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<th>Project</th>
<th>IEEE 802.16 Broadband Wireless Access Working Group [<a href="http://ieee802.org/16">http://ieee802.org/16</a>]</th>
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<td>Title</td>
<td>Enhancement of 802.16e to Support EAP-based Authentication / Key Distribution Rev. 0</td>
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| Re: | Call for contributions to 802.16e security adhoc (11/17/2003) |
| Abstract | Description of requirements, mechanism, and security considerations for EAP in 802.16e |
| Purpose | Provide basis for discussion and proposal of 802.16e Security Adhoc group |
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Enhancement of 802.16e to Support EAP-based Authentication / Key Distribution
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Streetwaves Networking

Scope of this document

This document outlines how to incorporate Extensible Authentication[2] and key management into 802.16e on the basis of previous work in other environments (particularly 802.11[4])

For the purposes of this document, the actual EAP authentication exchange and “inner method” can be regarded as a “black box”.

Background

Motivations

- To enable mobile operators to use other forms of credentials in addition to, or instead of, PKI-based device certificates (eg. Various forms of provider-supplied smartcards to be installed in an off-the-shelf device)
- Facilitation of handover to other media (ie. 802.11) by providing hooks for preauthentication or other functions

Requirements

The solution must satisfy the following:

- Interoperability with non-EAP enabled 802.16/e systems
- Conformance to the standard EAP/802.1x model so that methods and analysis pertaining to standard EAP will be applicable (though not necessarily recommended) for 802.16e
- Support for 802.16 primary, static, and dynamic security associations. These include SAs for both unicast and non-unicast MAC-layer connections.
- Provision for ciphersuite selection and key refresh mechanisms
- Appropriate compliance with security recommendations for EAP in a wireless environment
Description of Solution

Model of operation

To describe the model of operation we must address:

- authentication flows
- key distribution and management
- coexistence with 802.16 PKM

Model in Standard EAP/802.1x and 802.11i

Authentication flows in standard EAP/802.1x

In EAP [2]/802.1x [1], authentication exchanges take place in the data plane, and above the MAC layer. Accordingly, the MAC layer itself must support the logical port model described in section xx of the 802.1x specification: the MAC link between the station and access point consists of two distinct logical links. These are termed the “controlled port” and “uncontrolled port”.

According to the model, EAP/802.1x packets initially flow to and from the logical uncontrolled port.
After authentication is successful, the logical “controlled port” becomes enabled – and regular data can then flow across the MAC link.

Key Distribution in 802.1xRev and 802.11i

As described in [3], successful completion of the EAP/802.1x inner method will (if desired) result in a shared-secret AAA-Key being exported to the Client and Authenticator from their respective EAP modules. Methods for derivation of traffic keys from the AAA-Key is ciphersuite-specific and not within the scope of the 802.1x standard.

802.11i [4] specifies mechanisms for using the AAA-Key to establish and maintain the required security associations for the 802.11 environment (including encryption key and hash derivation). Specifically, these include:

- “4-way handshake” for installing unicast session keying material
- “Group Key handshake” to “push” the data broadcast keying material to the client in EAPOL-KEY messages

Model for EAP/802.16e

The following shows the functions of PKM with the corresponding EAP/802.1x functionality:

<table>
<thead>
<tr>
<th>PKM</th>
<th>EAP</th>
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<tbody>
<tr>
<td>AuthReq/Rsp</td>
<td>EAP Inner Method</td>
</tr>
<tr>
<td>AK transmission in AuthRsp</td>
<td>AAA-key derivation/export</td>
</tr>
<tr>
<td>KeyReq/Rsp</td>
<td>Key distribution in EAPOL-key</td>
</tr>
</tbody>
</table>

Note that in 802.16:

- EAP-based exchanges perform the same functions as the current PKM (ie. authentication and key/SA management).
- EAP-based functions must be separate from whatever convergence layer runs on top of the MAC layer.
Consequently:

- EAP operation and state machines will be completely contained within the 802.16 privacy layer.
- EAP messages will be encapsulated inside the payload of PKM MAC messages

**Controlled and uncontrolled logical ports in 802.16 MAC**

Our adaptation of the model into the MAC layer leads to the following assignment of the controlled/uncontrolled ports:

<table>
<thead>
<tr>
<th>Uncontrolled Port</th>
<th>Basic and primary management connections</th>
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<tbody>
<tr>
<td>Controlled Port</td>
<td>Secondary Management connection</td>
</tr>
</tbody>
</table>

**Format for transmission of EAP packets in 802.16 MAC Layer**

<import from ETRI document>

**Security Association and Key Management in EAP/802.16e**

Requirements for SA establishment and key distribution correspond to those in 802.11i

- Primary SA establishment (for secondary mgt. Connection) follows 802.11i unicast session
- SA establishment for Transport connections (static or dynamic) follows the 802.11i “group key handshake”

Details are TBD.

**Coexistence of EAP-based and PKM-based authentication**

Each BS and SS MUST support PKM-based authentication. Support for EAP-based authentication is optional in both the BS and SS.

A particular instance of a SS’s network entry procedure will use either EAP-based or PKM-based authentication, as indicated by the SBC capabilities exchange. It will not use both EAP and PKM in the same network entry procedure, as this would require tunnelling one authentication protocol within the other.

**Message sequences at network entry with EAP authentication**

1. Ranging and capabilities exchange
2. multiple EAP-request/EAP-response exchanges (in PKM encapsulation, initiated by BS)
3. EAP-success (BS to SS), establishment of Primary SA (secondary management connection)
4. Establishment of transport and non-unicast Security Associations
5. Registration
6. IP address acquisition
7. connection establishment via DSx

<diagram>

**Cryptographic Protection of EAP exchanges**

The specific threats against EAP traffic transmitted over “insecure media” (eg. Wireless) are as follows (from [2]):

[1] An attacker may try to discover user identities by snooping authentication traffic.

[2] An attacker may try to modify or spoof EAP packets.

[3] An attacker may launch denial of service attacks by spoofing lower layer indications or Success/Failure packets; by replaying EAP packets; or by generating packets with overlapping Identifiers.

[4] An attacker may attempt to recover the pass-phrase by mounting an offline dictionary attack.

[5] An attacker may attempt to convince the peer to connect to an untrusted network, by mounting a man-in-the-middle attack.

[6] An attacker may attempt to disrupt the EAP negotiation in order cause a weak authentication method to be selected.

[7] An attacker may attempt to recover keys by taking advantage of weak key derivation techniques used within EAP methods.

[8] An attacker may attempt to take advantage of weak ciphersuites subsequently used after the EAP conversation is complete.

[9] An attacker may attempt to perform downgrading attacks on lower layer ciphersuite negotiation in order to ensure that a weaker ciphersuite is used subsequently to EAP authentication.

[10] An attacker acting as an authenticator may provide incorrect information to the EAP peer and/or server via out-of-band mechanisms (such as via a AAA or lower layer protocol). This includes impersonating another authenticator, or providing inconsistent information to the peer and EAP server.

Of the above, [3] would appear to be not relevant as DoS can be easily accomplished via interference with the RF. Whereas [4]-[10] involve using EAP to exploit weaknesses elsewhere in the security architecture which we take care to prevent.

Hence it appears acceptable to rely exclusively on the cryptographic protection provided by the EAP inner method.
Specific 802.16e text changes

<ttb></ttb>

References

[1] IEEE 802.1Xrev
[2] RFC 2284bis IETF draft
[3] EAP Keying Framework IETF draft
[4] IEEE 802.11i