XEP-0420: Stanza Content Encryption

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<table>
<thead>
<tr>
<th>Status</th>
<th>Type</th>
<th>Short Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Standards Track</td>
<td>SCE</td>
</tr>
</tbody>
</table>

The Stanza Content Encryption (SCE) protocol is intended as a way to allow clients to securely exchange arbitrary extension elements using different end-to-end encryption schemes.
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1 Introduction

There is a number of different end-to-end encryption mechanisms that can be used to secure user communication against unauthorized access from malicious third parties. Popular examples for this are OMEMO Encryption (XEP-0384) and OpenPGP for XMPP (XEP-0373). While the latter allows for encryption of arbitrary extension elements, protocols such as OMEMO Encryption (XEP-0384) are limited to only encrypt the body of a message. This approach is not very flexible and prevents the combined usage with XMPP extension protocols such as Stateless Inline Media Sharing (XEP-0385) or Last Message Correction (XEP-0308) as their extension elements cannot be included in the encrypted part of the message, therefore leaking information about the message content.

This extension protocol proposes a solution to aforementioned issues by generalizing the OpenPGP Content Elements (e.g. \texttt{<signcrypt>}) introduced by OpenPGP for XMPP (XEP-0373) for the use with other encryption protocols.

2 Requirements

This proposal widens the scope of the security guarantees given by the used encryption mechanism from just the body of the message to all contents of the \texttt{<content/>} element. It is intended to serve as a "one size fits all" solution for extension element encryption in XMPP.

In order to achieve its goal, Stanza Content Encryption does the following:

- Define elements that hold sensitive information
- Specify rules about how extension elements are encrypted and embedded in the message
- Specify rules about which elements are allowed inside and outside the protected domain

3 Glossary

\textbf{Envelope Element} \texttt{<envelope/>} An XMPP extension element which is used to hold the encrypted \texttt{<content/>} element.

\textbf{Content Element} \texttt{<content/>} An element which is used to contain all of those extension elements that need to be encrypted. The XML representation of this element is encrypted and then embedded into the \texttt{<envelope/>} element.

\footnotesize
\begin{itemize}
\end{itemize}
4 Affix Elements

In order to prevent certain attacks, different affix elements MAY be added into the `<content/>` element.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Usage</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;rpad/&gt;</code></td>
<td>Random-length random-content padding</td>
<td>Prevent known ciphertext and message length correlation attacks. The content of this element is a randomly generated sequence of base64 characters of random length between 0 and 200 characters. TODO: sane boundaries?</td>
<td>None. This element is only used to change the length of the ciphertext and doesn't need to be verified</td>
</tr>
<tr>
<td><code>&lt;time/&gt;</code></td>
<td>Timestamp</td>
<td>Prevent replay attacks using old messages. This element MUST have one attribute 'stamp', whos value is a timestamp following the format described in XMPP Date and Time Profiles (XEP-0082) XEP-0082: XMPP Date and Time Profiles <a href="https://xmpp.org/extensions/xep-0082.html">https://xmpp.org/extensions/xep-0082.html</a>. The timestamp represents the time at which the message was encrypted by the sender.</td>
<td>Receiving clients MUST check whether the difference between the timestamp and the sending time derived from the stanza itself lays within a reasonable margin. The client SHOULD use the content of the timestamp element when displaying the send date of the message</td>
</tr>
<tr>
<td><code>&lt;to/&gt;</code></td>
<td>Recipient of the message</td>
<td>Prevent spoofing of the recipient. This element MUST have one attribute 'jid', whos value is the JID of the intended recipient.</td>
<td>Receiving clients MUST check, if the JID matches the to attribute of the enclosing stanza and otherwise alert the user/reject the message</td>
</tr>
</tbody>
</table>
5 Motivation

Some end-to-end encryption protocols like OMEMO Encryption (XEP-0384) are historically limited to encryption of the message body only. This approach excludes other extension elements from the protected domain of the payload element, exposing them to potential attackers.

Listing 2: An imperfectly encrypted message which leaks dangerous information about the conversation through the plaintext OOB extension element

```xml
<message from='narrator@jabber.org' to='viewer@jabber.org'>
  <encrypted xmlns='eu.siacs.conversations.axolotl'>
    <header sid='27183'>
      ...
    </header>
    <payload>
      SSBnb3QgaW4gZXZlcn1vbmUnCyBob3N0aWxlIGxpdHRsZSBmYWNlLjBzZXMsIHRoZXN1IGFyZSBi
      cnVpc2VzIGZyb20gZm1naHRpbi1lcywgSSdtIGNvbWVzcnRhYmxlIHRpdGggGhhdC4gSSBh
      bSBlbmxpZ2h0ZW51ZC4=
    </payload>
  </encrypted>
</message>
```

Encryption protocols that make use of Stanza Content Encryption MUST define their own profiles that describe mandatory behaviour of which of these elements are used. They MAY also define and add their own specific affix elements.

Listing 1: Examples of Affix Elements

- `<time stamp='2004-01-25T06:05:00+01:00'/>`
- `<to jid='missioncontrol@houston.nasa.gov'/>`
- `<from jid='opportunity@mars.planet'/>`
- `<rpad>C1DHNK9HK-9A25TSmwK4Hu1jji9%GKYK^sy11HT9TNl4</rpad>`

The example above obviously leaks information about the communication through the unencrypted OOB extension element.

Most end-to-end encryption mechanisms are also focussed solely on message content encryption and do not tackle <iq/> requests/replies at all. Stanza Content Encryption can be applied to those as well.

Listing 3: Unencrypted IQ request

```xml
<iq from='doctor@shakespeare.lit/pda'
    id='get-data-1'
    to='ladymacbeth@shakespeare.lit/castle'
    type='get'>
    <data xmlns='urn:xmpp:boob'
            cid='sha1+8f35fef110fffc5df08d579a50083ff9308fb6242@bob.xmpp.org'/>
</iq>
```

Listing 4: Likewise unencrypted reply

```xml
<iq from='ladymacbeth@shakespeare.lit/castle'
    id='get-data-1'
    to='doctor@shakespeare.lit/pda'
    type='result'>
    <data xmlns='urn:xmpp:boob'
            cid='sha1+8f35fef110fffc5df08d579a50083ff9308fb6242@bob.xmpp.org'
            max-age='86400'
            type='image/png'>
        iVBORw0KGgoAAAANSUhEUgAAAAoAAAAKCAYAAACNMs+9 AAAABGdBTUEAALGP C/xhBQAALwSF1zAAALEWACxMBAJqcGAAAAAd0SU1FB9YGarC5KB0XV+IA AAAdEYVdEnbW11bnQAQ3J1XZCB3aXRoIFRoZSBHUtJ72QlbgAAAF1J REFUGN0zL0ng1AxPEfDlTs4BZ44I0C70wQg2J09LE1exd1YVB8E7jg ch9/q1uH4TLzw4d6+ErXMMCxuHWxId3KOETrnnXXV6Mpcq2MLaI97E3N0 vr4MkhoXe0rZigAAABJRU5ErkJgg==
    </data>
</iq>

6 Use Cases

6.1 Use in <message/> stanzas

The main use case of Stanza Content Encryption is the use of end-to-end encryption protocols in combination with extension protocols that store sensitive information in other places than the message body. This applies to many extension elements that add additional information to <message/> stanzas, such as those of Out-of-Band Data (XEP-0066) 8.

Listing 5: Content element containing the messages body and the OBB element.

```xml
<content xmlns='urn:xmpp:sce:0'>
  <payload>
    <body xmlns='jabber:client'>[...]</body>
    <x xmlns='jabber:x:oob'>
      <url>https://en.wikipedia.org/wiki/Fight_Club#Plot</url>
    </x>
  </payload>
</content>
```

Listing 6: Finished message stanza containing the <content/> element from the previous example encrypted using a hypothetical encryption protocol and SCE.

```xml
<message from='narrator@jabber.org' to='viewer@jabber.org'>
  <encrypted xmlns='urn:xmpp:encryption:stub:sce:0'>
    <payload>
      PGNvbR1bnQgeG1sbnM9J3Vyb4bXBw0nNjZTowJz48cGF5bG9hZD48Ym9keSB4BWxucz0namFi
      YmVyOmNsaWVudC+SSBnb3QgaW4gZXZlcn1vbmUnccyBob3N0aWxlIGxpHRsZSBmYWNNliBZZXMs
      IHRoZXNlIIGyZSbicnVpc2VzIGZyb20gZmlnaHRpbmcuIFllcywgSSdtIGNvbWZvbnRhYmxlIHdp
dGggdGhhdC4gSSBhbySB1bmxpZ2huZW51ZC48L2JvZHk+
      PHggeG1sbnM9J2phYmJlcj40OmVwY1ic+PHVybBdHRwzGwL2VUWdpb21lZWRpY3Nvcmcvd2lraS9GaWdodF9DbHVlI1Bsb3Q8L3VybD48
      L3g+PC9wYX1sb2FkPjwvY29udGVudD4=
    </payload>
  </encrypted>
</message>
```

6.2 Use in <iq/> stanzas

Stanza Content Encryption thrives not only to allow for rich content encryption in <message/> stanzas, but is also applicable to <iq/> queries. A resource might want to query sensitive

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information from another resource capable of Stanza Content Encryption.

Listing 7: Sender prepares a `<content/>` element containing the query subject.

```xml
<content xmlns='urn:xmpp:sce:0'>
  <payload>
    <data xmlns='urn:xmpp:bob' cid='sha1+8f35fef110ffe5df08d579a50083ff9308fb62420bob.xmpp.org'/>
  </payload>
  <from jid='doctor@shakespeare.lit/pda'/>
  <to jid='ladymacbeth@shakespeare.lit/castle'/>
</content>
```

Listing 8: The sender then encrypts the `<content/>` element for the recipient and sends the `<iq/>` containing the result of the encryption.

```xml
<iq from='doctor@shakespeare.lit/pda' id='get-data-1' to='ladymacbeth@shakespeare.lit/castle' type='get'>
  <encrypted xmlns='urn:xmpp:encryption:stub:sce:0'>
    <payload>
      V2FpdCwgd2hhdD8gQXJlI1vdSBzWXJp3VzPBEaWQgeW91IHJ1YmxseSBqdXN0IGdyYW1geW91ciBmYXZvdXJpdGUGymFzZTY0IGR1Y29kZXIganVzdCB0byBjaGVjayB0aGlzIGRvY3VtZW50IGZvciBoaWRkZW4gbWVzc2FnZXM/
      IDoXYqYXJlI1vdSBzb21lIGtpbmQgb2YgbmVnVzdCB0byBjaGVjayB0aGlzIGRvY3VtZW50IGZvciBoaWRkZW4gbWVzc2FnZXM/
      ZWVrIHdpdGggYScKIA6FPgvbZQpeKg1NJQmrTQeOPgQyFwR6MwACaA8FJ
    </payload>
  </encrypted>
</iq>
```

Listing 9: The recipient prepares the reply to the request by assembling the `<content/>` element.

```xml
<content xmlns='urn:xmpp:sce:0'>
  <payload>
    <data xmlns='urn:xmpp:bob' cid='sha1+8f35fef110ffe5df08d579a50083ff9308fb62420bob.xmpp.org' max-age='86400' type='image/png'>
      iVBORw0KGgoAAAANSUhEUgAAAAoAAAAKCAMAAAC67D +PAAAAclBMVEUAAADYZArfaA9GIAoBAAGNQA3MXgniaAiEOgZMIATDXRXZZhHUBI1XhDrbQ6sUQ70YA2TRAubRwqMQq7VQlKHgMAAAK5WRfJ
      YBOORBFoMBCwUIQ/yca6FPgvbZQpeKg1NJQmrTQeOPgQyFwR6MwACaA8FJ
    </data>
  </payload>
</content>
```
Listing 10: The <content/> element is then encrypted and sent as a reply to the initiator of the request.
7 Sending an encrypted stanza

In order to send an encrypted message without leaking extension elements the sender prepares the message by placing the sensitive extension elements inside a `<payload/>` element inside a `<content/>` element. Depending on the encryption-specific SCE-profile, some affix elements are added as child elements of the `<content/>` element. The `<content/>` element is then serialized into XML and encrypted using the SCE-specific profile of the encryption mechanism in place. The result is appended to the message. Since the outer message element does not contain a `<body/>` element the sender appends an unencrypted `<store/>` hint as specified in Message Processing Hints (XEP-0334) ⁹. The message can then be sent to the recipient.

8 Receiving an encrypted stanza

The recipient of the message decrypts the content of the `<envelope/>` element to retrieve the `<content/>` element. Depending on the affix profiles specified by the used encryption protocol, the affix elements are verified to prevent certain attacks from taking place. Next the extension elements of the `<content/>` elements `<payload/>` element are checked against the whitelist/blacklist and any disallowed elements are discarded. As a last step, the original unencrypted stanza is recreated by replacing the `<envelope/>` element of the stanza with the contents of the `<payload/>` element.

9 Blacklist

The receiving client MUST ignore certain elements that may allow for attacks to take place. Since it is hard to come up with a complete list of blacklisted elements, a general rule of thumb would be the following: Blacklisted are all elements that need to be read by the server at some point. Below is an additional list of elements that are definitely forbidden inside the `<content/>` element and MUST instead be placed in the message unencrypted.

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin-ID elements of Unique and Stable Stanza IDs (XEP-0359) XEP-0359: Unique and Stable Stanza IDs <a href="https://xmpp.org/extensions/xep-0359.html">https://xmpp.org/extensions/xep-0359.html</a></td>
<td>IDs may be used to identify a message even though it cannot be decrypted.</td>
</tr>
</tbody>
</table>

TODO: Other elements?
10 Business Rules

Unencrypted <content/> elements are NOT ALLOWED as child elements of the stanza and MUST be dropped.
Elements in the <content/> elements <payload/> element MUST be identified using an element name and namespace. Notably the <body/> element MUST contain a valid namespace (i.e. ”jabber:client”).
The recipient must verify that the decrypted <content/> element contains valid XML before processing it any further. Invalid XML must be rejected.
After verifying the integrity of the <content/> element, the recipient needs to make sure that no blacklisted elements are found within the payload. Any forbidden elements MUST be dropped before the message is processed any further.
Furthermore the receiving client MUST ignore any extension elements considered as sensitive which are found outside of the <content/> element, especially as direct unencrypted child elements of the enclosing stanza.
Duplicate elements within the <content/> element MUST be dropped.
Elements in the <content/> element override elements in the enclosing stanza. TODO: Maybe we want to remove this rule by disallowing duplicate elements all together?
Since a message encrypted with SCE MUST NOT contain a <body/> element, it is not eligible for MAM message storage (Message Archive Management (XEP-0313) ¹⁰). Therefore sending entities MUST append an unencrypted Message Processing Hints (XEP-0334) ¹¹ <store/> hint as a direct child element to the message.

11 Implementation Notes

As a first, naïve approach a recipient of a message containing an <envelope/> element could simply reinject the reassembled unencrypted stanza into the XML stream. This might introduce some security issues. Most notably, there is no way to distinguish end-to-end encrypted elements from unencrypted elements.
Implementations should rather handle encrypted elements explicitly.

12 Security Considerations

For the sake of simplicity, the examples in this document are not encrypted. A real-world implementation MUST make use of real cryptographic protocols.

12.1 Encryption Profiles

This specification presents a set of affix elements which can be used to counter certain attacks. However it does not dictate any behaviour regarding what elements MUST be used/verified or when.
Different cryptographic protocols come with different possible attack scenarios which must be taken into consideration, so it is left up to those cryptographic protocols to define profiles that describe the use of affix elements.

13 XMPP Registrar Considerations

TODO: Maybe the Registrar should handle a blacklist of elements that are allowed as child elements of the <content/> element?

14 XML Schema

TODO.