XML External Entity (XXE) Prevention Cheat Sheet

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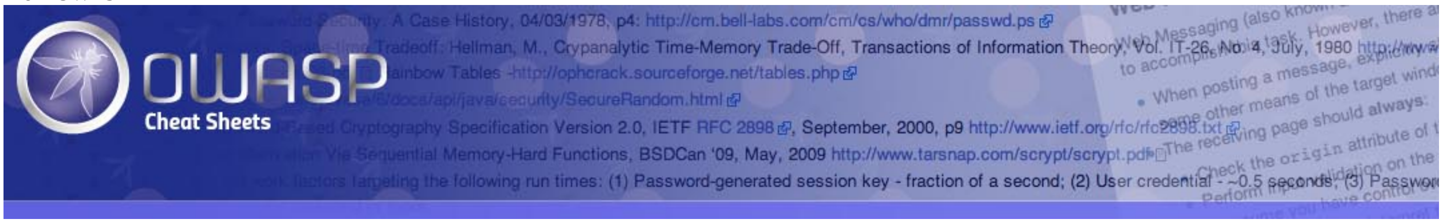

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Introduction

An *XML External Entity* attack is a type of attack against an application that parses XML input. This attack occurs when **XML input containing a reference to an ext** **weakly configured XML parser**. This attack may lead to the disclosure of confidential data, denial of service, server side request forgery, port scanning from the persp parser is located, and other system impacts. The following guide provides concise information to prevent this vulnerability. For more information on XXE, please visit Processing.

General Guidance

The safest way to prevent XXE is always to disable DTDs (External Entities) completely. Depending on the parser, the method should be similar to the following:

```
factory.setFeature("http://apache.org/xml/features/disallow-doctype-decl", true);
```

Disabling DTDs also makes the parser secure against denial of services (DOS) attacks such as Billion Laughs. If it is not possible to disable DTDs completely, then ext doctypes must be disabled in the way that's specific to each parser.

Detailed XXE Prevention guidance for a number of languages and commonly used XML parsers in those languages is provided below.

C/C++

libxml2

The Enum xmlParserOption (http://xmlsoft.org/html/libxml-parser.html#xmlParserOption) should not have the following options defined:

- XML_PARSE_NOENT: Expands entities and substitutes them with replacement text
- XML_PARSE_DTDLOAD: Load the external DTD

Note: Per: https://mail.gnome.org/archives/xml/2012-October/msg00045.html, starting with libxml2 version 2.9, XXE has been disabled by default as committed by the http://git.gnome.org/browse/libxml2/commit/?id=4629ee02ac649c27f9c0cf98ba017c6b5526070f.

libxerces-c

Use of XercesDOMParser do this to prevent XXE:

```
XercesDOMParser *parser = new XercesDOMParser;
parser->setCreateEntityReferenceNodes(false);
```

Use of SAXParser, do this to prevent XXE:

```
SAXParser* parser = new SAXParser;
parser->setDisableDefaultEntityResolution(true);
```

Use of SAX2XMLReader, do this to prevent XXE:

```
SAX2XMLReader* reader = XMLReaderFactory::createXMLReader();
parser->setFeature(XMLUni::fgXercesDisableDefaultEntityResolution, true);
```

Java

Java applications using XML libraries are particularly vulnerable to XXE because the default settings for most Java XML parsers is to have XXE enabled. To use these explicitly disable XXE in the parser you use. The following describes how to disable XXE in the most commonly used XML parsers for Java.

JAXP DocumentBuilderFactory, SAXParserFactory and DOM4J

DocumentBuilderFactory, SAXParserFactory and DOM4J XML Parsers can be configured using the same techniques to protect them against XXE. Only the Document presented here. The JAXP DocumentBuilderFactory setFeature (http://docs.oracle.com/javase/7/docs/api/javax/xml/parsers/DocumentBuilderFactory.html#setFeature(j method allows a developer to control which implementation-specific XML processor features are enabled or disabled. The features can either be set on the factory or th setFeature (http://docs.oracle.com/javase/7/docs/api/org/xml/sax/XMLReader.html#setFeature%28java.lang.String,%20boolean%29) method. Each XML processor im that govern how DTDs and external entities are processed.

For a syntax highlighted example code snippet using SAXParserFactory, look here (https://gist.github.com/asudhakar02/45e2e6fd8bcdfb4bc3b2).

```
import javax.xml.parsers.DocumentBuilderFactory;
 import javax.xml.parsers.ParserConfigurationException; // catching unsupported features
 ...

     DocumentBuilderFactory dbf = DocumentBuilderFactory.newInstance();
     String FEATURE = null;
     try {
       // This is the PRIMARY defense. If DTDs (doctypes) are disallowed, almost all XML entity attacks are prevented
       // Xerces 2 only - http://xerces.apache.org/xerces2-j/features.html#disallow-doctype-decl
       FEATURE = "http://apache.org/xml/features/disallow-doctype-decl";
       dbf.setFeature(FEATURE, true);

       // If you can't completely disable DTDs, then at least do the following:
       // Xerces 1 - http://xerces.apache.org/xerces-j/features.html#external-general-entities
       // Xerces 2 - http://xerces.apache.org/xerces2-j/features.html#external-general-entities
       // JDK7+ - http://xml.org/sax/features/external-general-entities
       FEATURE = "http://xml.org/sax/features/external-general-entities";
       dbf.setFeature(FEATURE, false);

       // Xerces 1 - http://xerces.apache.org/xerces-j/features.html#external-parameter-entities
       // Xerces 2 - http://xerces.apache.org/xerces2-j/features.html#external-parameter-entities
       // JDK7+ - http://xml.org/sax/features/external-parameter-entities
       FEATURE = "http://xml.org/sax/features/external-parameter-entities";
       dbf.setFeature(FEATURE, false);

       // Disable external DTDs as well
       FEATURE = "http://apache.org/xml/features/nonvalidating/load-external-dtd";
       dbf.setFeature(FEATURE, false);

       // and these as well, per Timothy Morgan's 2014 paper: "XML Schema, DTD, and Entity Attacks"
       dbf.setXIncludeAware(false);
       dbf.setExpandEntityReferences(false);

       // And, per Timothy Morgan: "If for some reason support for inline DOCTYPEs are a requirement, then
       // ensure the entity settings are disabled (as shown above) and beware that SSRF attacks
       // (http://cwe.mitre.org/data/definitions/918.html) and denial
       // of service attacks (such as billion laughs or decompression bombs via "jar:") are a risk."

       // remaining parser logic
       ...
       } catch (ParserConfigurationException e) {
             // This should catch a failed setFeature feature
             logger.info("ParserConfigurationException was thrown. The feature '" +
                 FEATURE + "' is probably not supported by your XML processor.");
             ...
```

```
        }
        catch (SAXException e) {
            // On Apache, this should be thrown when disallowing DOCTYPE
            logger.warning("A DOCTYPE was passed into the XML document");
            ...
        }
        catch (IOException e) {
            // XXE that points to a file that doesn't exist
            logger.error("IOException occurred, XXE may still possible: " + e.getMessage());
            ...
        }
```

Xerces 1 (http://xerces.apache.org/xerces-j/) Features (http://xerces.apache.org/xerces-j/features.html):

- Do not include external entities by setting this feature (http://xerces.apache.org/xerces-j/features.html#external-general-entities) to `false`.
- Do not include parameter entities by setting this feature (http://xerces.apache.org/xerces-j/features.html#external-parameter-entities) to `false`.
- Do not include external DTDs by setting this feature (http://xerces.apache.org/xerces-j/features.html#load-external-dtd) to `false`.

Xerces 2 (http://xerces.apache.org/xerces2-j/) Features (http://xerces.apache.org/xerces2-j/features.html):

- Disallow an inline DTD by setting this feature (http://xerces.apache.org/xerces2-j/features.html#disallow-doctype-decl) to `true`.
- Do not include external entities by setting this feature (http://xerces.apache.org/xerces2-j/features.html#external-general-entities) to `false`.
- Do not include parameter entities by setting this feature (http://xerces.apache.org/xerces2-j/features.html#external-parameter-entities) to `false`.
- Do not include external DTDs by setting this feature (http://xerces.apache.org/xerces-j/features.html#load-external-dtd) to `false`.

Note: The above defenses require Java 7 update 67, Java 8 update 20, or above, because the above countermeasures for DocumentBuilderFactory and SAXPa earlier Java versions, per: CVE-2014-6517 (http://www.cvedetails.com/cve/CVE-2014-6517/).

XMLInputFactory (a StAX parser)

StAX (http://en.wikipedia.org/wiki/StAX) parsers such as XMLInputFactory (http://docs.oracle.com/javase/7/docs/api/javax/xml/stream/XMLInputFactory.html) allow be set.

To protect a Java XMLInputFactory from XXE, do this:

```
xmlInputFactory.setProperty(XMLInputFactory.SUPPORT_DTD, false); // This disables DTDs entirely for that factory
xmlInputFactory.setProperty("javax.xml.stream.isSupportingExternalEntities", false); // disable external entities
```

TransformerFactory

To protect a Java TransformerFactory from XXE, do this:

```
TransformerFactory tf = TransformerFactory.newInstance();
tf.setAttribute(XMLConstants.ACCESS_EXTERNAL_DTD, "");
tf.setAttribute(XMLConstants.ACCESS_EXTERNAL_STYLESHEET, "");
```

Validator

To protect a Java Validator from XXE, do this:

```
SchemaFactory factory = SchemaFactory.newInstance("http://www.w3.org/2001/XMLSchema");
Schema schema = factory.newSchema();
Validator validator = schema.newValidator();
validator.setProperty(XMLConstants.ACCESS_EXTERNAL_DTD, "");
validator.setProperty(XMLConstants.ACCESS_EXTERNAL_SCHEMA, "");
```

SchemaFactory

To protect a SchemaFactory from XXE, do this:

```
SchemaFactory factory = SchemaFactory.newInstance("http://www.w3.org/2001/XMLSchema");
factory.setProperty(XMLConstants.ACCESS_EXTERNAL_DTD, "");
factory.setProperty(XMLConstants.ACCESS_EXTERNAL_SCHEMA, "");
Schema schema = factory.newSchema(Source);
```

SAXTransformerFactory

To protect a Java SAXTransformerFactory from XXE, do this:

```
SAXTransformerFactory sf = SAXTransformerFactory.newInstance();
sf.setAttribute(XMLConstants.ACCESS_EXTERNAL_DTD, "");
sf.setAttribute(XMLConstants.ACCESS_EXTERNAL_STYLESHEET, "");
sf.newXMLFilter(Source);
```

Note: Use of the following XMLConstants requires JAXP 1.5, which was added to Java in 7u40 and Java 8:

- javax.xml.XMLConstants.ACCESS_EXTERNAL_DTD
- javax.xml.XMLConstants.ACCESS_EXTERNAL_SCHEMA
- javax.xml.XMLConstants.ACCESS_EXTERNAL_STYLESHEET

XMLReader

To protect a Java XMLReader from XXE, do this:

```
XMLReader spf = XMLReaderFactory.createXMLReader();
spf.setFeature("http://xml.org/sax/features/external-general-entities", false);
spf.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
spf.setFeature("http://apache.org/xml/features/nonvalidating/load-external-dtd",false);
```

SAXReader

To protect a Java SAXReader from XXE, do this:

```
saxReader.setFeature("http://apache.org/xml/features/disallow-doctype-decl", true);
saxReader.setFeature("http://xml.org/sax/features/external-general-entities", false);
saxReader.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
```

Based on testing, if you are missing one of these, you can still be vulnerable to an XXE attack.

SAXBuilder

To protect a Java SAXBuilder from XXE, do this:

```
SAXBuilder builder = new SAXBuilder();
builder.setFeature("http://apache.org/xml/features/disallow-doctype-decl",true);
Document doc = builder.build(new File(fileName));
```

Note: When using SAXBuilder, the followings are not enough to prevent the XXE.

```
.setFeature("http://xml.org/sax/features/external-general-entities", false);
.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
```

Unmarshaller

Since an Unmarshaller parses XML and does not support any flags for disabling XXE, it's imperative to parse the untrusted XML through a configurable secure parser
result, and pass the source object to the Unmarshaller. For example:

```
SAXParserFactory spf = SAXParserFactory.newInstance();
spf.setFeature("http://xml.org/sax/features/external-general-entities", false);
spf.setFeature("http://xml.org/sax/features/external-parameter-entities", false);
spf.setFeature("http://apache.org/xml/features/nonvalidating/load-external-dtd", false);
```

```
Source xmlSource = new SAXSource(spf.newSAXParser().getXMLReader(), new InputSource(new StringReader(xml)));
JAXBContext jc = JAXBContext.newInstance(Object.class);
Unmarshaller um = jc.createUnmarshaller();
um.unmarshal(xmlSource);
```

XPathExpression

An XPathExpression is similar to an Unmarshaller where it can't be configured securely by itself, so the untrusted data must be parsed through another securable XML

```
DocumentBuilderFactory df = DocumentBuilderFactory.newInstance();
df.setAttribute(XMLConstants.ACCESS_EXTERNAL_DTD, "");
df.setAttribute(XMLConstants.ACCESS_EXTERNAL_SCHEMA, "");
DocumentBuilder builder = df.newDocumentBuilder();
xPathExpression.evaluate( builder.parse(new ByteArrayInputStream(xml.getBytes())) );
```

java.beans.XMLDecoder

The readObject() (https://docs.oracle.com/javase/8/docs/api/java/beans/XMLDecoder.html#readObject--) method in this class is fundamentally unsafe. Not only is the
but the method can be used to construct any Java object, and execute arbitrary code as described here (http://stackoverflow.com/questions/14307442/is-it-safe-to-use-x
files). And there is no way to make use of this class safe except to trust or properly validate the input being passed into it. As such, we'd strongly recommend complete
and replacing it with a safe or properly configured XML parser as described elsewhere in this cheat sheet.

Other XML Parsers

There are many 3rd party libraries that parse XML either directly or through their use of other libraries. Please test and verify their XML parser is secure against XXE
secure by default, look for flags supported by the parser to disable all possible external resource inclusions like the examples given above. If there's no control exposed
untrusted content is passed through a secure parser first and then passed to insecure 3rd party parser similar to how the Unmarshaller is secured.

Spring Framework MVC/OXM XXE Vulnerabilities

For example, some XXE vulnerabilities were found in Spring OXM (http://pivotal.io/security/cve-2013-4152) and Spring MVC (http://pivotal.io/security/cve-2013-73
Spring Framework are vulnerable to XXE:

- 3.0.0 to 3.2.3 (Spring OXM & Spring MVC)
- 4.0.0.M1 (Spring OXM)
- 4.0.0.M1-4.0.0.M2 (Spring MVC)

There were other issues as well that were fixed later, so to fully address these issues, Spring recommends you upgrade to Spring Framework 3.2.8+ or 4.0.2+.

For Spring OXM, this is referring to the use of org.springframework.oxm.jaxb.Jaxb2Marshaller. Note that the CVE for Spring OXM specifically indicates that 2 XML
developer to get right, and 2 are the responsibility of Spring and were fixed to address this CVE. Here's what they say:

```
Two situations developers must handle:
For a DOMSource, the XML has already been parsed by user code and that code is responsible for protecting against XXE.
For a StAXSource, the XMLStreamReader has already been created by user code and that code is responsible for protecting against XXE.
```

```
The issue Spring fixed:

For SAXSource and StreamSource instances, Spring processed external entities by default thereby creating this vulnerability.
Here's an example of using a StreamSource that was vulnerable, but is now safe, if you are using a fixed version of Spring OXM or Spring MVC:

 org.springframework.oxm.Jaxb2Marshaller marshaller = new org.springframework.oxm.jaxb.Jaxb2Marshaller();
 marshaller.unmarshal(new StreamSource(new StringReader(some_string_containing_XML)); // Must cast return Object to whatever type you are unmarshalling
```

So, per the Spring OXM CVE writeup (http://pivotal.io/security/cve-2013-4152), the above is now safe. But if you were to use a DOMSource or StAXSource instead, i
those sources to be safe from XXE.

.NET

The following information for XXE injection in .NET is directly from this web application of unit tests by Dean Fleming: https://github.com/deanf1/dotnet-security-uni
covers all currently supported .NET XML parsers, and has test cases for each demonstrating when they are safe from XXE injection and when they are not. Previously,
James Jardine's excellent .NET XXE article: https://www.jardinesoftware.net/2016/05/26/xxe-and-net/. It originally provided more recent and more detailed informatio
Microsoft on how to prevent XXE and XML Denial of Service in .NET: http://msdn.microsoft.com/en-us/magazine/ee335713.aspx, however, it has some inaccuracies t

The following table lists all supported .NET XML parsers and their default safety levels:

XML Parser	Safe by Default?
LINQ to XML	Yes
XmlDictionaryReader	Yes
XmlDocument	
...prior to 4.5.2	No
...in versions 4.5.2 +	Yes
XmlNodeReader	Yes
XmlReader	Yes
XmlTextReader	
...prior to 4.5.2	No
...in versions 4.5.2 +	Yes
XPathNavigator	
...prior to 4.5.2	No
...in versions 4.5.2 +	Yes
XslCompiledTransform	Yes

LINQ to XML

Both the XElement and XDocument objects in the System.Xml.Linq library are safe from XXE injection by default. XElement parses only the elements within the XM
altogether. XDocument has DTDs disabled by default (https://github.com/dotnet/docs/blob/master/docs/visual-basic/programming-guide/concepts/linq/linq-to-xml-secu
constructed with a different unsafe XML parser.

XmlDictionaryReader

System.Xml.XmlDictionaryReader is safe by default, as when it attempts to parse the DTD, the compiler throws an exception saying that "CData elements not valid at t
It becomes unsafe if constructed with a different unsafe XML parser.

XmlDocument

Prior to .NET Framework version 4.5.2, System.Xml.XmlDocument is **unsafe** by default. The XmlDocument object has an XmlResolver object within it that needs to b
4.5.2. In versions 4.5.2 and up, this XmlResolver is set to null by default. The following example shows how it is made safe:

```
static void LoadXML()
{
  string xml = "<?xml version=\"1.0\" ?><!DOCTYPE doc
        [<!ENTITY win SYSTEM \"file:///C:/Users/user/Documents/testdata2.txt\">]
        ><doc>&win;</doc>";

  XmlDocument xmlDoc = new XmlDocument();
  xmlDoc.XmlResolver = null;   // Setting this to NULL disables DTDs - Its NOT null by default.
  xmlDoc.LoadXml(xml);
  Console.WriteLine(xmlDoc.InnerText);
  Console.ReadLine();
}
```

XmlDocument can become unsafe if you create your own nonnull XmlResolver with default or unsafe settings. If you need to enable DTD processing, instructions on h
in detail in the referenced MSDN article (http://msdn.microsoft.com/en-us/magazine/ee335713.aspx).

XmlNodeReader

System.Xml.XmlNodeReader objects are safe by default and will ignore DTDs even when constructed with an unsafe parser or wrapped in another unsafe parser.

XmlReader

System.Xml.XmlReader objects are safe by default. They are set by default to have their ProhibitDtd property set to false in .NET Framework versions 4.0 and earlier,
set to Prohibit in .NET versions 4.0 and later. Additionally, in .NET versions 4.5.2 and later, the XmlReaderSettings belonging to the XmlReader has its XmlResolver s
provides an additional layer of safety. Therefore, XmlReader objects will only become unsafe in version 4.5.2 and up if both the DtdProcessing property is set to Parse
XmlResolver is set to a nonnull XmlResolver with default or unsafe settings. If you need to enable DTD processing, instructions on how to do so safely are described i
article (http://msdn.microsoft.com/en-us/magazine/ee335713.aspx).

XmlTextReader

System.Xml.XmlTextReader is **unsafe** by default in .NET Framework versions prior to 4.5.2. Here is how to make it safe in various .NET versions:

Prior to .NET 4.0

In .NET Framework versions prior to 4.0, DTD parsing behavior for XmlReader objects like XmlTextReader are controlled by the Boolean ProhibitDtd property found System.Xml.XmlReaderSettings and System.Xml.XmlTextReader classes. Set these values to true to disable inline DTDs completely.

```
XmlTextReader reader = new XmlTextReader(stream);
reader.ProhibitDtd = true;  // NEEDED because the default is FALSE!!
```

.NET 4.0 - .NET 4.5.2

In .NET Framework version 4.0, DTD parsing behavior has been changed. The ProhibitDtd property has been deprecated in favor of the new DtdProcessing property. H default settings so XmlTextReader is still vulnerable to XXE by default. Setting DtdProcessing to Prohibit causes the runtime to throw an exception if a <!DOCTYPE> To set this value yourself, it looks like this:

```
XmlTextReader reader = new XmlTextReader(stream);
reader.DtdProcessing = DtdProcessing.Prohibit;  // NEEDED because the default is Parse!!
```

Alternatively, you can set the DtdProcessing property to Ignore, which will not throw an exception on encountering a <!DOCTYPE> element but will simply skip over can set DtdProcessing to Parse if you do want to allow and process inline DTDs.

.NET 4.5.2 and later

In .NET Framework versions 4.5.2 and up, XmlTextReader's internal XmlResolver is set to null by default, making the XmlTextReader ignore DTDs by default. The X if if you create your own nonnull XmlResolver with default or unsafe settings.

XPathNavigator

System.Xml.XPath.XPathNavigator is **unsafe** by default in .NET Framework versions prior to 4.5.2. This is due to the fact that it implements IXPathNavigable objects also unsafe by default in versions prior to 4.5.2. You can make XPathNavigator safe by giving it a safe parser like XmlReader (which is safe by default) in the XPathDo example:

```
XmlReader reader = XmlReader.Create("example.xml");
XPathDocument doc = new XPathDocument(reader);
XPathNavigator nav = doc.CreateNavigator();
string xml = nav.InnerXml.ToString();
```

XslCompiledTransform

System.Xml.Xsl.XslCompiledTransform (an XML transformer) is safe by default as long as the parser it’s given is safe. It is safe by default because the default parser o XmlReader, which is safe by default (per above). The source code for this method is here. (http://www.dotnetframework.org/default.aspx/4@0/4@0/DEVDIV_TFS/Dev10/Releases/RTMRel/ndp/fx/src/Xml/System/Xml/Xslt/XslCompiledTransform@cs/1305 Some of the Transform() methods accept an XmlReader or IXPathNavigable (e.g., XmlDocument) as an input, and if you pass in an unsafe XML Parser then the Transf

iOS

libxml2

iOS includes the C/C++ libxml2 library described above, so that guidance applies if you are using libxml2 directly. However, the version of libxml2 provided up throug libxml2 (which protects against XXE by default).

NSXMLDocument

iOS also provides an NSXMLDocument type, which is built on top of libxml2. However, NSXMLDocument provides some additional protections against XXE that are Per the 'NSXMLDocument External Entity Restriction API' section of: http://developer.apple.com/library/ios/#releasenotes/Foundation/RN-Foundation-iOS/Foundation

- iOS4 and earlier: All external entities are loaded by default.
- iOS5 and later: Only entities that don't require network access are loaded. (which is safer)

However, to completely disable XXE in an NSXMLDocument in any version of iOS you simply specify NSXMLNodeLoadExternalEntitiesNever when creating the N

PHP

Per the PHP documentation (http://php.net/manual/en/function.libxml-disable-entity-loader.php), the following should be set when using the default PHP XML parser i

libxml_disable_entity_loader(true);

A description of how to abuse this in PHP is presented in a good SensePost article (https://www.sensepost.com/blog/2014/revisting-xxe-and-abusing-protocols/) describ vulnerability that was fixed in Facebook.

References

- Timothy Morgan's 2014 paper: "XML Schema, DTD, and Entity Attacks" (https://vsecurity.com//download/papers/XMLDTDEntityAttacks.pdf)
- FindSecBugs XXE Detection (https://find-sec-bugs.github.io/bugs.htm#XXE_SAXPARSER)
- XXEbugFind Tool (https://github.com/ssexxe/XXEBugFind)
- Testing for XML Injection (OTG-INPVAL-008)

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Other Cheatsheets

V · T · E (https://www.owasp.org/index.php?title=XML_External_Entity_(XXE)_Prevention_Cheat_Sheet&action=edit)	**Cheat Sheets**
Developer / Builder	3rd Party Javascript Management · Access Control · AJAX Security Cheat Sheet · Authentication (ES) · Bean Validation Cheat Sheet · Choosing and Using Security Questions · C-Based Toolchain Hardening · Credential Stuffing Prevention Cheat Sheet · Cross-Site Request Forgery (CSRF) Prevention · Cryptographic Storage · Deserialization · DOM base HTML5 Security · HTTP Strict Transport Security · Injection Prevention Cheat Sheet · Injection Prevention Cheat Sheet in Java · JSON Web Token (JWT) Cheat Sheet for Java · Ir LDAP Injection Prevention · Logging · Mass Assignment Cheat Sheet · .NET Security · OWASP Top Ten · Password Storage · Pinning · Query Parameterization · Ruby on I SAML Security · SQL Injection Prevention · Transaction Authorization · Transport Layer Protection · Unvalidated Redirects and Forwards · User Privacy Protection · Web Servi XSS (Cross Site Scripting) Prevention · **XML External Entity (XXE) Prevention Cheat Sheet**
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