
following (note that the first line wraps because of RFC editorial
conventions):

```
sip:bob@biloxi.example.org|sip:alice@atlanta.example.com|
a84b4c76e66710|231 BYE|Thu, 21 Feb 2002 14:19:51 GMT||
```

The resulting signature (sha1WithRsaEncryption) using the private RSA
key given above for biloxi.example.org, with base64 encoding, is the
following:

   sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS7Ltrg9dlxkWzo
   eU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp
   pPqOg1uXndzHbG7mR6Rl9BnUhHufVRbp51Mn3w0gfUs=

   Accordingly, the biloxi.example.org authentication service will
   create an Identity header containing that base64 signature string.
   It will also add an HTTPS URL where its certificate is made
   available. With those two headers added, the message looks like the
   following:

   BYE sip:alice@pc33.atlanta.example.com SIP/2.0
   Via: SIP/2.0/TLS 192.0.2.4;branch=z9hG4bKnashds10
   Max-Forwards: 70
   From: Bob <sip:bob@biloxi.example.org>;tag=a6c85cf
   To: Alice <sip:alice@atlanta.example.com>;tag=1928301774
   Date: Thu, 21 Feb 2002 14:19:51 GMT
   Call-ID: a84b4c76e66710
   CSeq: 231 BYE
   Identity:
     "sv5CTo05KqpSmtHt3dcEiO/1CWTSZtnG3iV+1nmurLXV/HmtyNS7Ltrg9dlxkWzo
      eU7d7OV8HweTTDobV3itTmgPwCFjaEmMyEI3d7SyN21yNDo2ER/Ovgtw0Lu5csIp
      pPqOg1uXndzHbG7mR6Rl9BnUhHufVRbp51Mn3w0gfUs="
   Identity-Info: <https://biloxi.example.org/biloxi.cer>;alg=rsa-sha1
   Content-Length: 0

   biloxi.example.org then forwards the request normally.

11. Identity and the TEL URI Scheme

   Since many SIP applications provide a Voice over IP (VoIP) service,
   telephone numbers are commonly used as identities in SIP deployments.
   In the majority of cases, this is not problematic for the identity
   mechanism described in this document. Telephone numbers commonly
   appear in the username portion of a SIP URI (e.g.,
   'sip:+17005551008@chicago.example.com;user=phone'). That username
   conforms to the syntax of the TEL URI scheme (RFC 3966 [13]). For
   this sort of SIP address-of-record, chicago.example.com is the
   appropriate signatory.

   It is also possible for a TEL URI to appear in the SIP To or From
   header field outside the context of a SIP or SIPS URI (e.g.,
   'tel:+17005551008'). In this case, it is much less clear which
   signatory is appropriate for the identity. Fortunately for the
   identity mechanism, this form of the TEL URI is more common for the
   To header field and Request-URI in SIP than in the From header field,
   since the UAC has no option but to provide a TEL URI alone when the
   remote domain to which a request is sent is unknown. The local
   domain, however, is usually known by the UAC, and accordingly it can

form a proper From header field containing a SIP URI with a username
in TEL URI form. Implementations that intend to send their requests
through an authentication service SHOULD put telephone numbers in the
From header field into SIP or SIPS URIs whenever possible.

If the local domain is unknown to a UAC formulating a request, it
most likely will not be able to locate an authentication service for
its request, and therefore the question of providing identity in
these cases is somewhat moot. However, an authentication service MAY
sign a request containing a TEL URI in the From header field. This
is permitted in this specification strictly for forward compatibility
purposes. In the longer-term, it is possible that ENUM [14] may
provide a way to determine which administrative domain is responsible
for a telephone number, and this may aid in the signing and
verification of SIP identities that contain telephone numbers. This
is a subject for future work.

12. Privacy Considerations

The identity mechanism presented in this document is compatible with
the standard SIP practices for privacy described in RFC 3323 [3]. A
SIP proxy server can act both as a privacy service and as an
authentication service. Since a user agent can provide any From
header field value that the authentication service is willing to
authorize, there is no reason why private SIP URIs that contain
legitimate domains (e.g., sip:anonymous@example.com) cannot be signed
by an authentication service. The construction of the Identity
header is the same for private URIs as it is for any other sort of
URIs.

Note, however, that an authentication service must possess a
certificate corresponding to the host portion of the addr-spec of the
From header field of any request that it signs; accordingly, using
domains like 'anonymous.invalid' will not be possible for privacy
services that also act as authentication services. The assurance
offered by the usage of anonymous URIs with a valid domain portion is
"this is a known user in my domain that I have authenticated, but I
am keeping its identity private". The use of the domain
'anonymous.invalid' entails that no corresponding authority for the
domain can exist, and as a consequence, authentication service
functions are meaningless.

The "header" level of privacy described in RFC 3323 requests that a
privacy service alter the Contact header field value of a SIP
message. Since the Contact header field is protected by the
signature in an Identity header, privacy services cannot be applied
after authentication services without a resulting integrity
violation.

RFC 3325 [12] defines the "id" priv-value token, which is specific to
the P-Asserted-Identity header. The sort of assertion provided by
the P-Asserted-Identity header is very different from the Identity
header presented in this document. It contains additional
information about the sender of a message that may go beyond what
appears in the From header field; P-Asserted-Identity holds a
definitive identity for the sender that is somehow known to a closed
network of intermediaries that presumably the network will use this
identity for billing or security purposes. The danger of this
network-specific information leaking outside of the closed network
motivated the "id" priv-value token. The "id" priv-value token has
no implications for the Identity header, and privacy services MUST
NOT remove the Identity header when a priv-value of "id" appears in a
Privacy header.

Finally, note that unlike RFC 3325, the mechanism described in this
specification adds no information to SIP requests that has privacy
implications.

13. Security Considerations

13.1. Handling of digest-string Elements

This document describes a mechanism that provides a signature over
the Contact, Date, Call-ID, CSeq, To, and From header fields of SIP
requests. While a signature over the From header field would be
sufficient to secure a URI alone, the additional headers provide
replay protection and reference integrity necessary to make sure that
the Identity header will not be used in cut-and-paste attacks. In
general, the considerations related to the security of these headers
are the same as those given in RFC 3261 for including headers in
tunneled 'message/sip' MIME bodies (see Section 23 in particular).
The following section details the individual security properties
obtained by including each of these header fields within the
signature; collectively, this set of header fields provides the
necessary properties to prevent impersonation.

The From header field indicates the identity of the sender of the
message, and the SIP address-of-record URI in the From header field
is the identity of a SIP user, for the purposes of this document.
The To header field provides the identity of the SIP user that this
request targets. Providing the To header field in the Identity
signature serves two purposes: first, it prevents cut-and-paste
attacks in which an Identity header from legitimate request for one
user is cut-and-pasted into a request for a different user; second,
it preserves the starting URI scheme of the request, which helps
prevent downgrade attacks against the use of SIPS.

The Date and Contact headers provide reference integrity and replay
protection, as described in RFC 3261, Section 23.4.2.
Implementations of this specification MUST NOT deem valid a request
with an outdated Date header field (the RECOMMENDED interval is that
the Date header must indicate a time within 3600 seconds of the
receipt of a message). Implementations MUST also record Call-IDs
received in valid requests containing an Identity header, and MUST
remember those Call-IDs for at least the duration of a single Date
interval (i.e., commonly 3600 seconds). Because a SIP-compliant UA
never generates the same Call-ID twice, verifiers can use the Call-ID
to recognize cut-and-paste attacks; the Call-ID serves as a nonce.
The result of this is that if an Identity header is replayed within
the Date interval, verifiers will recognize that it is invalid
because of a Call-ID duplication; if an Identity header is replayed
after the Date interval, verifiers will recognize that it is invalid
because the Date is stale. The CSeq header field contains a numbered
identifier for the transaction, and the name of the method of the
request; without this information, an INVITE request could be cut-
and-pasted by an attacker and transformed into a BYE request without
changing any fields covered by the Identity header, and moreover
requests within a certain transaction could be replayed in
potentially confusing or malicious ways.

The Contact header field is included to tie the Identity header to a
particular user agent instance that generated the request. Were an
active attacker to intercept a request containing an Identity header,
and cut-and-paste the Identity header field into its own request
(reusing the From, To, Contact, Date, and Call-ID fields that appear
in the original message), the attacker would not be eligible to
receive SIP requests from the called user agent, since those requests
are routed to the URI identified in the Contact header field.
However, the Contact header is only included in dialog-forming
requests, so it does not provide this protection in all cases.

It might seem attractive to provide a signature over some of the
information present in the Via header field value(s). For example,
without a signature over the sent-by field of the topmost Via header,
an attacker could remove that Via header and insert its own in a
cut-and-paste attack, which would cause all responses to the request
to be routed to a host of the attacker's choosing. However, a
signature over the topmost Via header does not prevent attacks of
this nature, since the attacker could leave the topmost Via intact
and merely insert a new Via header field directly after it, which
would cause responses to be routed to the attacker's host "on their
way" to the valid host, which has exactly the same end result.
Although it is possible that an intermediary-based authentication
service could guarantee that no Via hops are inserted between the
sending user agent and the authentication service, it could not

prevent an attacker from adding a Via hop after the authentication
service, and thereby preempting responses. It is necessary for the
proper operation of SIP for subsequent intermediaries to be capable
of inserting such Via header fields, and thus it cannot be prevented.
As such, though it is desirable, securing Via is not possible through
the sort of identity mechanism described in this document; the best
known practice for securing Via is the use of SIPS.

This mechanism also provides a signature over the bodies of SIP
requests. The most important reason for doing so is to protect
Session Description Protocol (SDP) bodies carried in SIP requests.
There is little purpose in establishing the identity of the user that
originated a SIP request if this assurance is not coupled with a
comparable assurance over the media descriptors. Note, however, that
this is not perfect end-to-end security. The authentication service
itself, when instantiated at a intermediary, could conceivably change
the SDP (and SIP headers, for that matter) before providing a
signature. Thus, while this mechanism reduces the chance that a
replayer or man-in-the-middle will modify SDP, it does not eliminate
it entirely. Since it is a foundational assumption of this mechanism
that the users trust their local domain to vouch for their security,
they must also trust the service not to violate the integrity of
their message without good reason. Note that RFC 3261, Section 16.6,
states that SIP proxy servers "MUST NOT add to, modify, or remove the
message body."

In the end analysis, the Identity and Identity-Info headers cannot
protect themselves. Any attacker could remove these headers from a
SIP request, and modify the request arbitrarily afterwards. However,
this mechanism is not intended to protect requests from men-in-the-
middle who interfere with SIP messages; it is intended only to
provide a way that SIP users can prove definitively that they are who
they claim to be. At best, by stripping identity information from a
request, a man-in-the-middle could make it impossible to distinguish
any illegitimate messages he would like to send from those messages
sent by an authorized user. However, it requires a considerably
greater amount of energy to mount such an attack than it does to
mount trivial impersonations by just copying someone else's From
header field. This mechanism provides a way that an authorized user
can provide a definitive assurance of his identity that an
unauthorized user, an impersonator, cannot.

One additional respect in which the Identity-Info header cannot
protect itself is the 'alg' parameter. The 'alg' parameter is not
included in the digest-string, and accordingly, a man-in-the-middle
might attempt to modify the 'alg' parameter. However, it is
important to note that preventing men-in-the-middle is not the
primary impetus for this mechanism. Moreover, changing the 'alg'

would at worst result in some sort of bid-down attack, and at best
cause a failure in the verifier. Note that only one valid 'alg'
parameter is defined in this document and that thus there is
currently no weaker algorithm to which the mechanism can be bid down.
'alg' has been incorporated into this mechanism for forward-
compatibility reasons in case the current algorithm exhibits
weaknesses, and requires swift replacement, in the future.

13.2. Display-Names and Identity

   As a matter of interface design, SIP user agents might render the
   display-name portion of the From header field of a caller as the
   identity of the caller; there is a significant precedent in email
   user interfaces for this practice. As such, it might seem that the
   lack of a signature over the display-name is a significant omission.

   However, there are several important senses in which a signature over
   the display-name does not prevent impersonation. In the first place,
   a particular display-name, like "Jon Peterson", is not unique in the
   world; many users in different administrative domains might
   legitimately claim that name. Furthermore, enrollment practices for
   SIP-based services might have a difficult time discerning the
   legitimate display-name for a user; it is safe to assume that
   impersonators will be capable of creating SIP accounts with arbitrary
   display-names. The same situation prevails in email today. Note
   that an impersonator who attempted to replay a message with an
   Identity header, changing only the display-name in the From header
   field, would be detected by the other replay protection mechanisms
   described in Section 13.1.

   Of course, an authentication service can enforce policies about the
   display-name even if the display-name is not signed. The exact
   mechanics for creating and operationalizing such policies is outside
   the scope of this document. The effect of this policy would not be
   to prevent impersonation of a particular unique identifier like a SIP
   URI (since display-names are not unique identifiers), but to allow a
   domain to manage the claims made by its users. If such policies are
   enforced, users would not be free to claim any display-name of their
   choosing. In the absence of a signature, man-in-the-middle attackers
   could conceivably alter the display-names in a request with impunity.
   Note that the scope of this specification is impersonation attacks,
   however, and that a man-in-the-middle might also strip the Identity
   and Identity-Info headers from a message.

   There are many environments in which policies regarding the display-
   name aren't feasible. Distributing bit-exact and internationalizable
   display-names to end-users as part of the enrollment or registration
   process would require mechanisms that are not explored in this

document. In the absence of policy enforcement regarding domain
names, there are conceivably attacks that an adversary could mount
against SIP systems that rely too heavily on the display-name in
their user interface, but this argues for intelligent interface
design, not changes to the mechanisms. Relying on a non-unique
identifier for identity would ultimately result in a weak mechanism.

13.3. Securing the Connection to the Authentication Service

   The assurance provided by this mechanism is strongest when a user
   agent forms a direct connection, preferably one secured by TLS, to an
   intermediary-based authentication service. The reasons for this are
   twofold:

      If a user does not receive a certificate from the authentication
      service over this TLS connection that corresponds to the expected
      domain (especially when the user receives a challenge via a
      mechanism such as Digest), then it is possible that a rogue server
      is attempting to pose as an authentication service for a domain
      that it does not control, possibly in an attempt to collect shared
      secrets for that domain.

      Without TLS, the various header field values and the body of the
      request will not have integrity protection when the request
      arrives at an authentication service. Accordingly, a prior
      legitimate or illegitimate intermediary could modify the message
      arbitrarily.

   Of these two concerns, the first is most material to the intended
   scope of this mechanism. This mechanism is intended to prevent
   impersonation attacks, not man-in-the-middle attacks; integrity over
   the header and bodies is provided by this mechanism only to prevent
   replay attacks. However, it is possible that applications relying on
   the presence of the Identity header could leverage this integrity
   protection, especially body integrity, for services other than replay
   protection.

   Accordingly, direct TLS connections SHOULD be used between the UAC
   and the authentication service whenever possible. The opportunistic
   nature of this mechanism, however, makes it very difficult to
   constrain UAC behavior, and moreover there will be some deployment
   architectures where a direct connection is simply infeasible and the
   UAC cannot act as an authentication service itself. Accordingly,
   when a direct connection and TLS are not possible, a UAC should use
   the SIPS mechanism, Digest 'auth-int' for body integrity, or both
   when it can. The ultimate decision to add an Identity header to a

   request lies with the authentication service, of course; domain
   policy must identify those cases where the UAC's security association
   with the authentication service is too weak.

13.4. Domain Names and Subordination

   When a verifier processes a request containing an Identity-Info
   header, it must compare the domain portion of the URI in the From
   header field of the request with the domain name that is the subject
   of the certificate acquired from the Identity-Info header. While it
   might seem that this should be a straightforward process, it is
   complicated by two deployment realities. In the first place,
   certificates have varying ways of describing their subjects, and may
   indeed have multiple subjects, especially in 'virtual hosting' cases
   where multiple domains are managed by a single application.
   Secondly, some SIP services may delegate SIP functions to a
   subordinate domain and utilize the procedures in RFC 3263 [4] that
   allow requests for, say, 'example.com' to be routed to
   'sip.example.com'. As a result, a user with the AoR
   'sip:jon@example.com' may process its requests through a host like
   'sip.example.com', and it may be that latter host that acts as an
   authentication service.

   To meet the second of these problems, a domain that deploys an
   authentication service on a subordinate host MUST be willing to
   supply that host with the private keying material associated with a
   certificate whose subject is a domain name that corresponds to the
   domain portion of the AoRs that the domain distributes to users.
   Note that this corresponds to the comparable case of routing inbound
   SIP requests to a domain. When the NAPTR and SRV procedures of RFC
   3263 are used to direct requests to a domain name other than the
   domain in the original Request-URI (e.g., for 'sip:jon@example.com',
   the corresponding SRV records point to the service
   'sip1.example.org'), the client expects that the certificate passed
   back in any TLS exchange with that host will correspond exactly with
   the domain of the original Request-URI, not the domain name of the
   host. Consequently, in order to make inbound routing to such SIP
   services work, a domain administrator must similarly be willing to
   share the domain's private key with the service. This design
   decision was made to compensate for the insecurity of the DNS, and it
   makes certain potential approaches to DNS-based 'virtual hosting'
   unsecurable for SIP in environments where domain administrators are
   unwilling to share keys with hosting services.

   A verifier MUST evaluate the correspondence between the user's
   identity and the signing certificate by following the procedures
   defined in RFC 2818 [11], Section 3.1. While RFC 2818 deals with the
   use of HTTP in TLS, the procedures described are applicable to

verifying identity if one substitutes the "hostname of the server" in
HTTP for the domain portion of the user's identity in the From header
field of a SIP request with an Identity header.

Because the domain certificates that can be used by authentication
services need to assert only the hostname of the authentication
service, existing certificate authorities can provide adequate
certificates for this mechanism. However, not all proxy servers and
user agents will be able to support the root certificates of all
certificate authorities, and moreover there are some significant
differences in the policies by which certificate authorities issue
their certificates. This document makes no recommendations for the
usage of particular certificate authorities, nor does it describe any
particular policies that certificate authorities should follow, but
it is anticipated that operational experience will create de facto
standards for authentication services. Some federations of service
providers, for example, might only trust certificates that have been
provided by a certificate authority operated by the federation. It
is strongly RECOMMENDED that self-signed domain certificates should
not be trusted by verifiers, unless some previous key exchange has
justified such trust.

For further information on certificate security and practices, see
RFC 3280 [9]. The Security Considerations of RFC 3280 are applicable
to this document.

13.5. Authorization and Transitional Strategies

Ultimately, the worth of an assurance provided by an Identity header
is limited by the security practices of the domain that issues the
assurance. Relying on an Identity header generated by a remote
administrative domain assumes that the issuing domain used its
administrative practices to authenticate its users. However, it is
possible that some domains will implement policies that effectively
make users unaccountable (e.g., ones that accept unauthenticated
registrations from arbitrary users). The value of an Identity header
from such domains is questionable. While there is no magic way for a
verifier to distinguish "good" from "bad" domains by inspecting a SIP
request, it is expected that further work in authorization practices
could be built on top of this identity solution; without such an
identity solution, many promising approaches to authorization policy
are impossible. That much said, it is RECOMMENDED that
authentication services based on proxy servers employ strong
authentication practices such as token-based identifiers.

One cannot expect the Identity and Identity-Info headers to be
supported by every SIP entity overnight. This leaves the verifier in
a compromising position; when it receives a request from a given SIP

user, how can it know whether or not the sender's domain supports
Identity? In the absence of ubiquitous support for identity, some
transitional strategies are necessary.

   A verifier could remember when it receives a request from a domain
   that uses Identity, and in the future, view messages received from
   that domain without Identity headers with skepticism.

   A verifier could query the domain through some sort of callback
   system to determine whether or not it is running an authentication
   service. There are a number of potential ways in which this could
   be implemented; use of the SIP OPTIONS method is one possibility.
   This is left as a subject for future work.

In the long term, some sort of identity mechanism, either the one
documented in this specification or a successor, must become
mandatory-to-use for the SIP protocol; that is the only way to
guarantee that this protection can always be expected by verifiers.

Finally, it is worth noting that the presence or absence of the
Identity headers cannot be the sole factor in making an authorization
decision. Permissions might be granted to a message on the basis of
the specific verified Identity or really on any other aspect of a SIP
request. Authorization policies are outside the scope of this
specification, but this specification advises any future
authorization work not to assume that messages with valid Identity
headers are always good.

14. IANA Considerations

This document requests changes to the header and response-code sub-
registries of the SIP parameters IANA registry, and requests the
creation of two new registries for parameters for the Identity-Info
header.

14.1. Header Field Names

This document specifies two new SIP headers: Identity and Identity-
Info. Their syntax is given in Section 9. These headers are defined
by the following information, which has been added to the header
sub-registry under http://www.iana.org/assignments/sip-parameters.

     Header Name: Identity
     Compact Form: y
     Header Name: Identity-Info
     Compact Form: n

14.2. 428 'Use Identity Header' Response Code

   This document registers a new SIP response code, which is described
   in Section 6. It is sent when a verifier receives a SIP request that
   lacks an Identity header in order to indicate that the request should
   be re-sent with an Identity header. This response code is defined by
   the following information, which has been added to the method and
   response-code sub-registry under
   http://www.iana.org/assignments/sip-parameters.

         Response Code Number: 428
         Default Reason Phrase: Use Identity Header

14.3. 436 'Bad Identity-Info' Response Code

   This document registers a new SIP response code, which is described
   in Section 6. It is used when the Identity-Info header contains a
   URI that cannot be dereferenced by the verifier (either the URI
   scheme is unsupported by the verifier, or the resource designated by
   the URI is otherwise unavailable). This response code is defined by
   the following information, which has been added to the method and
   response-code sub-registry under
   http://www.iana.org/assignments/sip-parameters.

         Response Code Number: 436
         Default Reason Phrase: Bad Identity-Info

14.4. 437 'Unsupported Certificate' Response Code

   This document registers a new SIP response code, which is described
   in Section 6. It is used when the verifier cannot validate the
   certificate referenced by the URI of the Identity-Info header,
   because, for example, the certificate is self-signed, or signed by a
   root certificate authority for whom the verifier does not possess a
   root certificate. This response code is defined by the following
   information, which has been added to the method and response-code
   sub-registry under http://www.iana.org/assignments/sip-parameters.

         Response Code Number: 437
         Default Reason Phrase: Unsupported Certificate

14.5. 438 'Invalid Identity Header' Response Code

   This document registers a new SIP response code, which is described
   in Section 6. It is used when the verifier receives a message with
   an Identity signature that does not correspond to the digest-string
   calculated by the verifier. This response code is defined by the
   following information, which has been added to the method and
   response-code sub-registry under
   http://www.iana.org/assignments/sip-parameters.

         Response Code Number: 438
         Default Reason Phrase: Invalid Identity Header

14.6. Identity-Info Parameters

   The IANA has created a new registry for Identity-Info headers. This
   registry is to be prepopulated with a single entry for a parameter
   called 'alg', which describes the algorithm used to create the
   signature that appears in the Identity header. Registry entries must
   contain the name of the parameter and the specification in which the
   parameter is defined. New parameters for the Identity-Info header
   may be defined only in Standards Track RFCs.

14.7. Identity-Info Algorithm Parameter Values

   The IANA has created a new registry for Identity-Info 'alg' parameter
   values. This registry is to be prepopulated with a single entry for
   a value called 'rsa-sha1', which describes the algorithm used to
   create the signature that appears in the Identity header. Registry
   entries must contain the name of the 'alg' parameter value and the
   specification in which the value is described. New values for the
   'alg' parameter may be defined only in Standards Track RFCs.

Appendix A. Acknowledgements

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   bit-archive presented in Appendix B follows the pioneering example of
   RFC 4475 [16]. Thanks to Hans Persson and Tao Wan for thorough nit
   reviews.

Appendix B. Bit-Exact Archive of Examples of Messages

   The following text block is an encoded, gzip-compressed TAR archive
   of files that represent the transformations performed on the examples
   of messages discussed in Section 10. It includes for each example:

   o (foo).message: the original message
   o (foo).canonical: the canonical string constructed from that
      message
   o (foo).sha1: the SHA1 hash of the canonical string (hexadecimal)
   o (foo).signed: the RSA-signed SHA1 hash of the canonical string
      (binary)
   o (foo).signed.enc: the base64 encoding of the RSA-signed SHA1 hash
      of the canonical string as it would appear in the request
   o (foo).identity: the original message with the Identity and
      Identity-Info headers added

   Also included in the archive are two public key/certificate pairs,
   for atlanta.example.com and biloxi.example.org, respectively,
   including:

   o (foo).cer: the certificate of the domain
   o (foo).privkey: the private key of the domain
   o (foo).pubkey: the public key of the domain, extracted from the
      cert file for convenience

   To recover the compressed archive file intact, the text of this
   document may be passed as input to the following Perl script (the
   output should be redirected to a file or piped to "tar -xzvf -").

```
#!/usr/bin/perl
use strict;
my $bdata = "";
use MIME::Base64;
while(<>) {
 if (/-- BEGIN MESSAGE ARCHIVE --/ .. /-- END MESSAGE ARCHIVE --/) {
     if ( m/^\s*[^\s]+\s*$/) {
         $bdata = $bdata . $_;
     }
   }
}
print decode_base64($bdata);
```

Alternatively, the base-64 encoded block can be edited by hand to
remove document structure lines and fed as input to any base-64
decoding utility.

B.1. Encoded Reference Files

   -- BEGIN MESSAGE ARCHIVE --
   H4sICFfaz0QCA25ld2lkZW50LnRhcgDsW0us5NhZ7gUSwqiF2CAhFikiIQhFt992
   +U46it+u8qPK5Uc9WPlVfj/KdpXtomEDCxaAhFggISE2WSHCIoIFioQQC8gqAhRA
   QQTY8JJAbMgGIYTv7b7T09PT0xNl+mqS3F8qVd3jY/uc85//+87/nXOLoIv9oGjB
   B2/PIAiDSBwfv1GERInxG8EwAh6/37UHMIQRKIljCI4+gGCUGKtP8Ad3YKemderJ
   5EFSBW1QN2Xxmnp5GtblqXqUPfIffBdZcet/p82conUee0H9sfsfhiACw17nfwQa
   y+Dra+MkQGFkrI+TOPJgAt37/63bo2tjeHGuTVh+bc6FOUub/E0poM7nLGqyLJ06
   Id3NGTocPxytMWF6jNJYpDqIoXVLoDlmr+pNx+o7ztZ1ke8WtnXhFUClU5GGLZ6l
   O3YN8T3P0Usm1GyG9lQGEiBXFE6+yPecSSvPykuV4TPB5ne9xNEO8KxQVXnk3cqn
   /TaK3C3T7A08cRGokyJPUzmrV7k5pHK7i5bQyOambNcDLxUmH9zMD2sl8FGa+WGt
   BG6bGe5nHafvFnK5n0dnT6N1nmF0mgt3EK3OxQVdiuMzZrNOhPxNOF37W7w4LmsL
   OA0Mpeqt7RTKTrDX1CztZgezbM7rLlvQeBnhWzWOV5qDZEdMahLZTo8Wq0oZOL4X
   FgkgMhY4pNBdU53sHVvlaIX5TjqH0+JkYXAXmmzgSI7H9N3RvHingrIOAUIzCph4
   GhsdHGDwET+WCO5SuDtwxXKNvneGYrWiQ5WhaTEJXb0LXb6Trgd2DS0ZZscLWm6B
   au3aO48HZK4GEWgzN2oRTuBaG/vLXA+aZKh8kDBYyJj7bHWREXgjMWxIgFQrxPyx
   b3eUc3EEH6iEptuYL1zFRCpr22rPXujFs9EPx0s+o67pbhzRa/eOjvEZX+wjt1hH
   gKpDHdvdXJA5er1Y22tRXXed+KwyxzFadFtZyW1st4E7V7ROO4Rqw5Cnx6ncXb/Z
   5ztdUOmx34dX3Ck8cydPc76+a5uO4XLTMI9Q3iIwDJBOloNbUahd5OK7FnQu637t
   L/cQdlSHel5tRVjh84Jfhl7pDfV2zZyPeEVs3D3t8XoKAVzDo3YAad6sp4r8nCUb
   UmxUUWAL9lRiS848gHAm+nZNcQF78RIY2lk6qq6DnFO30Q4B2JaLG2WTkcZ2uVx7
   ezqGS4vqngA30c5r3KsI8ODevsvtFf6v6vicBsMd8j+ME+Qt/0PjAnCsT5AQes//
   d8z/a4OerNZze4z+iczvXqwBtvrI+7TMhDq3WqlMK9nlKt3a0z2RHGGlCQ8jMtub
   akAY2zocFupKgghFgbyFoS8BZx7Yl3mZXDZt5ZwYcj5kezmjEwY/YCO4rk+lFQc+
   26mK7GYb+rhviUDaVKy2X5DZVUvOAOd8VeYQUtOfJ6QxVKtCW0DakDRBDOb3cIk3h
   F7toGs5wBFldupDkxU1TXS7dnKN1mgFumFWGNmhb8AJH0omt08VC23Jtj1O0A9sn
   ZMFvA6KMp8s6FYZmkbj7RdcoudzWYdsCq+3SmrVIvq9iqJOxaIu1+6ho406UU2vF
   ohHFJNVUDOr4sEIxeK0O6nJKHFZhclxeLK4DpvUqSdSqG1+eerx35ELXrPfF5gzq
   BWs4joD2qSUehFTp8aXsremUp0mrLxp+tnVMFALaFWhZHg6HWorIohz2um5KZcV4
   QUcNh4BdC9HZV8ikckSn5WM83neiONKavbQlS4MlANoplaQn67JbMLQ2XSPumQa1

          OD9iBLYPiyDjudXR4en9xuHQdHmIDGp6VsjyyBvTE85DwIJMty65T2PDtkJqa4Gz
          Va/KPcjRF8i38qUytVhdmrEUb1rqHDnx7lFyGd+2RC1FCYwFOMErfKO3oymKyceF
          n8Q7oyfs1eqMEFsqJw1oOfhmaoQNCmJluerLmeSox20+g1idmdZA7zKolVXLMvKY
          TpCp3KwzlSHYhjpmBCGHXZEp1CnlI0nalZdxHPxtUDLsEFlNGfqGBRCgY9CCd97w
          YpuQ4HlY8Kyus6wBZ3LIb0tNXx2XmpOdd9EwqPv1VlB8Dgvdbr2S4dNWBnZVirLp
          Qbgsh0MSKJ646reXI3K8nKSLaHL9nlrRQdVtsbWRviDVDWyrTzD+n9yPGf7fhP8j
          5kO3+I/AN/k/gZHYPf7fMf6vLEaZs++FfvGg0pDIGkfRmLsj2PLX6R5NY6JGcywT
          6x9OCcDrOOGjUgLwOk74qJQAvJYT3o3O93f6e3b958ZZ2cdvQ/55s/6DvEf/QbBr
          /YeAifv4/yToP3DCsnQyfZP+s32j/mOO6Tp3ub75uf6TLipXpDDH5DWVbp7VCzve
          sGxrnfDuWEEErgvprjN2eda4aFS9PzVXGWzLmTSsmvSgcTQyfgYtK6/LkOsy4D2F
          nX15k4AAm6p+k9Y/FxD2LOBs+nMgph+o/YgXev+u9pM/746BZ4EotJ7YZ0qunQHX
          ZJni8v5B4wWaXjKJTnfhLmWvRYMzIXYbFjI5jFzInZwlZZR0gmoAGoi39e6ENYEk
          HsO0UyJ7umXRkl/i+LGOLxE6zD3bkFOqoJYZrS3Mo5bYjjSc16cLjwvABjZ3Tbgw
          EIHu51MYjruBLihkPUwjBwTDKJjJ0MqZLpQpjMVG40i2HhaHDtNTcH08ZDpASGdm
          Vh2T7DzUC/SINbE6epSnaWfJNGP36oT2b+QcHeOFULeg/XStYOQGpFdc6+EMcDBK
          fXviBR7sukN3IxIljBR2fkm/UvlF3SHaEOu9Kng98MJNO5PObPM9s20E9IU2zrbV
          NVXduLbrRP35fLmVfYCXdZ9mrHGr+yzi5y5+n7CIsCNRdBx901oTYGirG/vMgJcP
          mP/XeqHOxIMszduZuT2I2qEqFtsYT9j4suzz3WwHhFkxa4eV4ATDkcJN0Tub7Obi
          l4xiVww3PVTrTb0F53O84Qlbcl16TBnsXHb33UWn26oCVojgnBJk1lLYPuAkDTkf
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          97rPvb3K/29B/nmz/kOit/wPI+NaYFz/49j9/s8nR/8Jb/UfFixdZqes1VXSpDV9
          3CxjcUVb/RwFc6SNYbjHPOfImvRJ2OKeEoQ6QBb58aQspcM86u350UQOEGHRULYs
          Ec0uDzIlkqqZ2q6txQOdKTuL4xNyu1G4OXtA95ICEEINTlmB7GqdqrH0TG7jhdyX
          vs2yPshFrEmJ1dTmymAmDflxuQHlpgjqeJi/pP8syEMjzOWtnCabMJmljbhsIwM1
          CpjqVwY78D7TH/gcWSUkqF0uQRaDK2/pxB6UAouR+r3iqCEHiQ/mogxSvcX05ukQ
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          nFKywvH7qaS7J1ZZbIUp4WYQ7+LMtf5DoESp0loF6Q4K5LsNryOnNhebXZ9ujcPA
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          o/IxNzemOTZbgzDarnmDbqXj4GtxsYVSA1xHnVSTeSqZFpqCKiD0etuj2BwV5Yuz
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          xJivQOQx9BCwY+fq9i/QVIwJTI2/HiOPsXfc2im86MmFikTMlQunifwGHm9Rnf6R
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          7LaxVTMUgkkSewhwThtcTT4UmB4CrJNlj+bc1eRlXBsvGMHxavIc3h4C8+chcjX5
          dHPGWbOEcPlYGXkrtajv8fEShNmNaezbQkRjewoX+alWtjYo5e2gGaTS1iHlZ326
          uZQPgckLCyzSJ5f2TOoC0+RK10bj1szDVccKicPn6sDPUZ80Bg2BB40rEX4NLs9h
          20HKCfeaefXSw6rVcRnCp23hXyRXJPM1sc4oprAi6XSw126Fw2qBdlB4sJonn37R
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P0b7Veqnf3f9W3/5n9/42+/75f/65g/4f3X4+p/9w0/8wt8Mv/97f/jX/zt88Stf
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8UlHKOT1ubOBsqtnREzwI5G436TkSgkxzYVkxr9bYbTDCFT/r0y9yshXUrRhlxRF
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yP+bUQE23P+JqD/zfxpZ9P5fewv8vwXo/d/W7OecjaRZhGWaZq04LtGUjCPIwkUQ
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N4ci/iZ7gtkGAAAAAAAAAAAAAAAAAAAAAAAAABAPX4DY+BfEQB4AAA=
-- END MESSAGE ARCHIVE --

Appendix C. Original Requirements

   The following requirements were crafted throughout the development of
   the mechanism described in this document. They are preserved here
   for historical reasons.

   o The mechanism must allow a UAC or a proxy server to provide a
      strong cryptographic identity assurance in a request that can be
      verified by a proxy server or UAS.
   o User agents that receive identity assurances must be able to
      validate these assurances without performing any network lookup.
   o User agents that hold certificates on behalf of their user must be
      capable of adding this identity assurance to requests.
   o Proxy servers that hold certificates on behalf of their domain
      must be capable of adding this identity assurance to requests; a
      UAC is not required to support this mechanism in order for an
      identity assurance to be added to a request in this fashion.
   o The mechanism must prevent replay of the identity assurance by an
      attacker.
   o In order to provide full replay protection, the mechanism must be
      capable of protecting the integrity of SIP message bodies (to
      ensure that media offers and answers are linked to the signaling
      identity).
   o It must be possible for a user to have multiple AoRs (i.e.,
      accounts or aliases) that it is authorized to use within a
      domain, and for the UAC to assert one identity while
      authenticating itself as another, related, identity, as permitted
      by the local policy of the domain.

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