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Enriching Bootstrapping with Authorization Information
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Abstract

Some work has been done in the area of bootstrapping in the IETF recently. Bootstrapping refers to the process of creating state (typically security associations) between two or more entities based

on a trust relationship between these two or more parties and a trusted third party. So far work has mostly focused on creating security associations. This document aims to attach authorization information to the bootstrapping process.

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1. Introduction and Problem Statement

Some work has been done in the area of bootstrapping in the IETF recently. The goal of bootstrapping is to create state (typically security related information such as security associations) between two or more entities. We focus on the two party case and call them Alice and Bob. To securely establish state is simple if (a) Alice and Bob share some information to protect the signaling exchange (e.g., share secret or the ability to verify a digital signature) and (b) if they are able to authorize the other party. (a) is the problem of key management problem and (b) addresses an important aspect in real world deployments - authorization.

Hence, to develop a satisfactory bootstrapping solution it is necessary to solve these two aspects:

- o In order to solve the key management problem a number of mechanisms have been introduced including bootstrapping mechanisms. For example, [9] and [10] give an overview of bootstrapping (and imprinting) and give protocol and architectural considerations. Moreover, the problem of bootstrapping is a hot topic in MIPv6 WG: for a Mobile IPv6 bootstrapping problem statement see [11]. Several solutions have also been proposed so far: some of them, such as [12] and [13], exploit the authentication and protocol exchanges performed by the mobile node for network access (e.g. PANA, EAP) in order to bootstrap a Mobile IPv6 security association with the HA: in this way, to bootstrap a MIPv6 SA no other authentication phase is needed. Other solutions are completely independent from network access authentication: for example, [14] proposes to use IKEv2, while with [15] a MIPv6 security association for [16] is created using PANA [1]. Finally, a solution for bootstrapping a DHCP RFC 3118 [17] security association using EAP/PANA was specified in [18] and in [19] and a proposal to bootstrap a Kerberos Ticket Granting Ticket based on a successful EAP protocol exchange is provided in [20].

- o The aspect of authorization has received little attention in the existing literature. Its importance has been discovered during the work on the EAP keying framework [21] document but does not go beyond investigating information carried by AAA protocols. Actually the authentication and the implicit authorization performed through a pre-shared key or a key management protocol may not be sufficient to conclude that a node (a user) is authorized for a particular service. Considering the case of Mobile IPv6 service as an example, the fact that the MN shares a pre-shared key with the Home Agent and is able to setup an IPsec Security Association to protect Mobile IPv6 signaling does not

imply that it is authorized to provide the Mobile IPv6 service. For example the Mobility Service Provider (MSP) might want to prevent the usage of MIPv6 if the credit of the MN is going to exhaust or based on the time of the day. This implies that solving the key management problem is not enough to bootstrap a service: a mechanism to explicitly authorize the user is needed to design a bootstrapping solution.

This document describes a "single sign-on" framework that addresses these issues through the usage of EAP and the AAA infrastructure of the involved service providers (i.e. the home and the visited service providers). This framework does not depend on the EAP method, the EAP lower layer, the AAA protocol used even if some EAP method (e.g. PEAPv2, which creates a secure channel between the client and the server) and some EAP lower layer (e.g. PANA) could bring some (more) benefits. Several mechanisms can be used to carry authorization data, such as Diameter, PANA or EAP.

This document addresses authorization by utilizing capabilities of the Security Assertion Markup Language (SAML). For details about SAML see [2], [3] and [22]. Please note that it would be possible to use other languages for describing authorization capabilities as well, such as SPKI [23] or X.509 Authorization Certificates [24].

Based on the previously published solution it can be seen that the Extensible Authentication Protocol (EAP) [4] plays an important role in a bootstrapping solution since

- o it provides support for multiple authentication and key exchange

protocols;

- o allows three entities to be involved (EAP peer, EAP server and the Authenticator);
- o extensively deployed in the context of operational environments.

As a protocol between the Authenticator and the EAP server RADIUS [5] and DIAMETER [6] are important to complete the architecture.

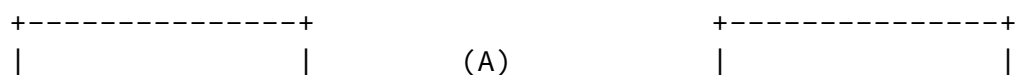
The manage of the authorization process related to the bootstrapping is being considered as an important aspect of the services deployment within the next generation networks. In this context the proposal of this document is to describe how the use of SAML could provide the user consumer of a service of the material needed to access in a secure way the services and to link it with the permission and grants associated to the user.

[2.](#) Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [7].

This section illustrates the bootstrapping framework and the involved entities. The framework is based on a single sign-on paradigm: a first authentication and authorization protocol exchange is exploited to exchange general authorization data and to bootstrap subsequent security associations and services. The framework is independent from the container used to carry the needed authorization data; however in this draft the usage of SAML is described, since it seems to offer several advantages.

Figure 1 shows the entities typically involved in bootstrapping.



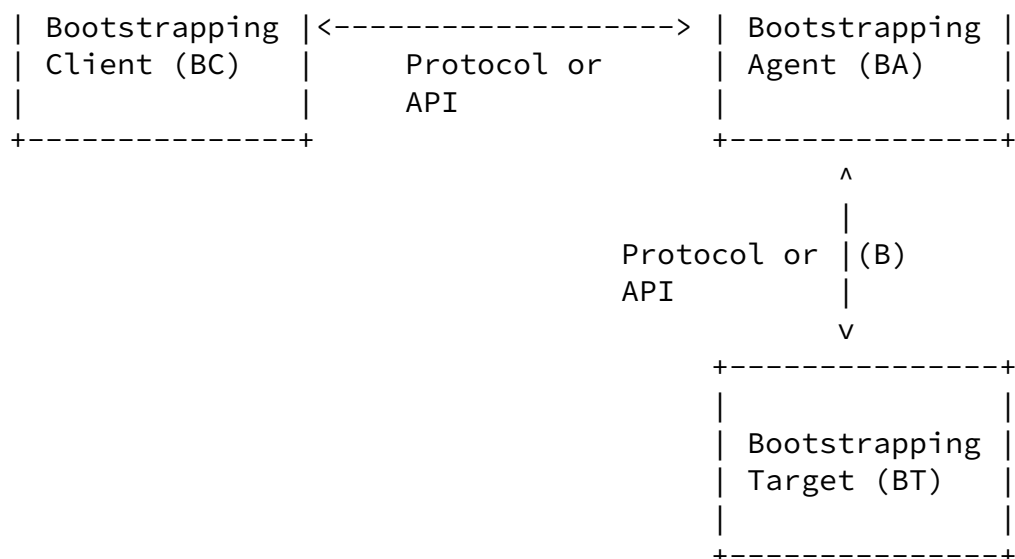


Figure 1: Bootstrapping Framework

Existing bootstrapping proposals nicely fit into this architecture. Below we provide an attempt for classification based on the following distinguishing properties:

- o Which protocol is used between the BC and the BA?
- o Which protocol is used between the BA and the BT?
- o What information is bootstrapped?

The authors argue that the first two bullets are the most important once. Ideally a generic bootstrapping protocol would provide enough flexibility for bootstrapping a variety of bootstrapping data items.

As an example we classify a few proposals:

Protocol	BC<->BA	BA<->BT	Bootstrapped Info
IKEv2 (1)	IKEv2	API	IPsec SAs
Jee et al. (2)	PANA + DIAMETER	DIAMETER	IKE SA

Tschofenig et al (3)	PANA	API	SA for MIP6 Auth.
.....
MIP6 Auth.(4)	MIP6 Ext.	API	SA for MIP6 Auth.
.....
Giaretta et al. (5)	EAP	Not specified	IKE SA
.....
Bournelle et al (6)	PANA	Not specified	IKE SA
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where (1) refers to [25], [14] and also to , (2) refers to [12], (3) refers to [15], (4) refers to [16], (5) refers to [13] and (6) refers to [26]. It is a matter of taste to call [25] or [16] a bootstrapping protocol.

The bootstrapping framework, shown in Figure 1, can nicely be mapped to the Authorization Framework Figure 3. The Bootstrapping client corresponds to the entity that is used to request the assertion/artifact, the Bootstrapping Agent can be related to the Assertion Granting Entity and the Assertion Verifying Entity corresponds to the Bootstrapping Target.

When Alice is successfully authorized it receives the Artifact either via PANA, IKEv2 or any other protected channel established via certain EAP methods. Alice might want to make the Artifact available to other protocols. When Alice wants to make a service request with Bob then the Artifact is attached. Bob will need to interact with Cecil in order to fetch the Assertion. Bob might want to use DIAMETER to fetch the Assertion and to execute functions such as accounting and credit control. DIAMETER is particularly attractive if keying material needs to be distributed to create a security association between Alice and Bob to secure subsequent communication. If the establishment of keying material is not important then other mechanisms (such as HTTP) could be used.

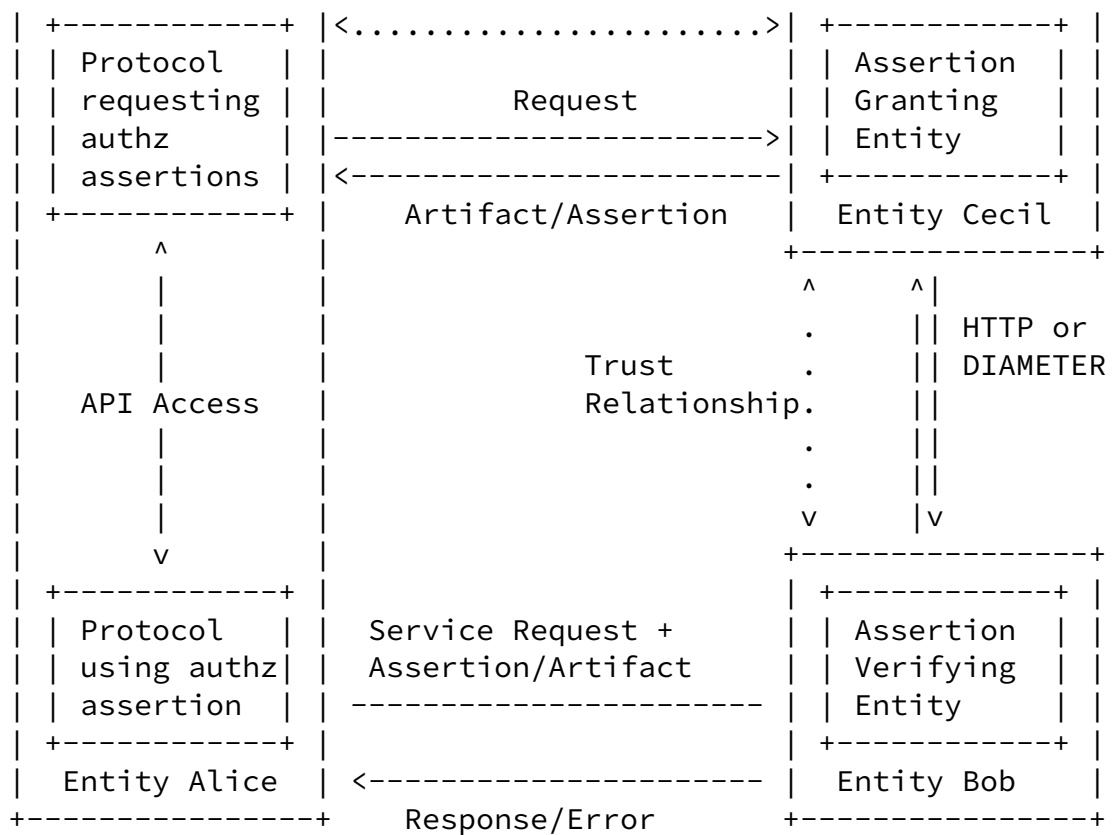


Figure 3: Authorization Framework

4. Scenarios

The content of this section is partially based on [27] which addresses trait-based authorization in SIP. This document has a strong relationship with [27] but aims to be more generic (instead of focusing on SIP). Furthermore, [Section 4.1](#) borrows also from [28] and from [29].

Two scenarios are meant to illustrate the functionality of SAML for authorization in combination with bootstrapping. First, we describe how authorization in a QoS signaling environment can be used and then we illustrate a SIP service authorization example.

4.1 Authorization in QoS signaling protocols

Cryptographic computations are expensive and computing authorization decisions might require a lot of time and multiple messages between the entity enforcing the decisions and the entity computing the authorization decision. Particularly in a mobile environment these entities are physically separated - or not even in the same administrative domain. Accordingly, the notion of "single sign-on" is another potential application of authorization assertions, and trait-based authorization - a user is authenticated and authorized through one protocol, and can reuse the resulting authorization assertion in other, potential unrelated protocol exchanges.

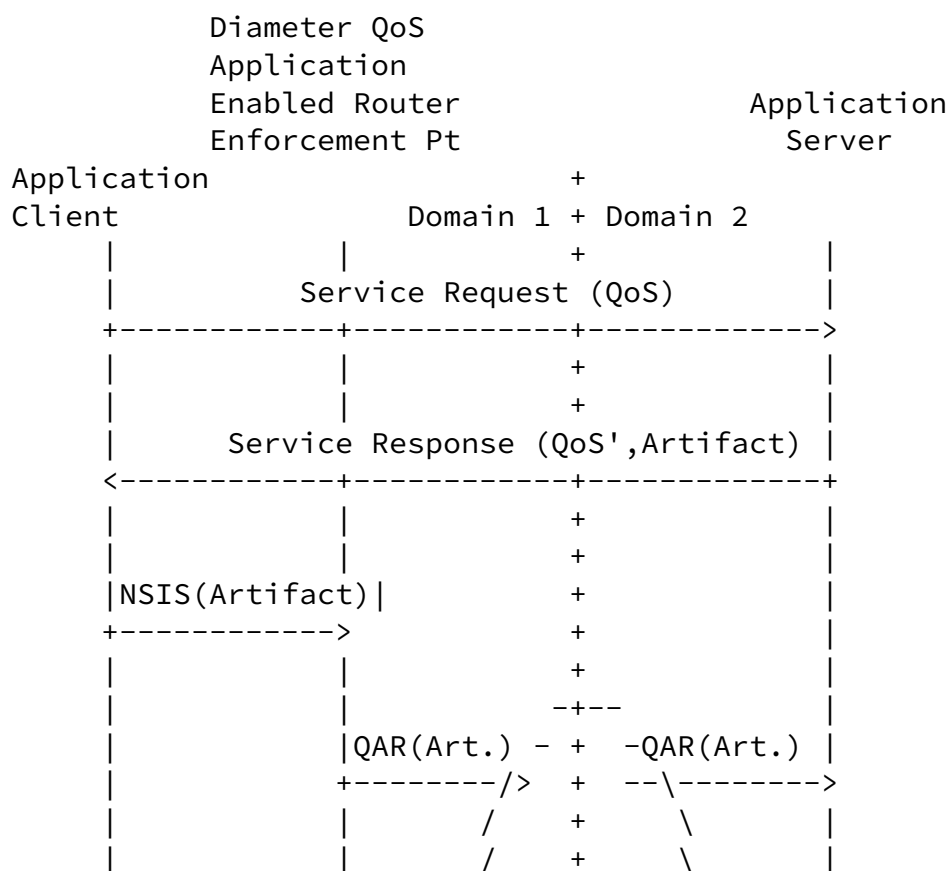
For example, in some environments it is useful to make the authorization decision for a "high-level" service (such a voice call). The authorization for the "voice call" itself might include authorization for SIP signaling and also for lower level network functions, for example a quality-of-service (QoS) reservation to improve the performance of real-time media sessions established by SIP. Since the SIP signaling protocol and the QoS reservation protocol are totally separate, it is necessary to link the authorization decisions of the two protocols. The authorization decision might be valid for a number of different protocol exchanges, for different protocols and for a certain duration or some other attributes.

To enable this mechanism as part of the initial authorization step an authorization assertion is returned to the end host of the SIP UAC (cryptographically protected). If QoS is necessary, the end host might reuse the returned assertion in the QoS signaling protocol. Any domains in the federation that would honor the assertion generated to authorize the SIP signaling would similar honor the use of the assertion in the context of QoS. Upon the initial generation

of the assertion by an authorization server, traits could be added that specify the desire level of quality that should be granted to

the media associated with a SIP session.

The message flow shown in Figure 4 illustrates such an exchange where a client (such as a SIP user agent) uses some signaling exchange which allows the end host to obtain an Artifact. This is Artifact is later used as input for a QoS signaling protocol and provides client authorization. The QoS aware router can either process the request locally or use the Diameter QoS application for verifying the authorization decision at the entity which created the Artifact. In order to perform the processing local it is required to obtain an Assertion rather than an Artifact (which is not further illustrated in Figure 4). The DIAMETER QoS application contacts the Application Server to obtain the Assertion, to authorize the request and to start accounting.



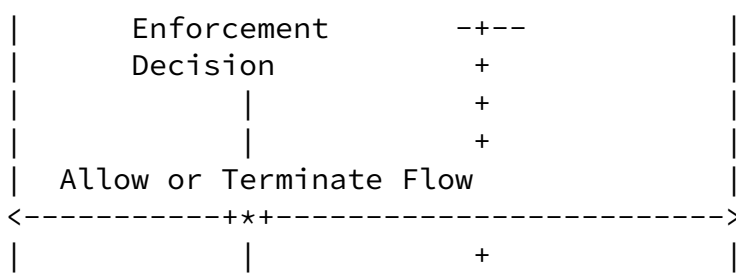
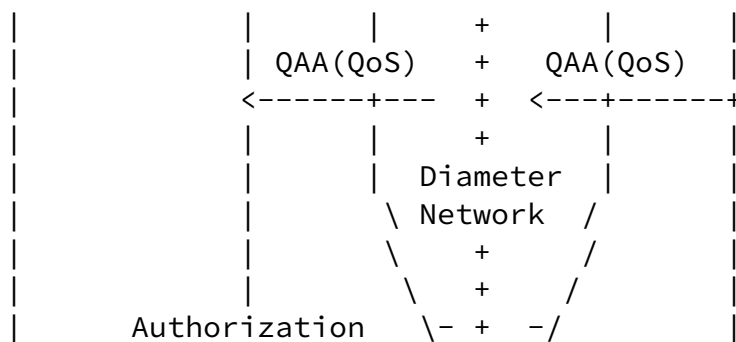


Figure 4: Message flow with NSIS and Diameter QoS Application

4.2 SIP Service Bootstrapping

This scenario exploits the inclusion of SAML for SIP which has been introduced with [30].

In Figure 5 user Alice runs a protocol with an Authentication Server whereby authentication and authorization is provided. This protocol exchange might be based on a number of protocols, such as EAP, PANA, HTTP or something similar. It is not required that the authentication and key exchange protocol terminates at this entity but the Artifact is created and returned to the user (based on a successful protocol execution). When a SIP message (e.g., an INVITE) is sent towards a SIP Server or even to another SIP UA then the Artifact is attached to the SIP message. As shown in Figure 5 the SIP service contacts the Authentication Server (for example via DIAMETER) to request the Assertion. This message exchange also allows the SIP service to obtain keying material.

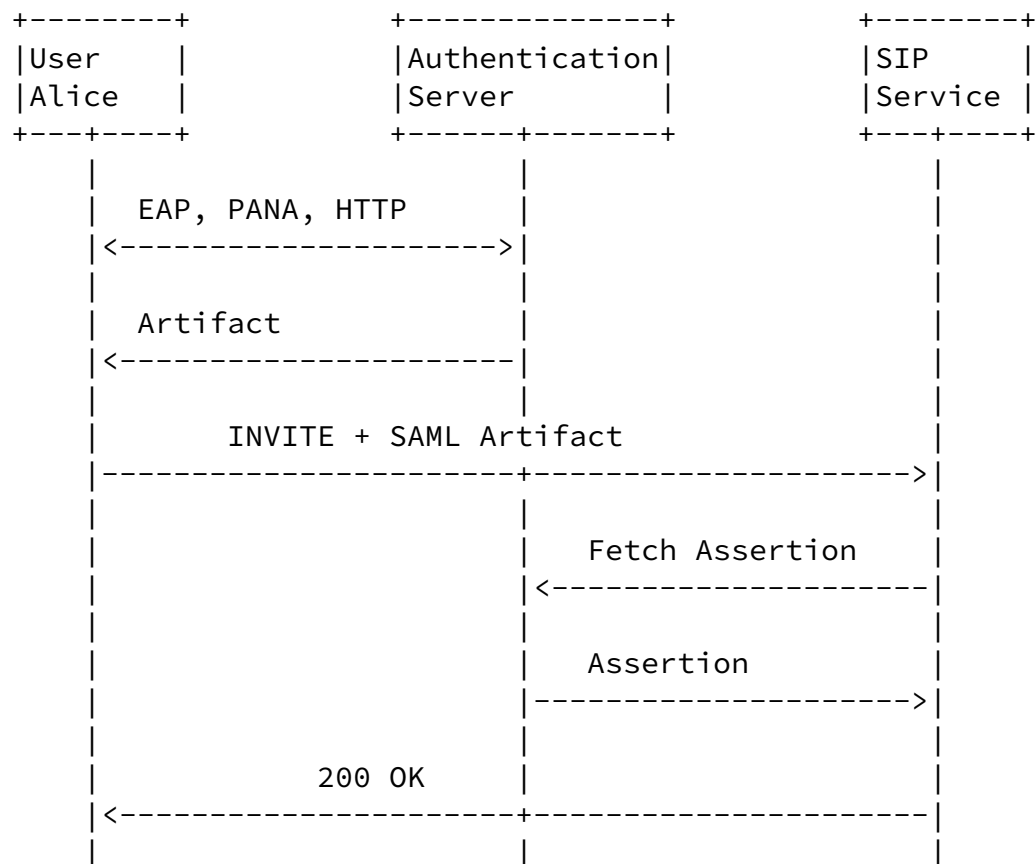


Figure 5: Message flow for SIP service authorization

[5.](#) Obtaining a SAML Artifact/Assertion

This section describes how an end host obtains an Artifact via PANA or EAP which subsequently be used for service authorization. Depending on whether the home network or the visited network should create an Assertion/Artifact EAP and/or PANA will be used. If for example, services in the visited network should be authorized then an entity in the visited network should create the Assertion/Artifact and it will be returned via PANA to the end host.

It is not suggested to exchange a SAML Assertion either via EAP or via PANA. An Assertion is an XML document which is, for security reasons, digitally signed. Both PANA and EAP/EAP methods suffer from size limitations. EAP and most EAP methods do not support fragmentation. PANA should avoid IP layer fragmentation.

A number of mechanisms exist to fetch an Assertion with the help of an Artifact. HTTP is the most common mechanisms. This document also

suggests to use DIAMETER to assist in this step since it additionally allows to distribute previously created keying material, to benefit from accounting extensions [31] and other DIAMETER applications such as Credit Control [32].

EDITOR's Note: A "notification" mechanism might be useful to indicate that the user wants to obtain an Artifact (or that the server does not provide this extension).

[5.1](#) SAML Artifact transport in EAP methods

Currently there are a number of EAP authentication methods that have the capability to convey generic information items (e.g., PEAPv2 [33], EAP-PSK [34] or EAP-IKEv2 [35]). In fact they are being used send additional information during authentication process inside a protected channel between an EAP peer and the authenticator or between the EAP peer and the EAP server in the case authenticator is acting as a pass-through. This capability is, for example, being considered to transport MIPv6 authorization data [13]. Following this approach SAML information (i.e., the SAML artifact) could be conveyed in this kinds of EAP methods too by creating another payload or AVP that carries this information.

[5.2](#) SAML Artifact transport in PANA

Another alternative, that would allow to use EAP methods that are not able to transport generic information (e.g., EAP-TLS [36]), is to use PANA protocol to convey authorization information (SAML artifact) from the PANA Authentication Agent (PAA) to the PANA Authentication Client (PaC). The usage of PANA provides more flexibility with

respect to the entity creating the artifact and the bootstrapped service. This circumstance is shown in Figure 6. The PANA protocol is used between the PAA and PaC. It might be necessary that a AAA server is contacted. EAP is carried inside PANA and might then again be encapsulated into a AAA protocol such as RADIUS or DIAMETER (see [37] and [38]). AAA interaction with EAP is typically the case if a user roams to a visited network and the EAP method runs between the EAP peer and the EAP server (whereby the EAP server is at the user's home network). The service which will be later used might be at a different administrative domain. The service could be at the visited network, at the home network or at any other network. To allow

bootstrapping to work it is necessary to have an existing trust relationship between the entity that created the SAML assertion and the service which will later use it. DIAMETER might be used between these two entities to transfer keying material (and other information).

If PANA terminates at the first hop router, as proposed in [1], then PANA allows to create the SAML artifact in the visited network (by some entity) and to subsequently use services either in the visited network itself (as shown in Figure 4 or in networks which have some trust relationship with the visited network with regard to the later service usage.

```
+-----+
| Authentication |
| Authorization  |
| Accounting     |
```

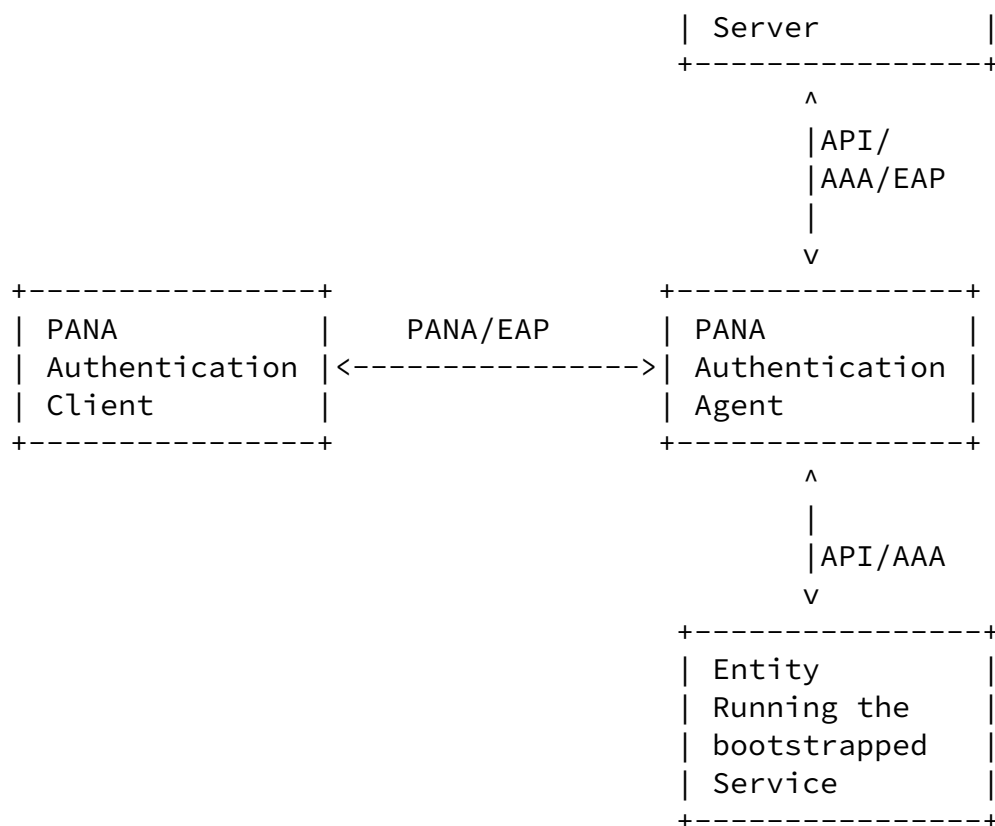



Figure 6: SAML Artifact transport in PANA

To create a working solution it is necessary that the SAML artifact can be carried in a AAA protocol (e.g., DIAMETER or RADIUS) between the AAA server and the PAA and is then finally delivered from the PAA to the PaC by using PANA. According to the PANA specification [1] the PANA-FirstAuth-End-Request (PFER) (if both NAP and ISP authentication is carried out) and/or Pana-Binding-Request (PBR) message can transport new AVPs. Confidentiality protection must be provided for this purpose. Authorization information could be carried by defining new AVPs to be transported inside these messages. Note that new attributes or AVPs to carry SAML in DIAMETER (or RADIUS) also need to be defined.

6. Binding Authorization Information to Credentials

SAML introduces the concept of a holder-of-the-key assertion to bind the assertions (authorization information) to a cryptographic key. See Section 5.1 of [\[2\]](#)

A number of credentials can be used with the KeyInfo element of the Holder-of-the-Key assertion as described in Section 4.4 of [\[8\]](#), such as:

- o KeyName element, which is a string containing an identifier to a key.
- o KeyValue element, which contains the public key
- o RetrievalMethod element, which is a reference to a key
- o The X509Data element even contains one or more identifiers of keys, X.509 certificates, certificate identifiers or a revocation list.
- o PGPDData element that is used to convey information related to PGP public key pairs
- o SPKIData element carries information related to SPKI public key pairs, certificates and other SPKI data.
- o MgmtData element can contain a string value used to convey in-band key distribution or agreement data

These concept allows the SAML assertion to be associated with the bootstrapped credentials. For example, binding a public key to a SAML assertion might also be a helpful when the public / private key pair is also bootstrapped based using EAP and uses a pseudonym to allow user identity confidentiality. In this case this approach would provide credential based authorization. This would then allow subsequent application layer protocols interactions to be secured while authorization information can be attached and provided via SAML.

Binding a Kerberos Ticket Granting Ticket or a Kerberos Service Ticket to a SAML assertion is also possible but a Kerberos ticket does not have a unique identifier, such as a SerialNumber provided by X.509 certificates. One possible approach to attach the same unique and randomly chosen identifier to both, the KeyName element and to the authorization-data field of the encrypted part of the Kerberos ticket.

Furthermore, it is possible to binding the SAML assertion to the AAA-key. This binding therefore associates the network authentication and authorization protocol run to the assertion. Each time the user needs to re-authenticate, the assertion can be presented to grant access to the network (and also allowing the both entities to generate a new AAA-key). Such a procedure might be helpful when handovers within different access routers in the access network is desired (intra-domain mobility) or even with inter-domain mobility.

[7.](#) Security Considerations

The security of the proposed mechanism relies on the selected EAP method, on SAML and on the bootstrapping mechanism. A security analysis of different EAP methods is outside the scope of this document. It is assumed that the bootstrapping mechanism (possibly involving AAA key distribution mechanisms) and the selected EAP method is secure.

This section discusses a number of selected security threats and their countermeasures.

[7.1](#) Stolen Assertion

Threat:

If an eavesdropper can eavesdrop the SAML Assertion and construct a service request, then the eavesdropper could be able to impersonate the user at other entities.

Countermeasures:

By providing adequate confidentiality, eavesdropping of a SAML assertion can be avoided.

[7.2](#) MitM Attack

Threat:

Since the SAML assertion is presented to a service when authorization is desired, a malicious service provider could impersonate the user at some other entities. These entities would

believe that the adversary has the rights indicated in the assertion.

Countermeasures:

If the adversary is a not-participating in the SIP signaling itself (i.e., it is not a SIP proxy or a SIP UA), this threat can be eliminated by employing inherent SIP security mechanisms , such as TLS. However, if this entity is part of the communication itself then reference integrity needs to be provided. Assertions with tight restrictions (e.g., validity of the assertion) can also limit the possible damage.

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[7.3](#) Forged Assertion

Threat:

A malicious user could forge or alter a SAML assertion in order to communicate with other entities.

Countermeasures:

To avoid this kind of attack, the entities must assure that proper mechanisms for protecting the SAML assertion needs to be in place. It is recommended to protect the assertion using a digital signature. Note that the current proposal uses Artifacts in most places (EAP methods or PANA) and makes it therefore difficult for an adversary to be able to mount such an attack.

[7.4](#) Replay Attack

Threat:

An adversary who is able to gain access to an Assertion or an Artificat might be able to attach this token to a resource request to gain special privileges.

Countermeasures:

The Artificat must be encrypted when the user obtains it. It also needs to be transmitted encrypted when it is used for authorization. To make it even more difficult for an adversary to reuse the Artificat it is possible to associate credentials (either symmetric or asymmetric keying material) with the Assertion. An adversary can then only impersonate the legitimate user if he knows the Artificat or Assertion and the corresponding credentials.

[7.5](#) Privacy

Threat:

An adversary might be able to eavesdrop both the EAP communication and the usage of SAML Artifacts and Assertions. This information might reveal user identities and usage patterns.

Countermeasures:

EAP methods provide mechanisms to hide the true user identity.

This is, however, useless if a SAML Assertion again reveals the true user identity. Since the Assertion is possibly only exchanged using DIAMETER an adversary needs to be located at a AAA client or server. The Artificat itself does not reveal user specific information since it is only a pointer to the Assertion. Only legitimate entities are allowed to fetch the Assertion using an Artifact. Furthermore, SAML does not mandate the inclusion of a user identity in the Assertion.

[8.](#) Acknowledgments

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