Session, Cookie, and Web Security

Building Modern Web Applications - CPEN322

Karthik Pattabiraman
Kumseok Jung


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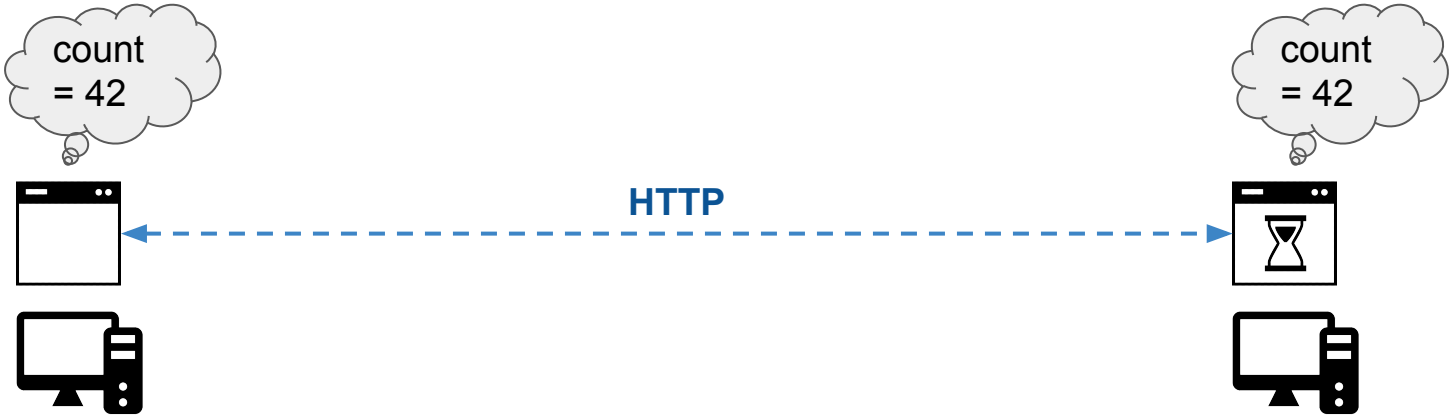
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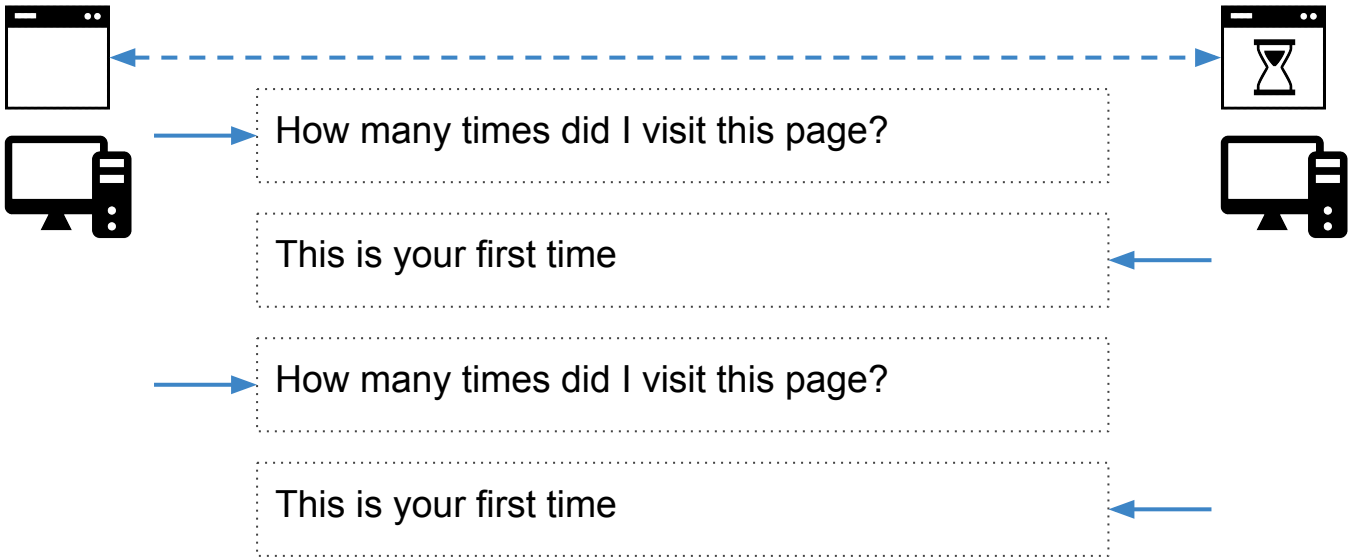
Session

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?

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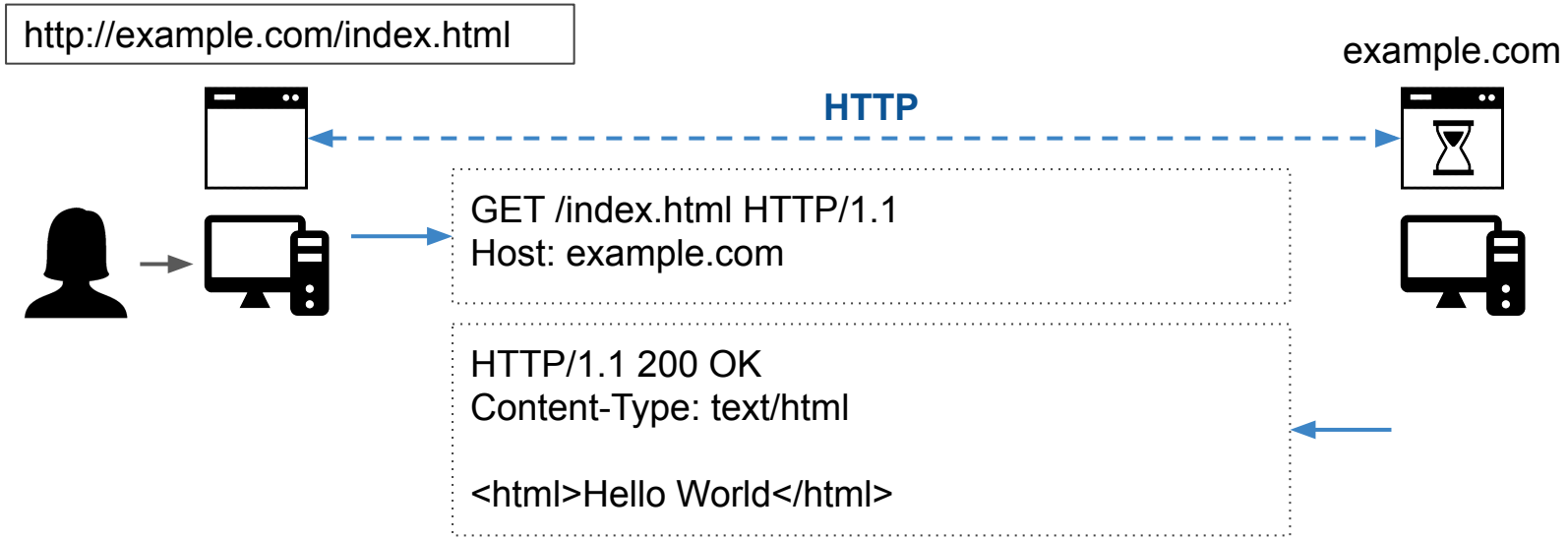

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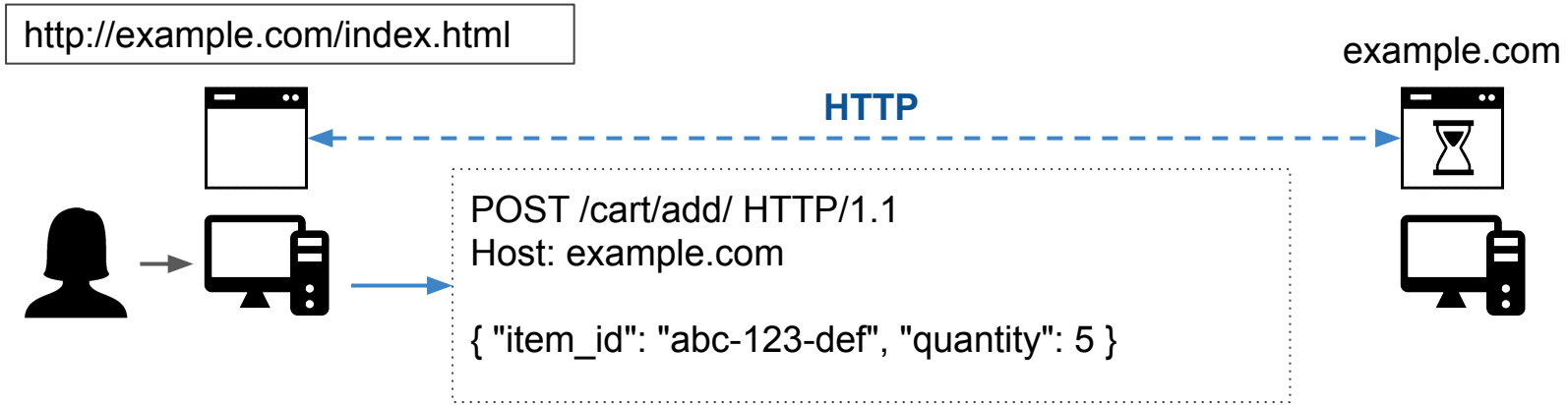

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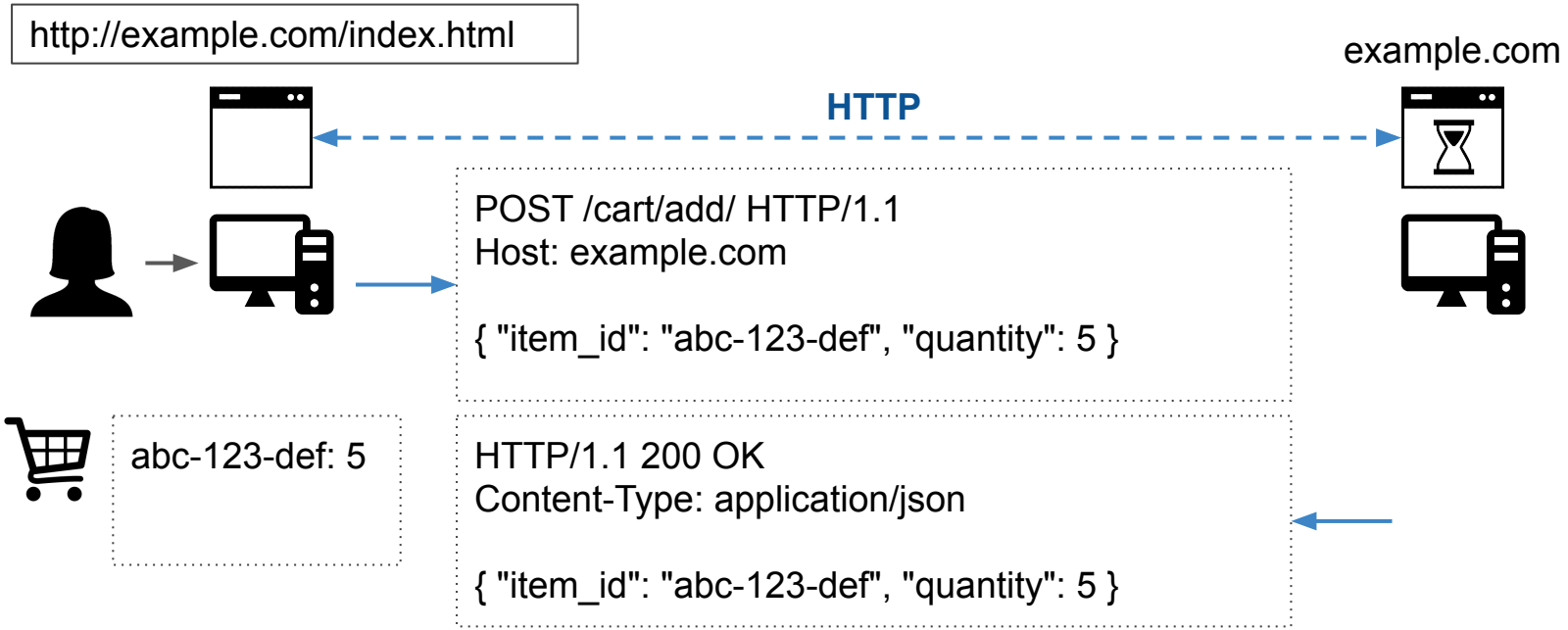

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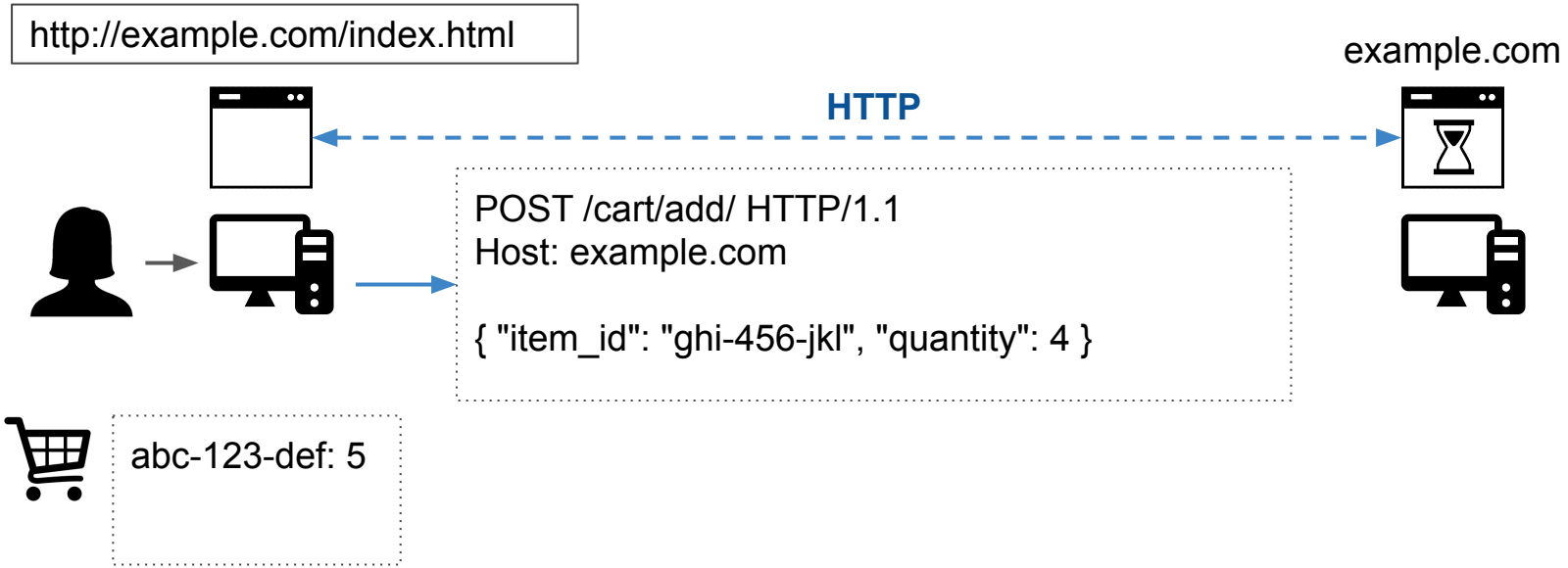

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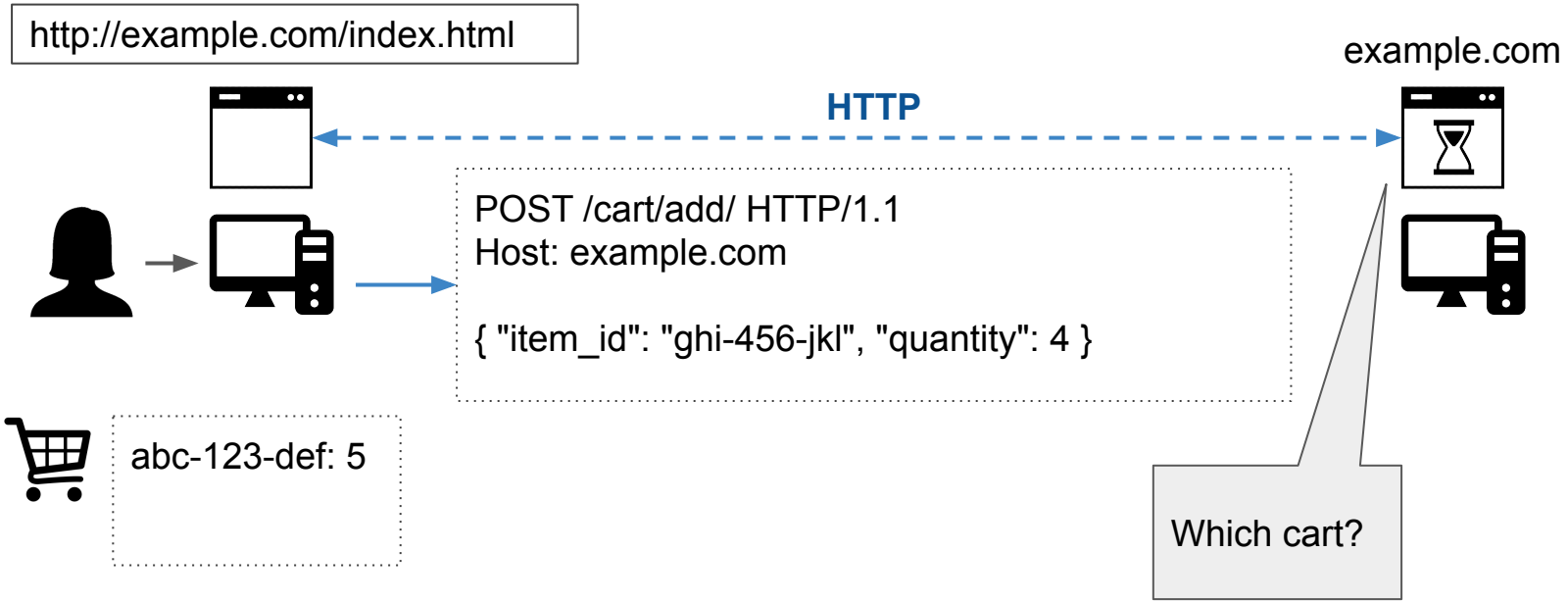

Session: Why is it relevant to Web Applications?

- 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?

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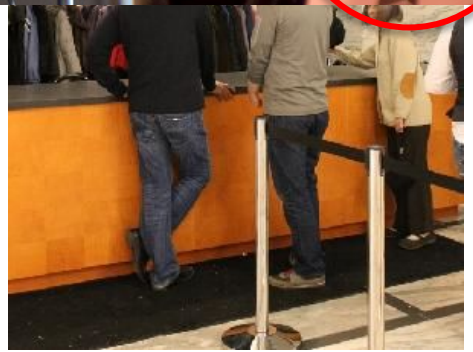

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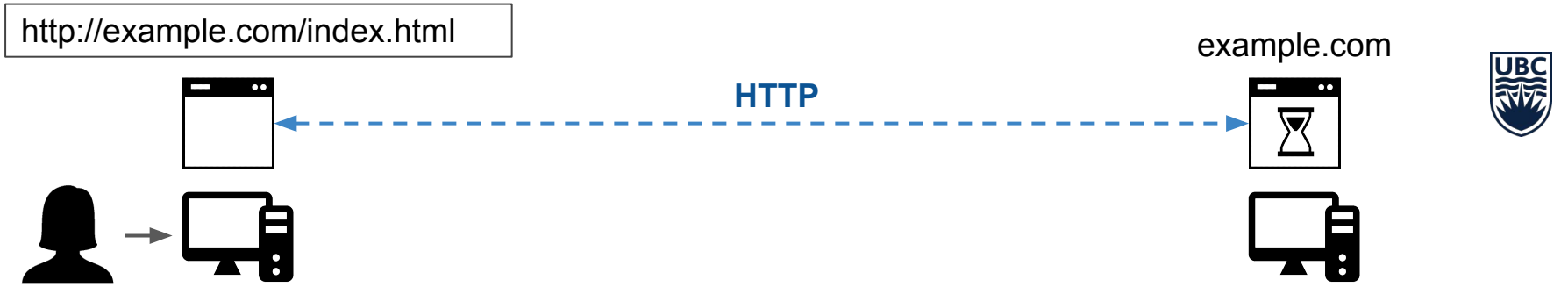

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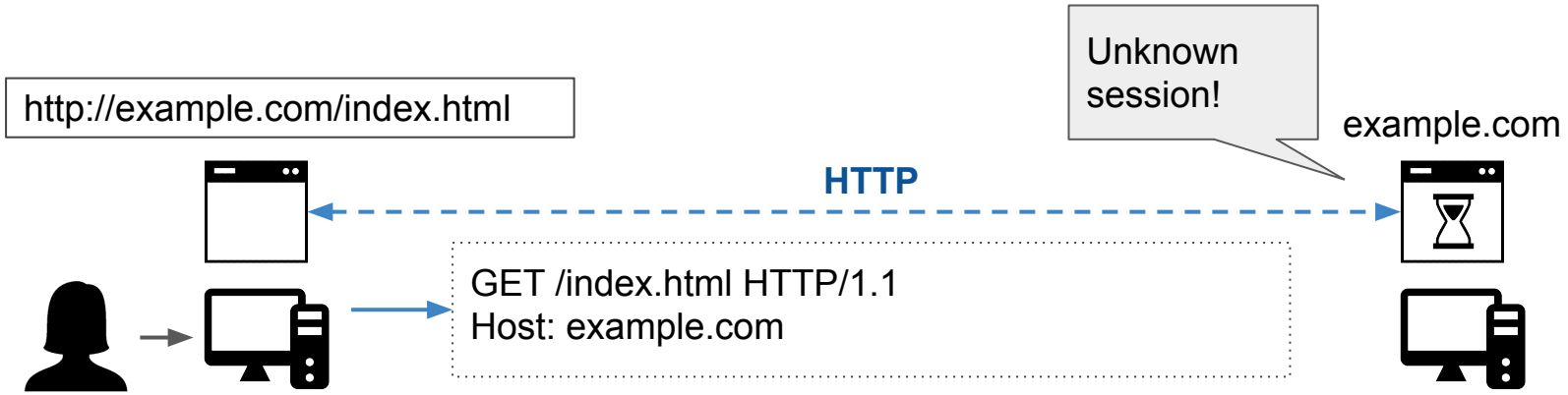

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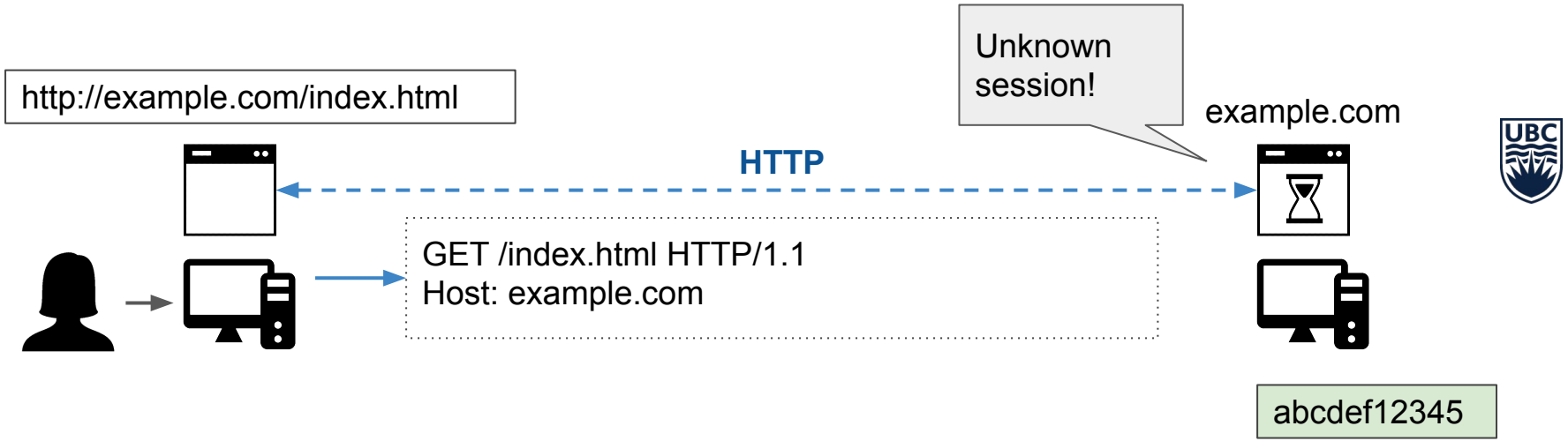

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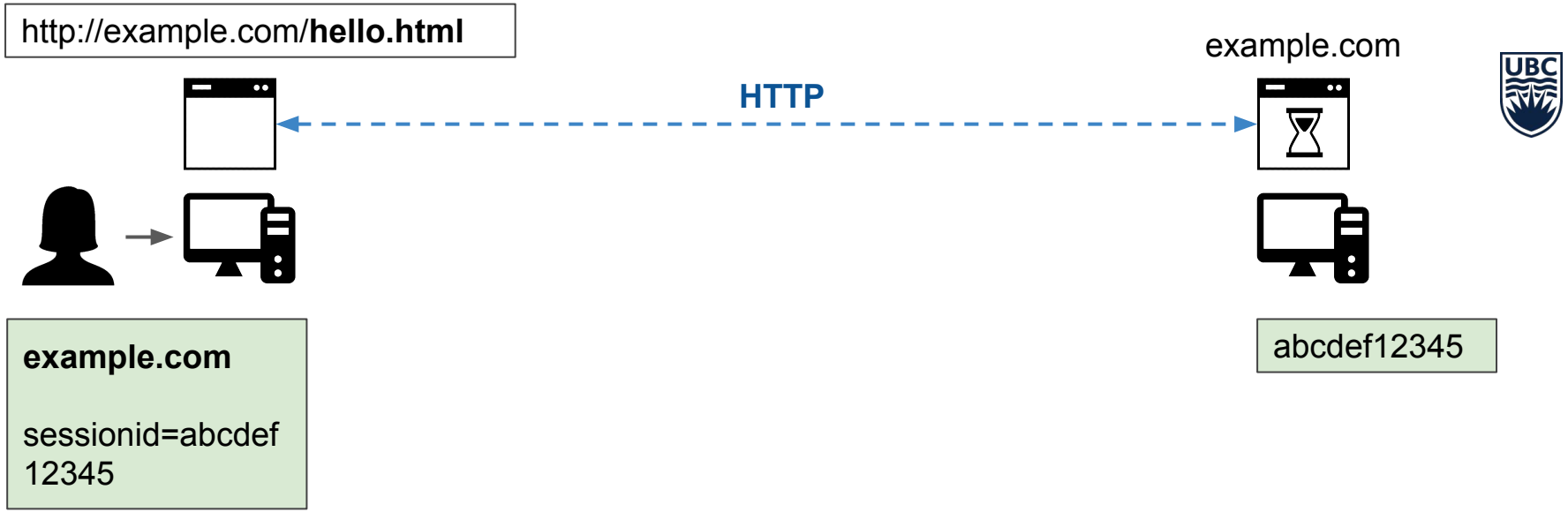

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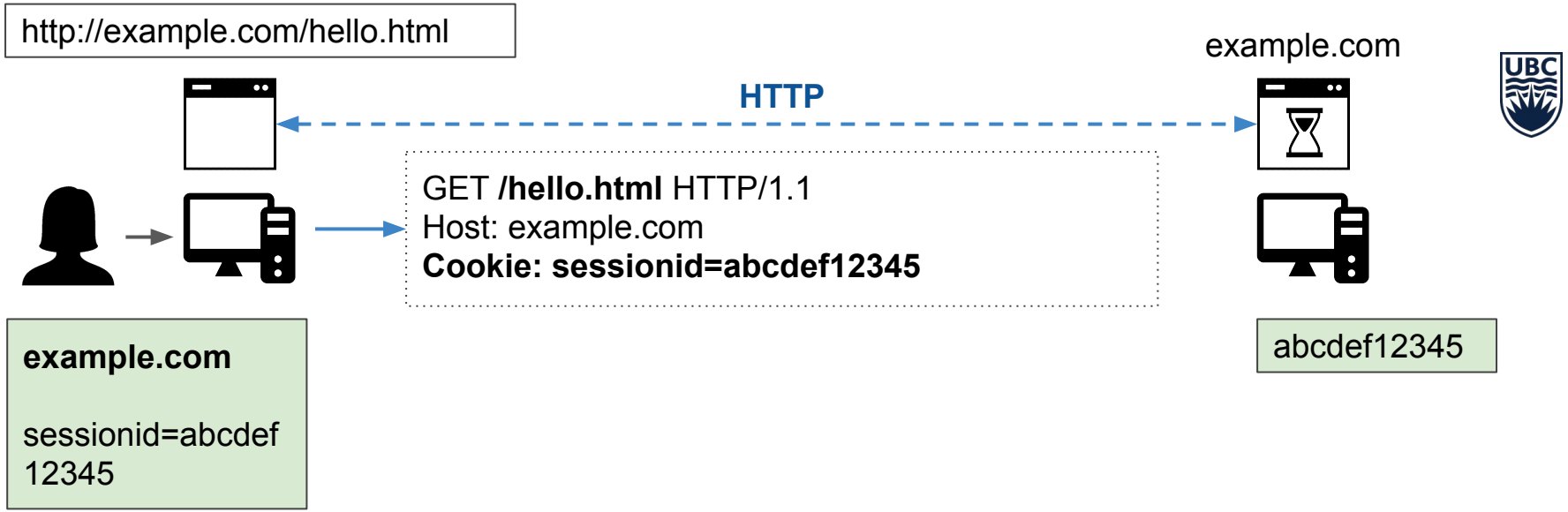

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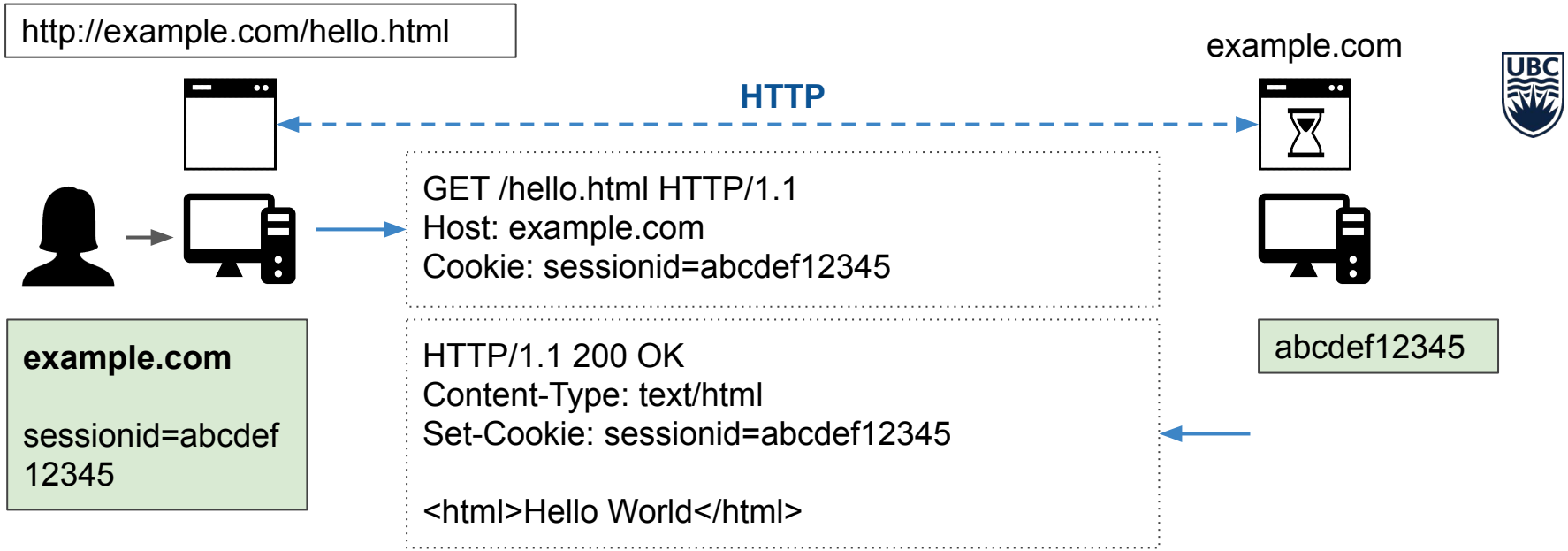


Cookie: Format

- 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 CPEN322. Using the session cookie, you want to impersonate Vicky and then transfer her money to your account.

Bank of CPEN322 Bank App is at: http://99.79.38.47:5000

Your username: `Your Github Username`

Your password: `Your Student Number`

Vicky's session cookie: `db7068de02ff8861c1a1432b651ef0c2`

Web Security

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

Web Security

- Same-Origin Policy
- Cross-site Scripting (XSS)
  - Cookie Stealing and Session Hijacking
- Cross-site Request Forgery (XRF or CSRF)

Web Security: Same-Origin Policy

- Same-Origin Policy says only scripts loaded from the same origin can be executed in the page
  - Enforced by all browsers
- Intent: Two different web domains should not be able to tamper with each other's contents
- Easy to state, but many exceptions in practice
  - Visual display is shared
  - Timing and DOM events are shared
  - Cookies can be shared
  - Send/receive messages for Cross-Origin Requests

Web Security: Same-Origin Policy

- Assign an origin for each resource in a web page (e.g., cookies, DOM sub-tree, network)
  - A script can only access elements belonging to the same origin as itself
- Definition of an origin (URI scheme, Hostname, port)
  - URI Scheme: Protocol (typically http or https)
  - Hostname: domain name (e.g., **example.com**:8000)
  - Port: example.com:8000 (if unspecified, defaults to 80 for http and 443 for https))

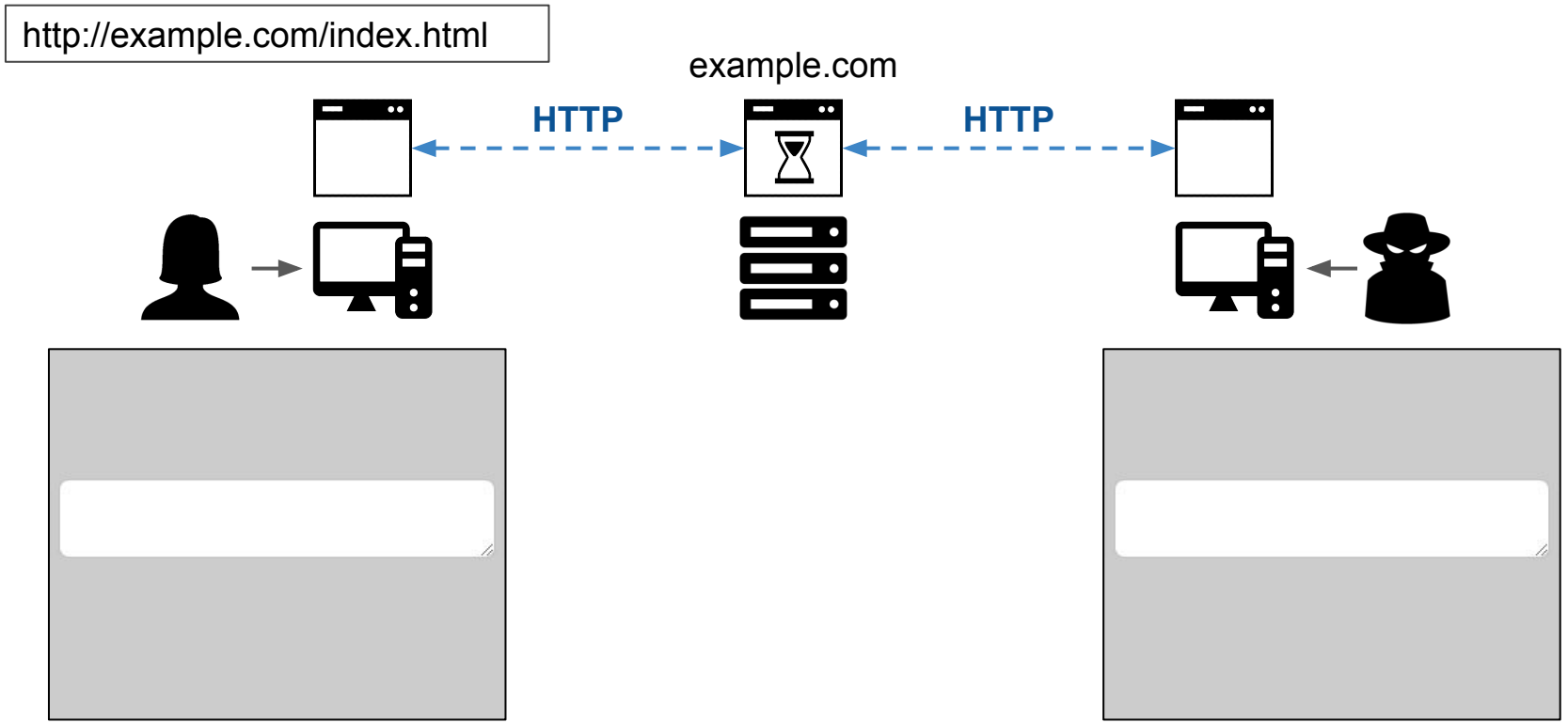
Web Security: Same-Origin Policy

- Each frame gets the origin of its URL
- Scripts executed by a frame execute with the authority of the HTML file's origin
  - True for both inline scripts and those pulled from external domains
- Passive content (e.g., CSS, Images) can't run code and is hence given zero authority

Web Security: Same-Origin Policy

- A Frame is a self-contained entity in a webpage which has scripts and content
- A frame's origin is set to the domain it comes from, but if and only if it explicitly sets the property domain="xyz.com"
- Subframes can set their "domain=" property to only their parent domain(s) or themselves
    - Example: "ece.ubc.ca" can set its domain property to "ubc.ca", but not "utoronto.ca" (for example)

Web Security: Cross-site Scripting



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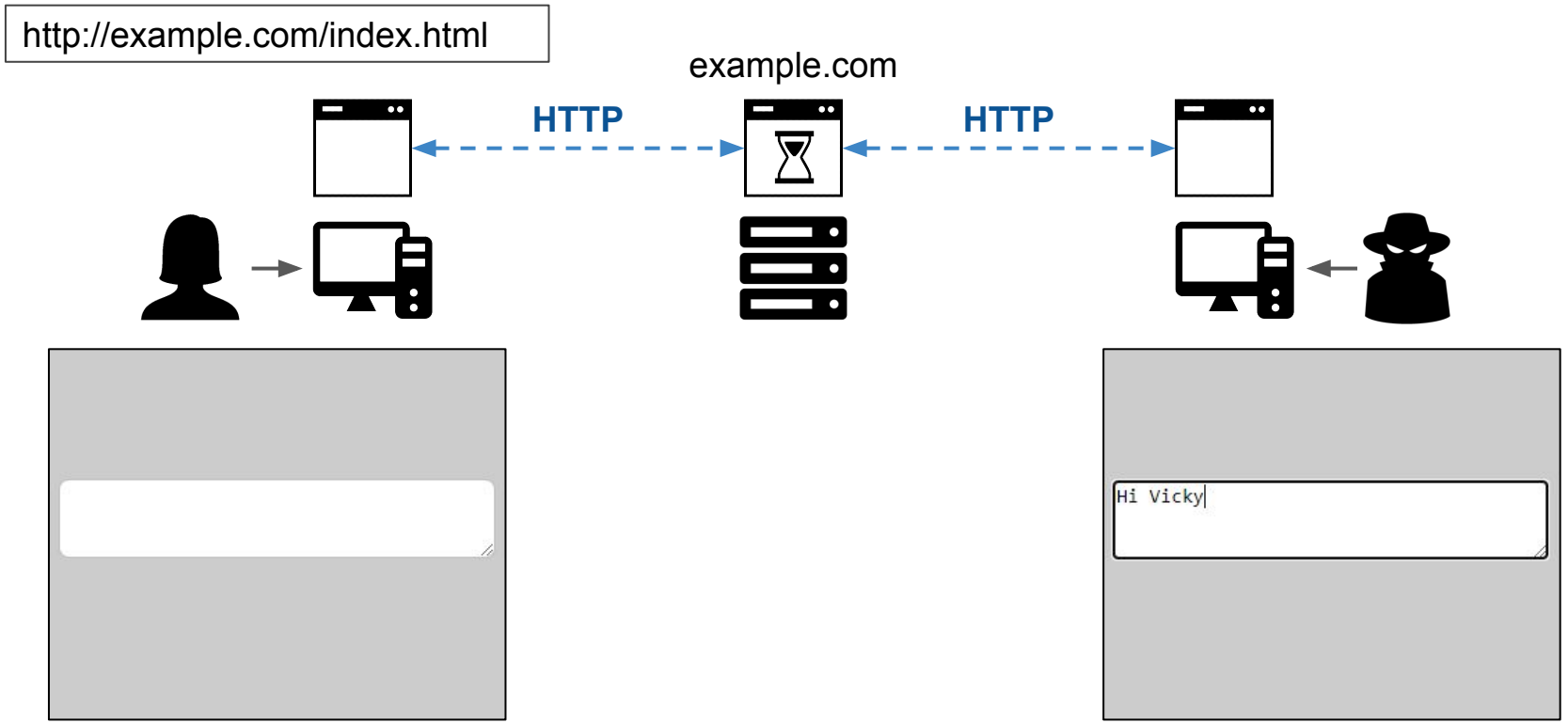

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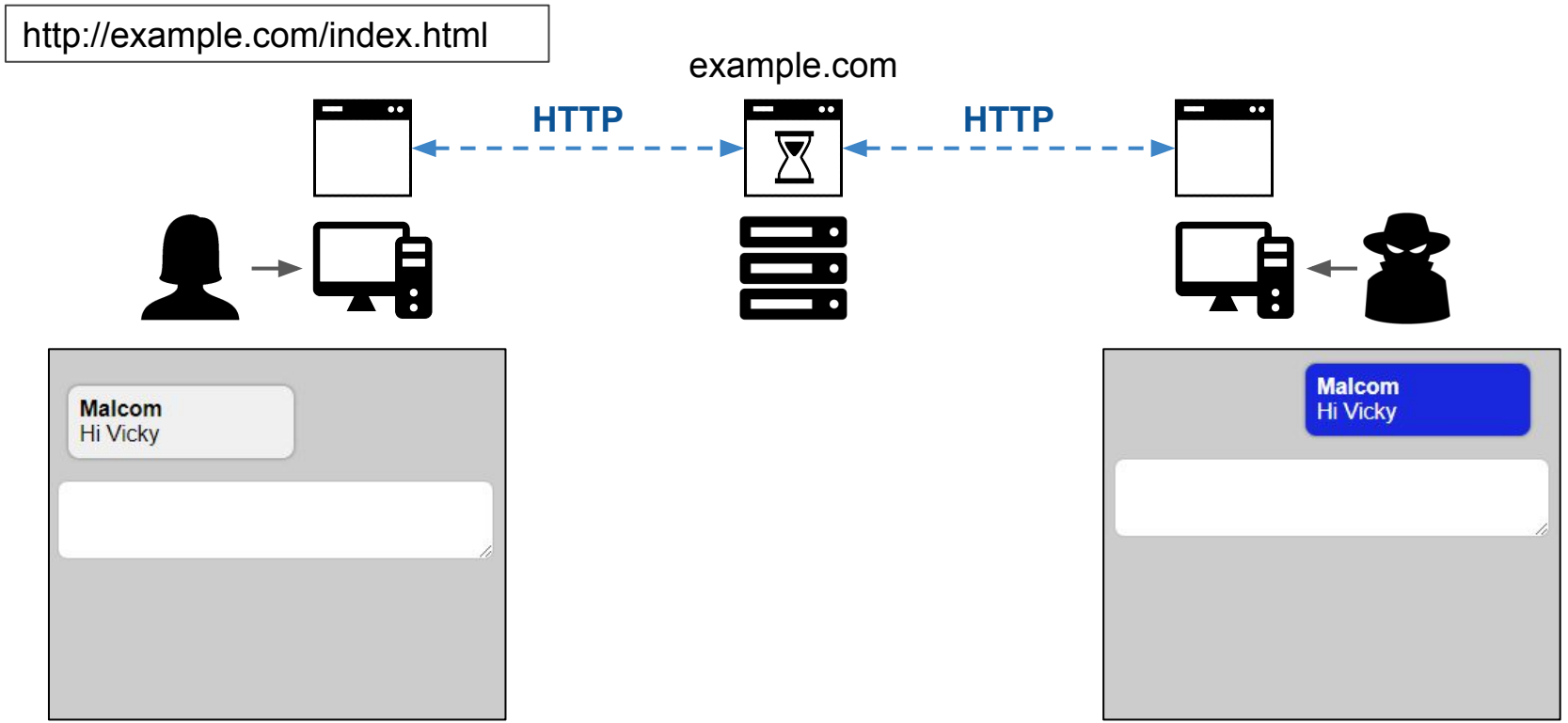
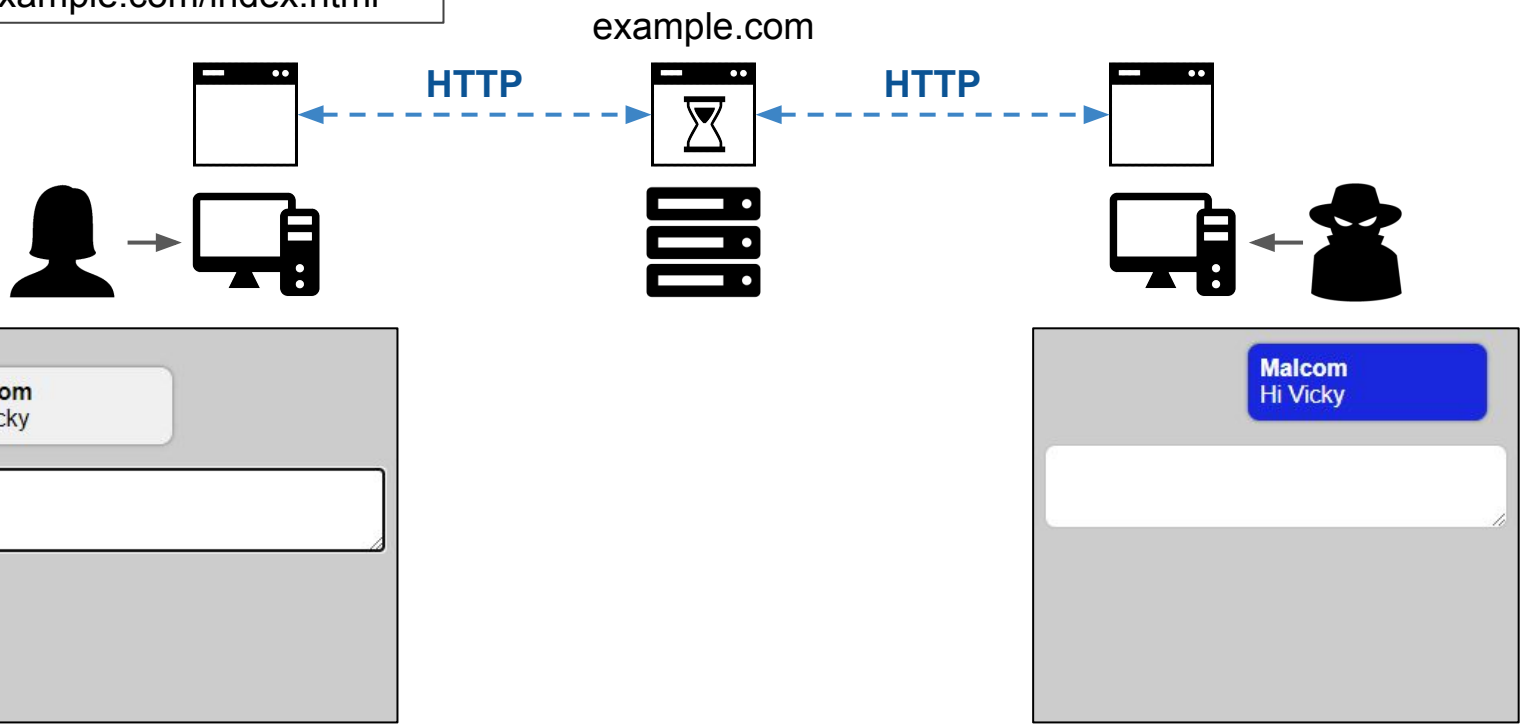


Web Security: Cross-site Scripting

http://example.com/index.html



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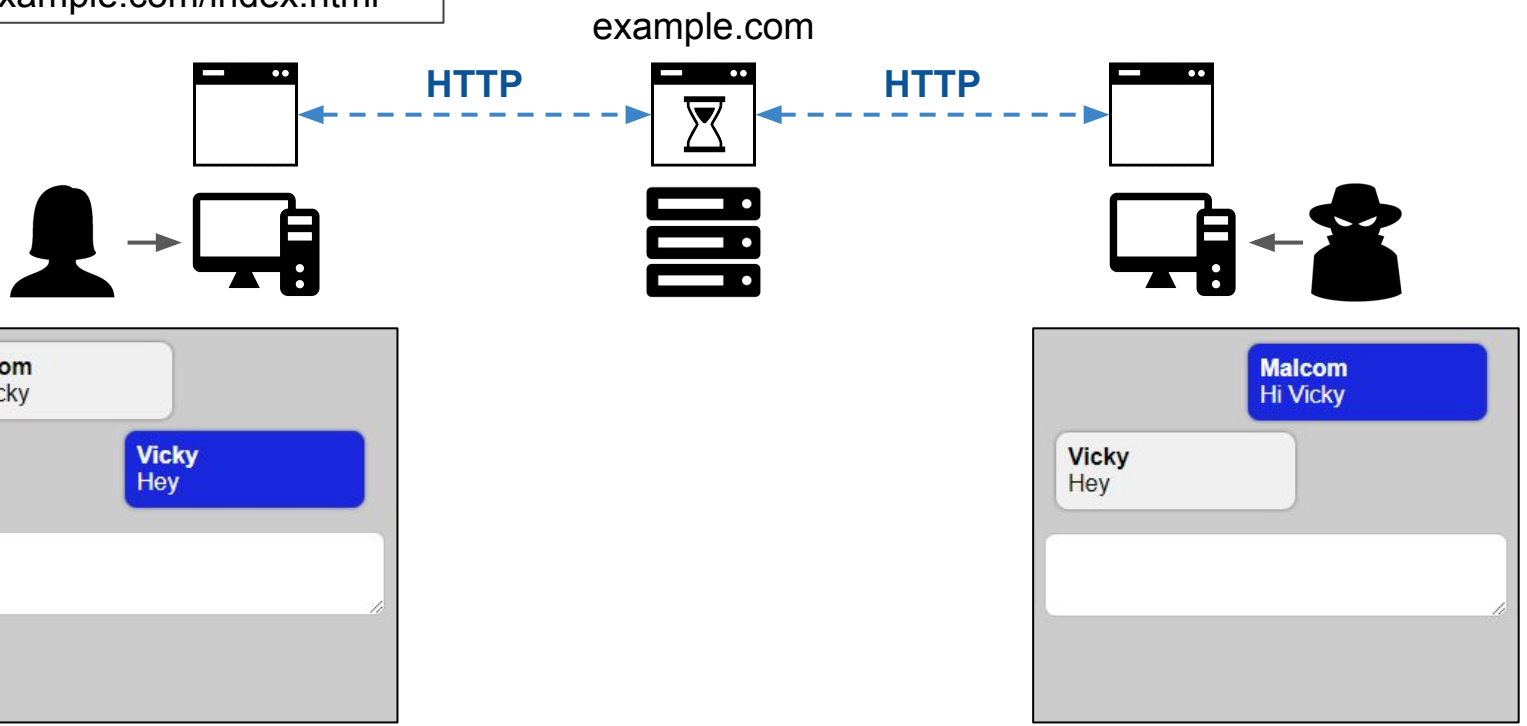

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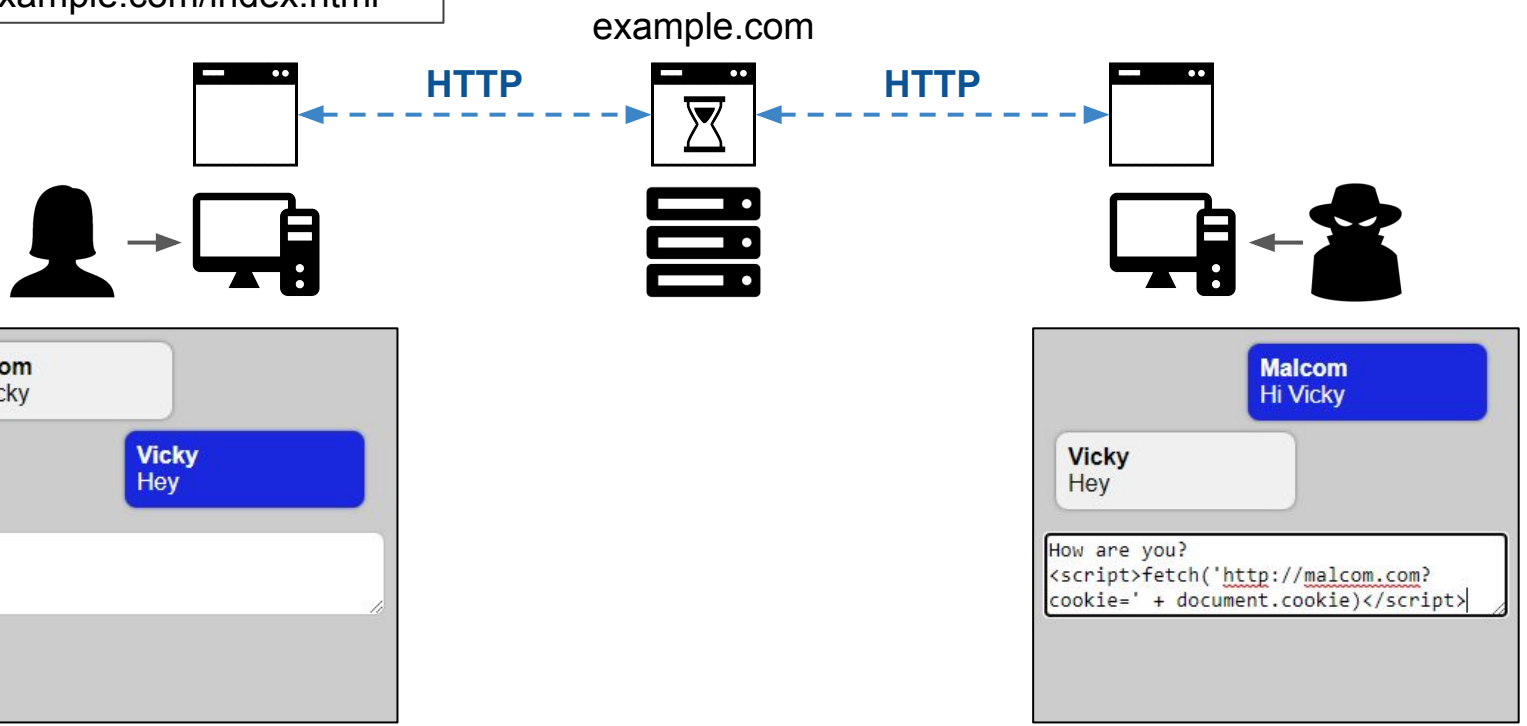

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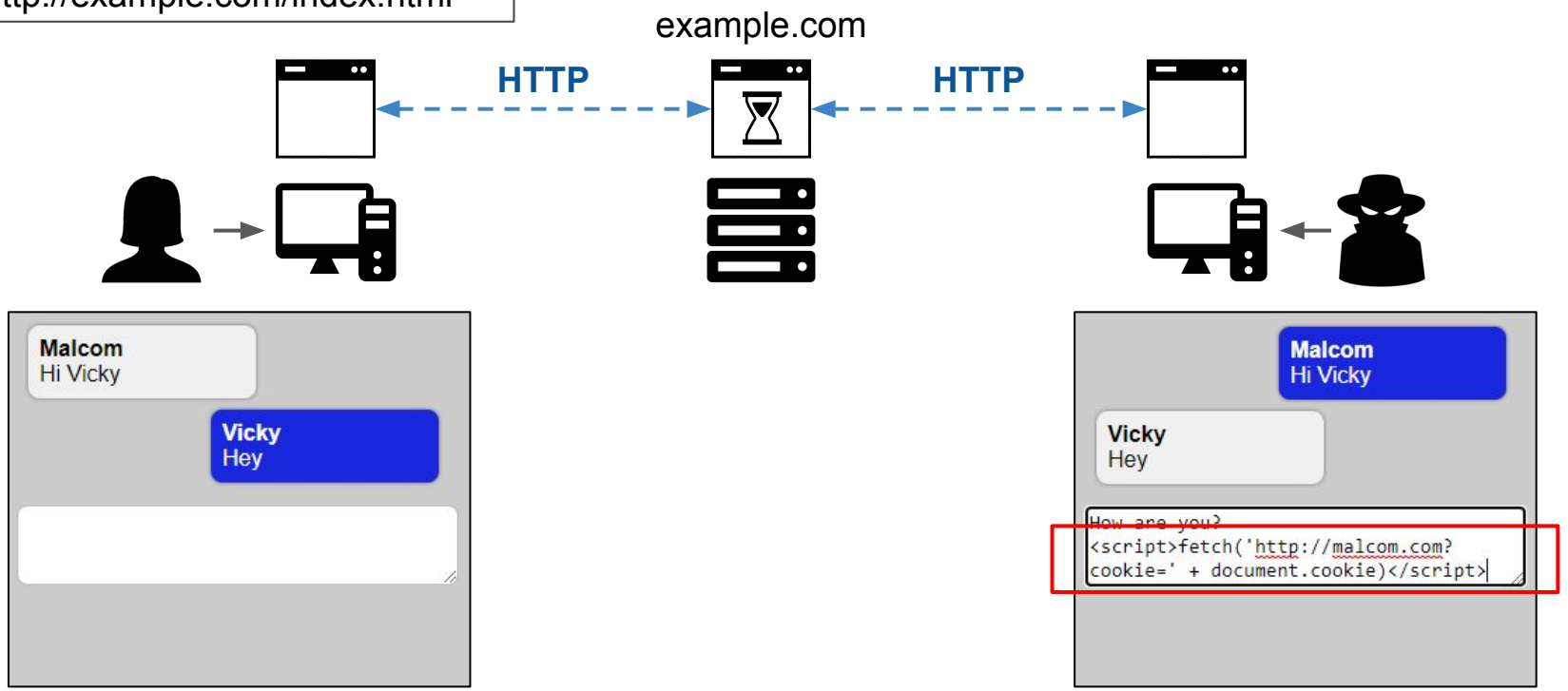

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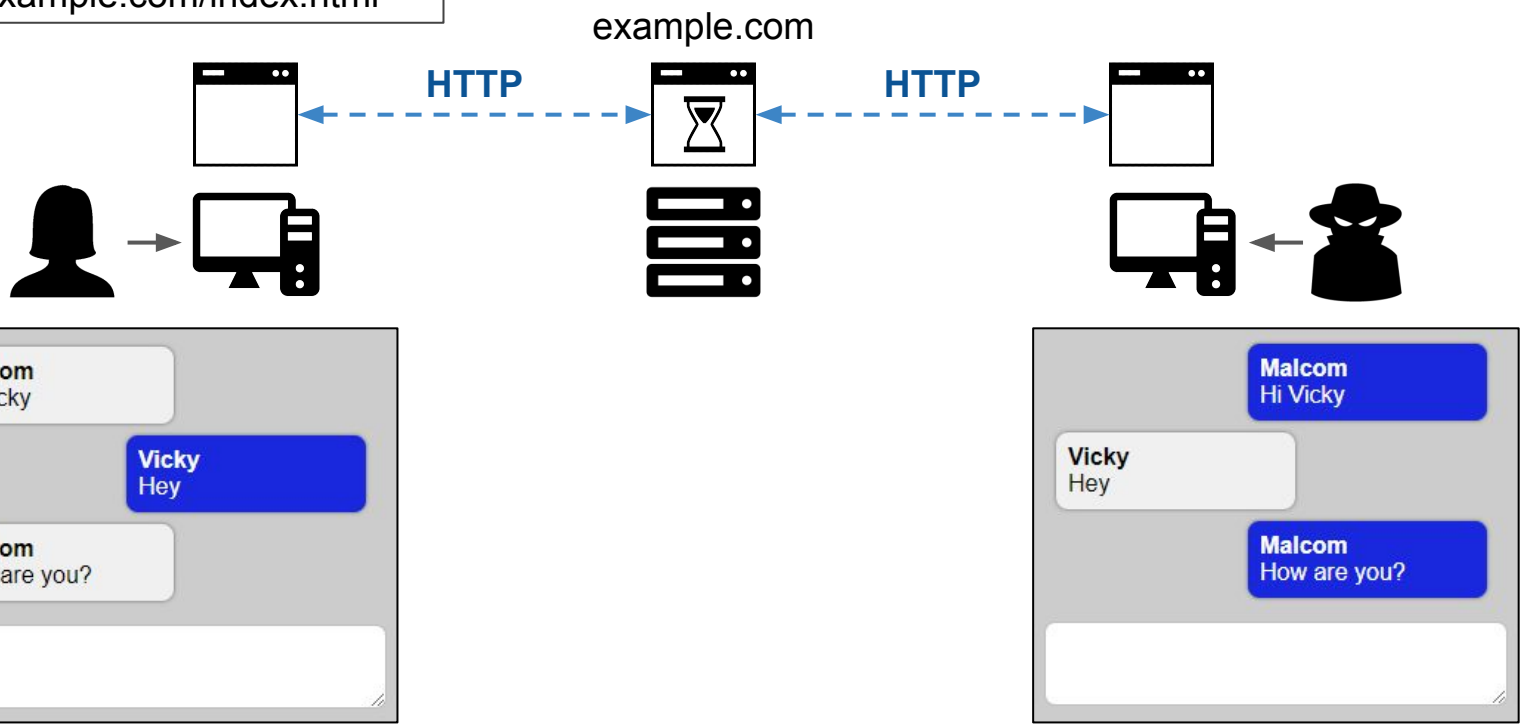

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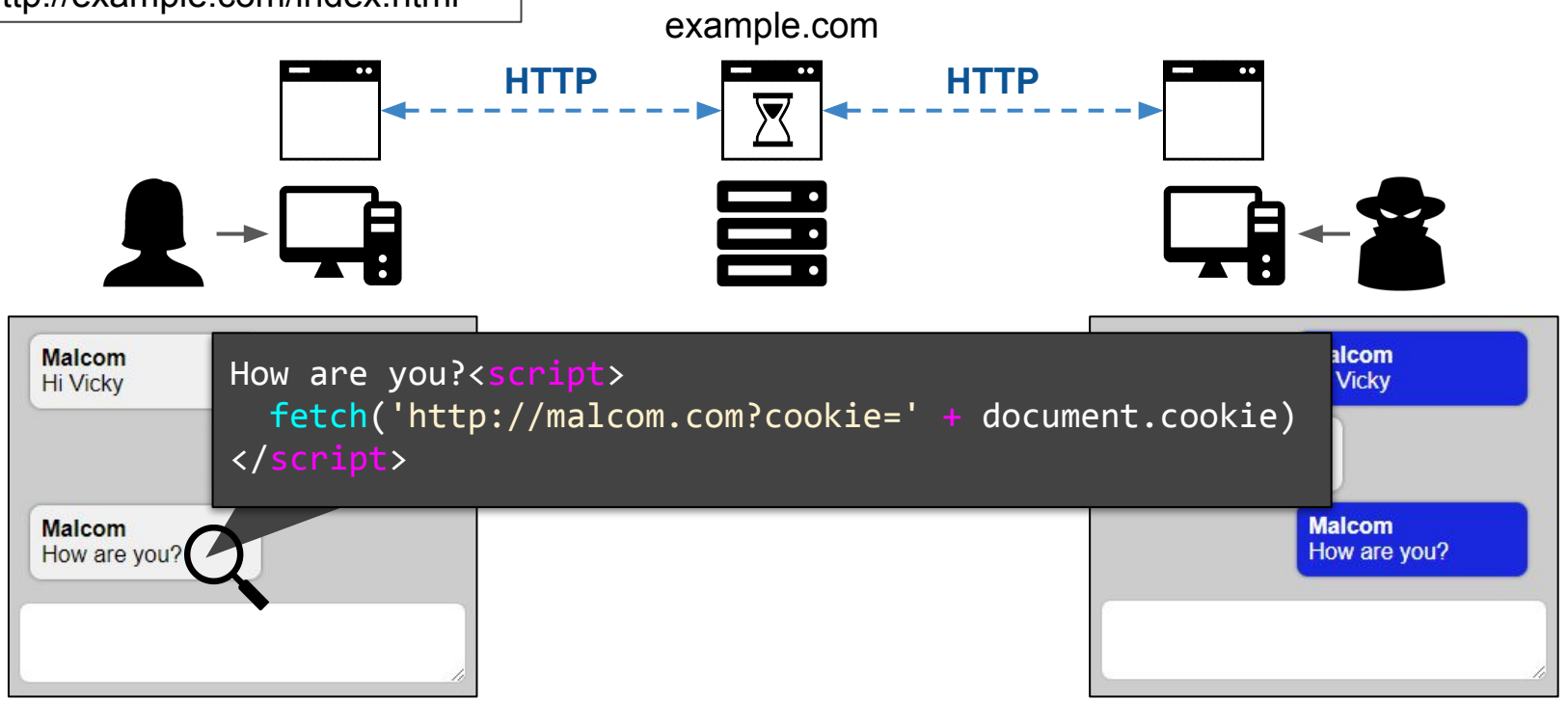

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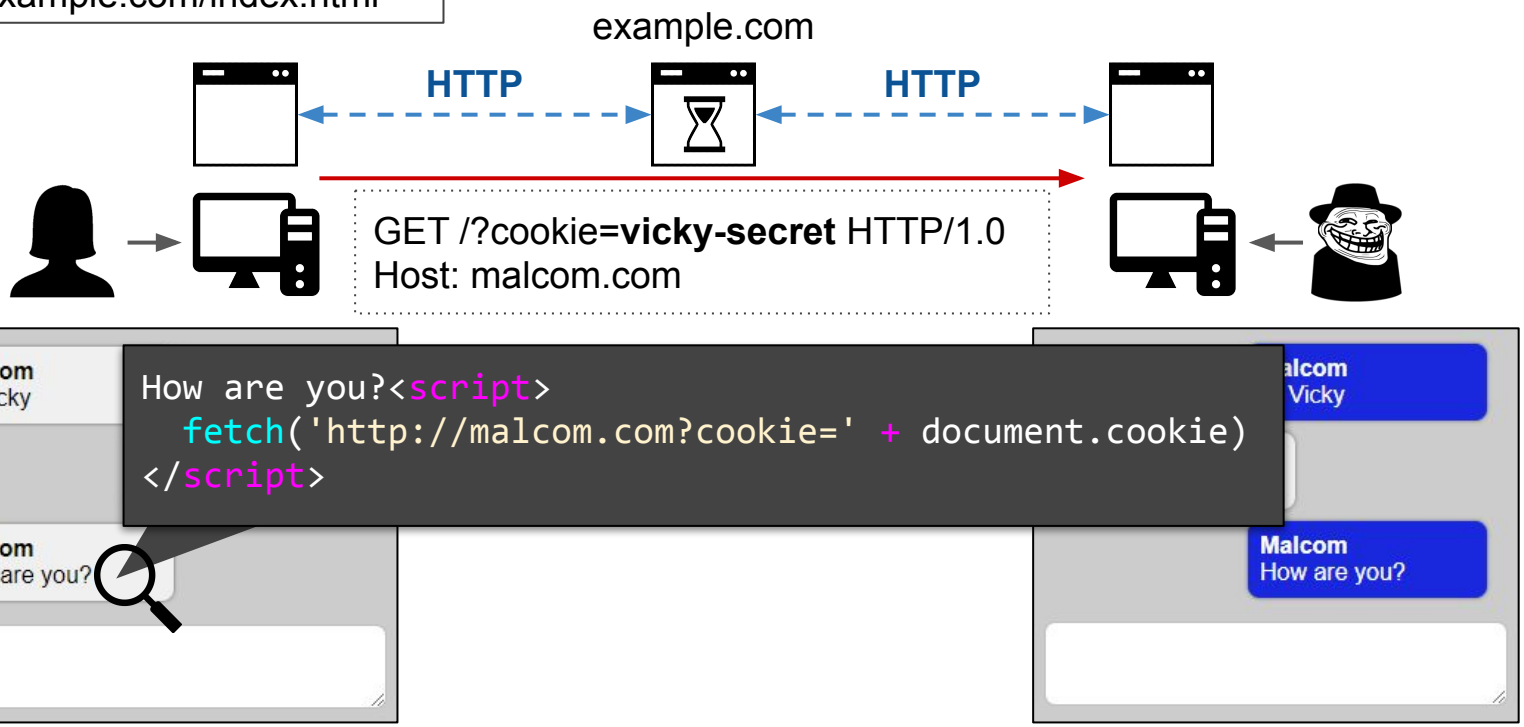


Web Security: Cross-site Scripting

- 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.

CPEN322 Online Store is at: http://99.79.38.47:3000

Your personal storage is at: http://99.79.38.47:8000/USERNAME

To push data to your storage, use:

http://99.79.38.47:8000/USERNAME/push?text=DATA

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

http://99.79.38.47:8000/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.

CPEN322 Instant Messenger App is at: http://99.79.38.47:4000

Your personal storage is at: http://99.79.38.47:8000/USERNAME

To push data to your storage, use:

http://99.79.38.47:8000/USERNAME/push?text=DATA

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

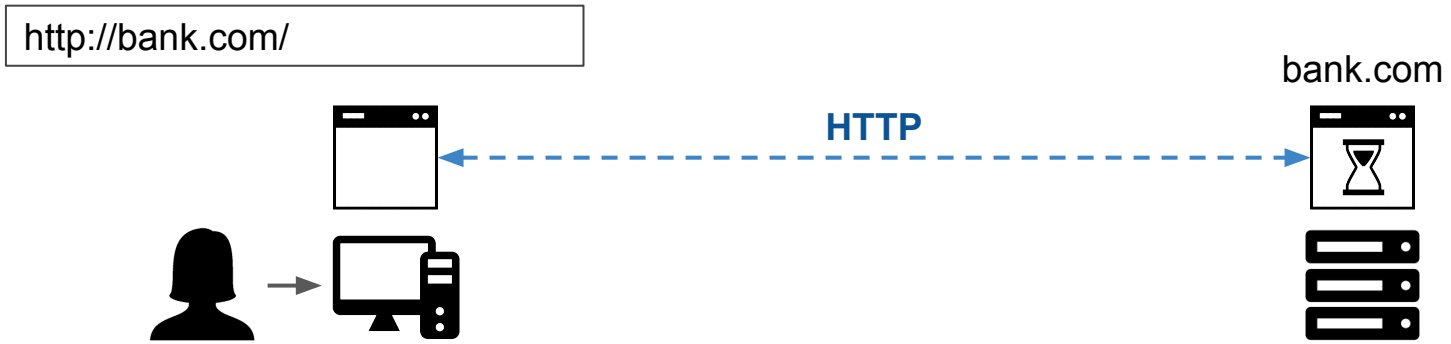
http://99.79.38.47:8000/USERNAME?access=StudentNumber

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



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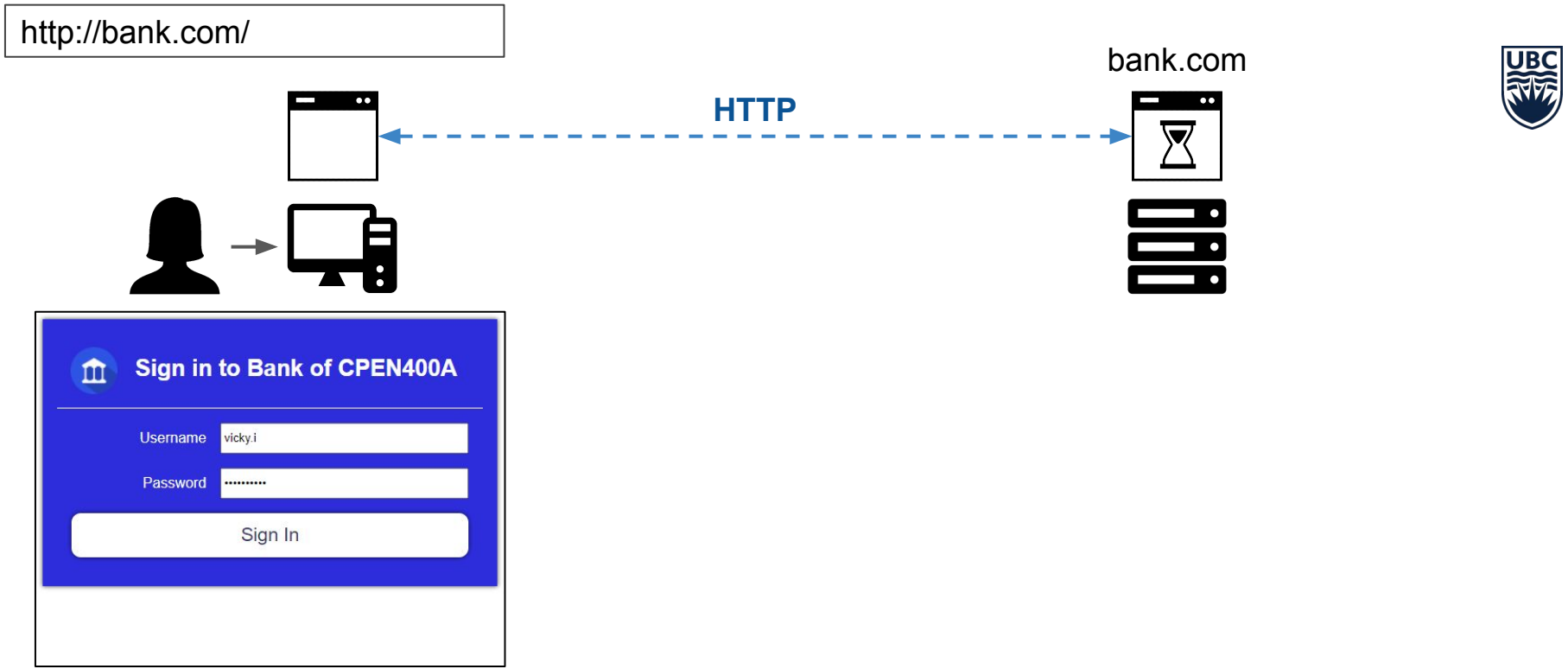

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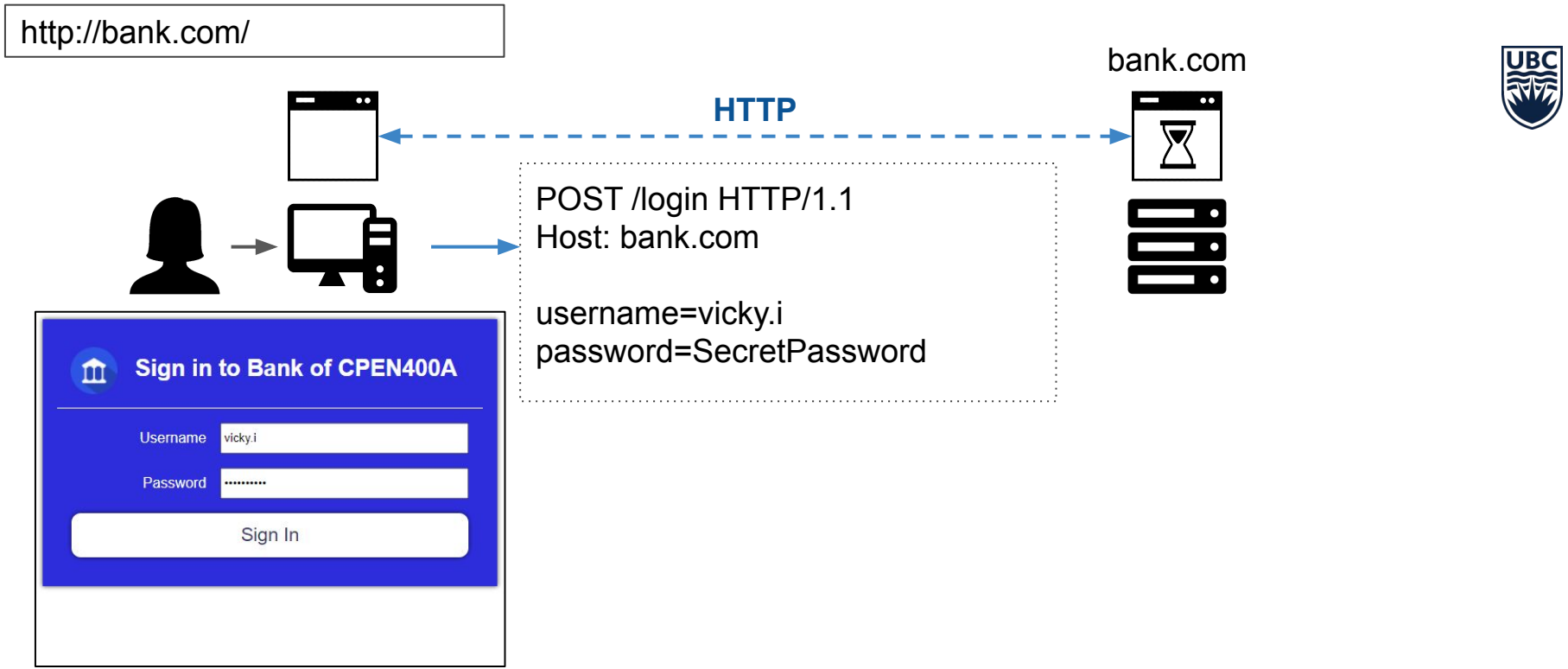

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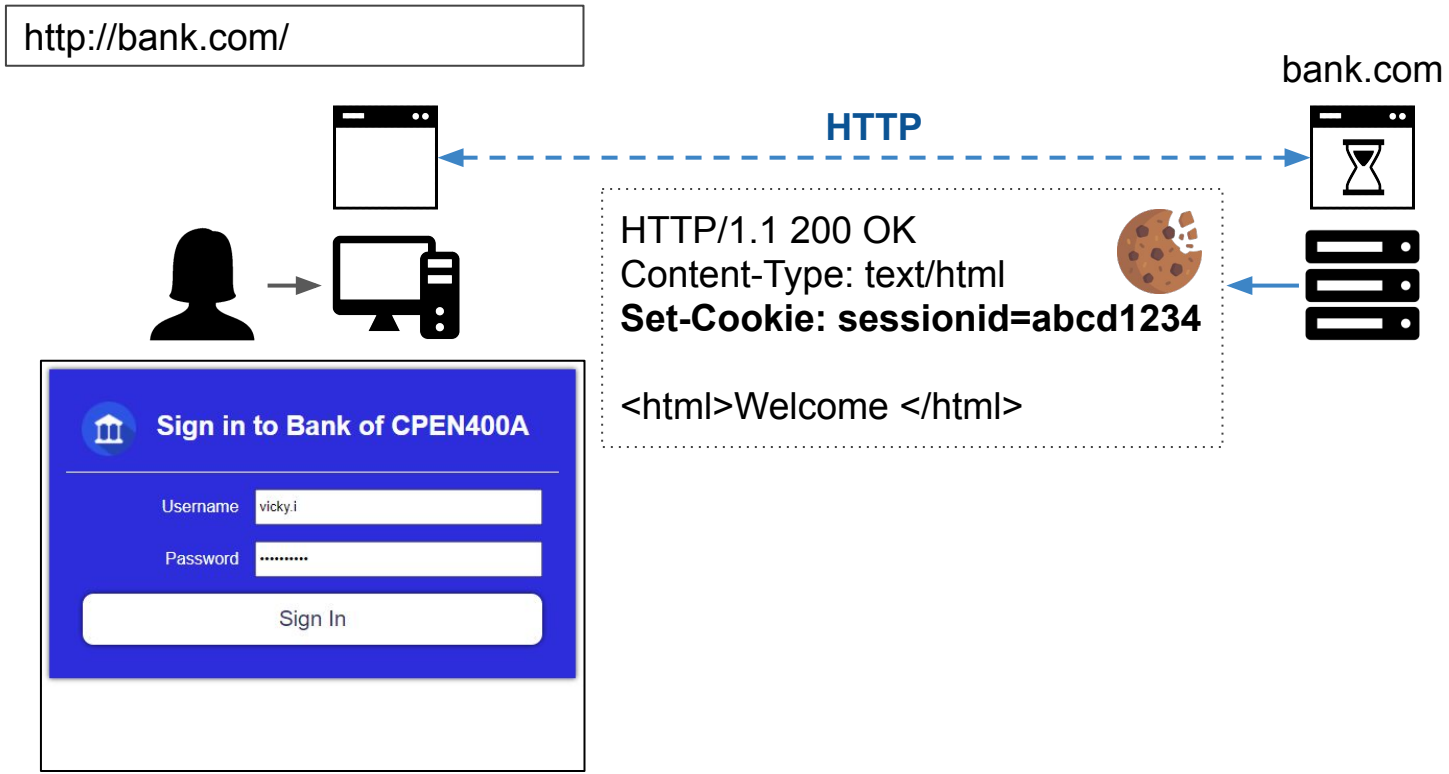
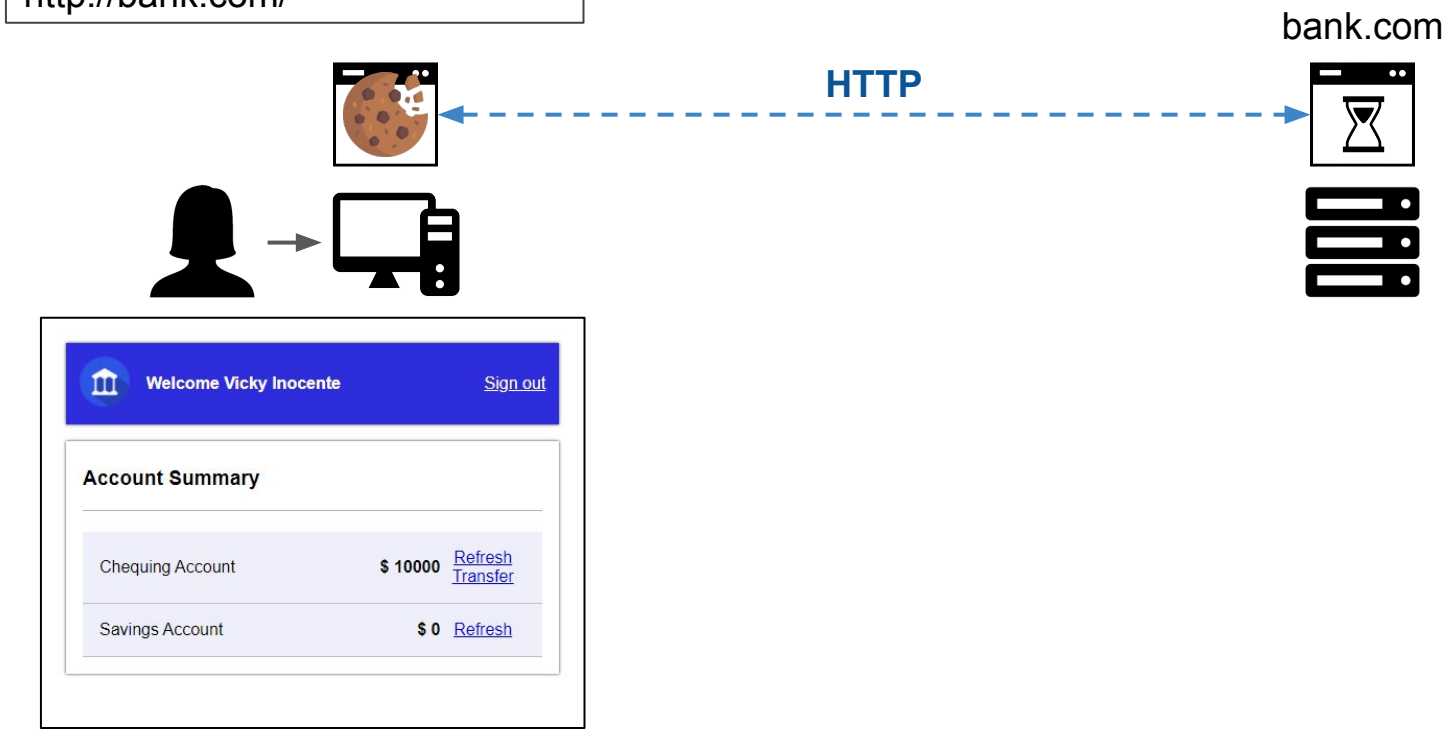


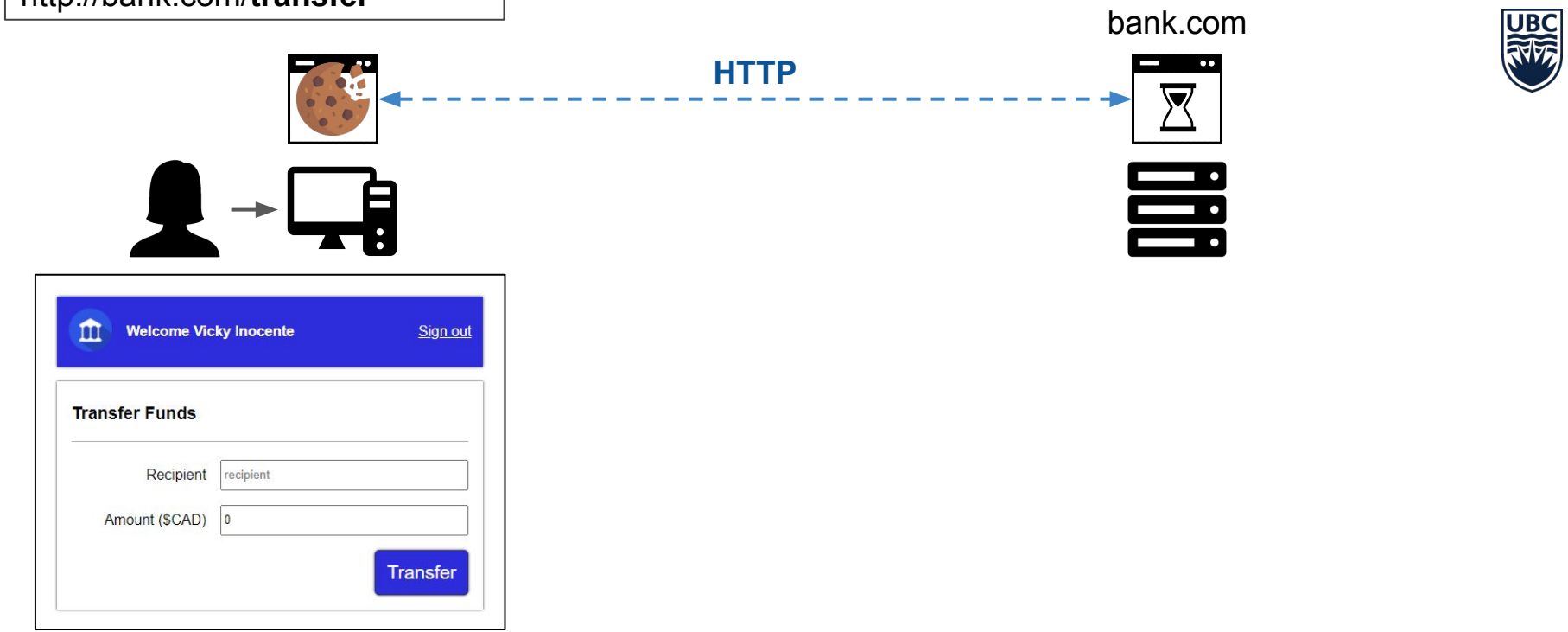
Web Security: Cross-site Request Forgery

http://bank.com/



Web Security: Cross-site Request Forgery

http://bank.com/**transfer**



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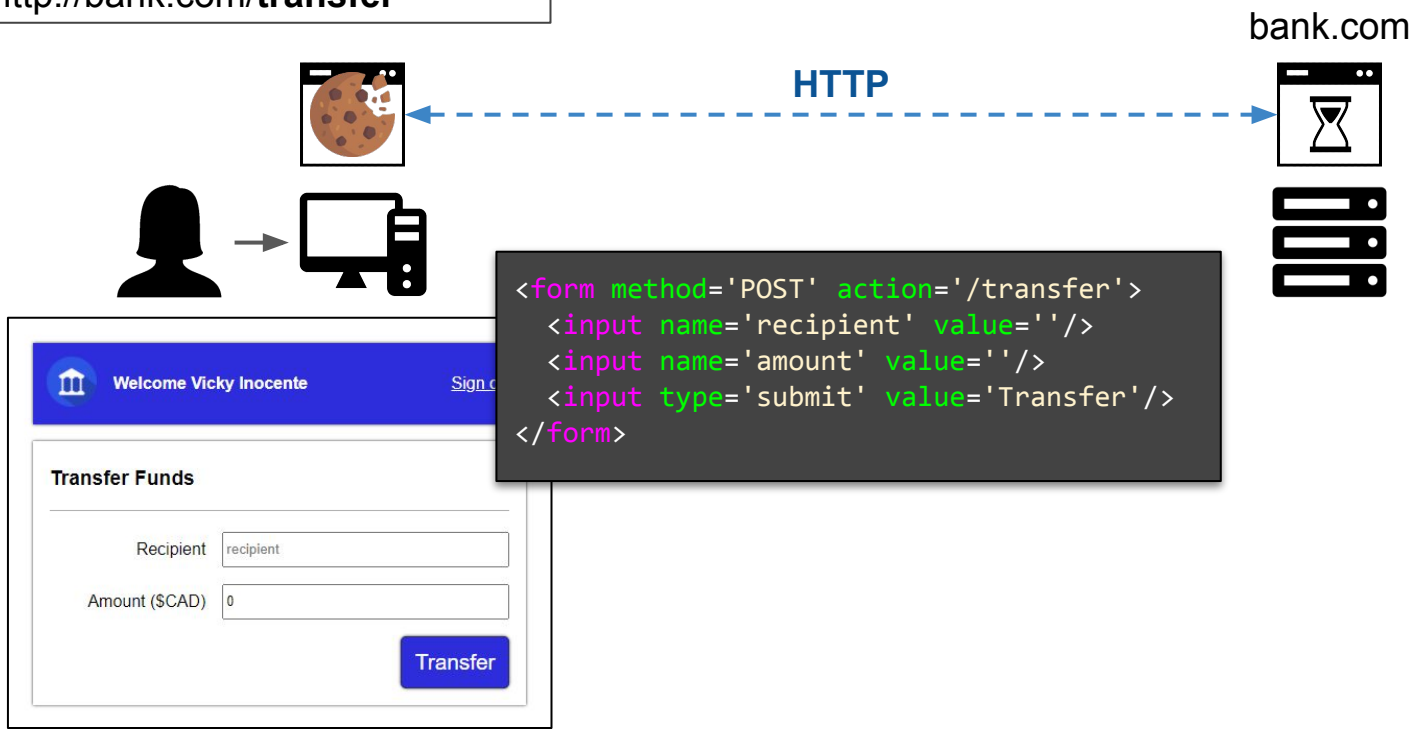
http://bank.com/**transfer**



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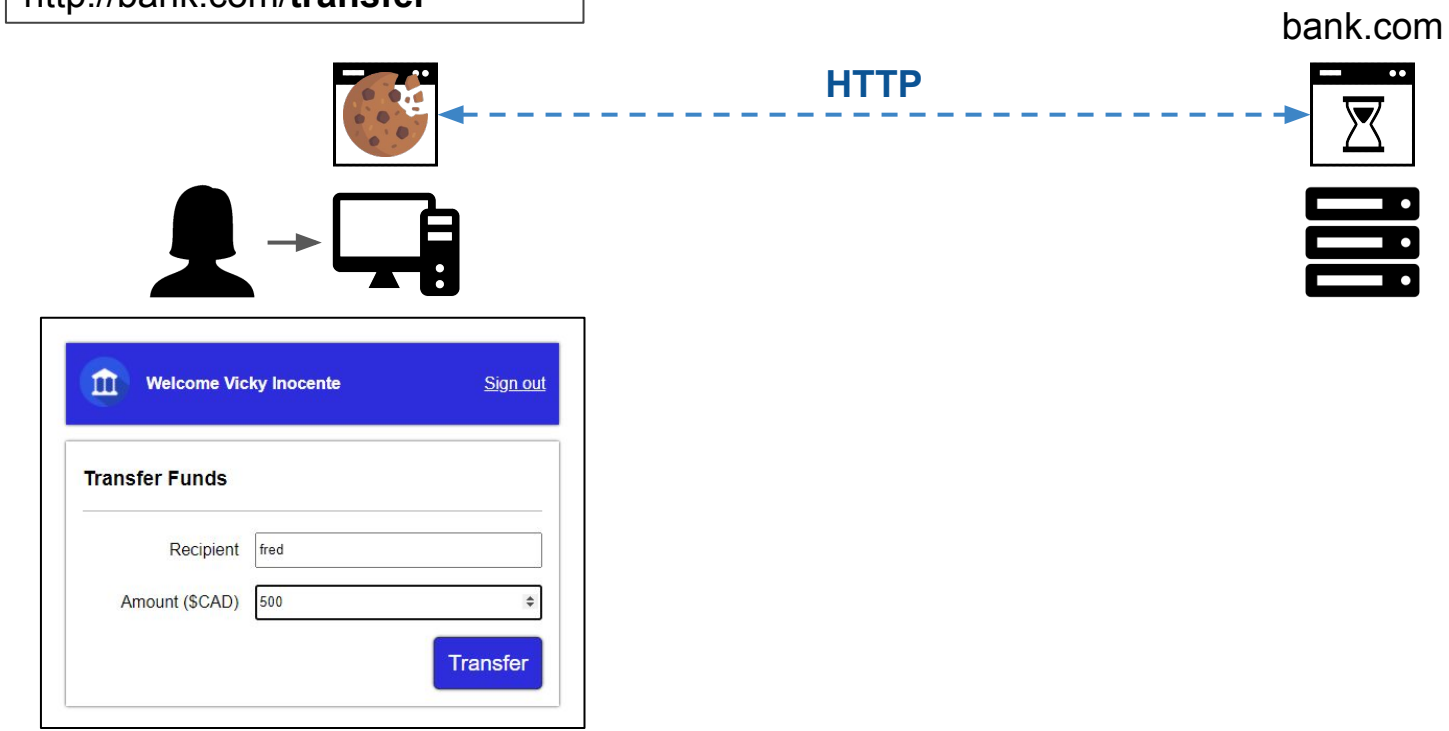

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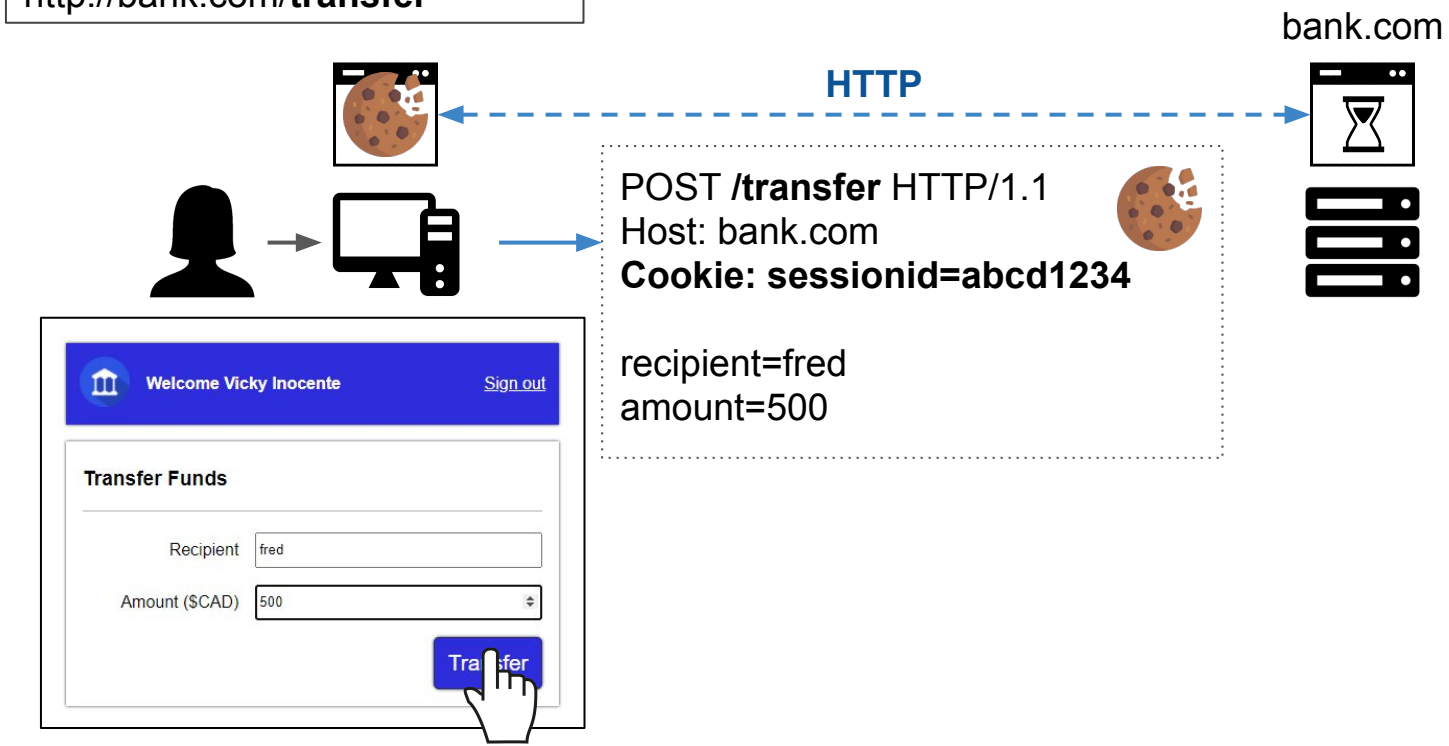

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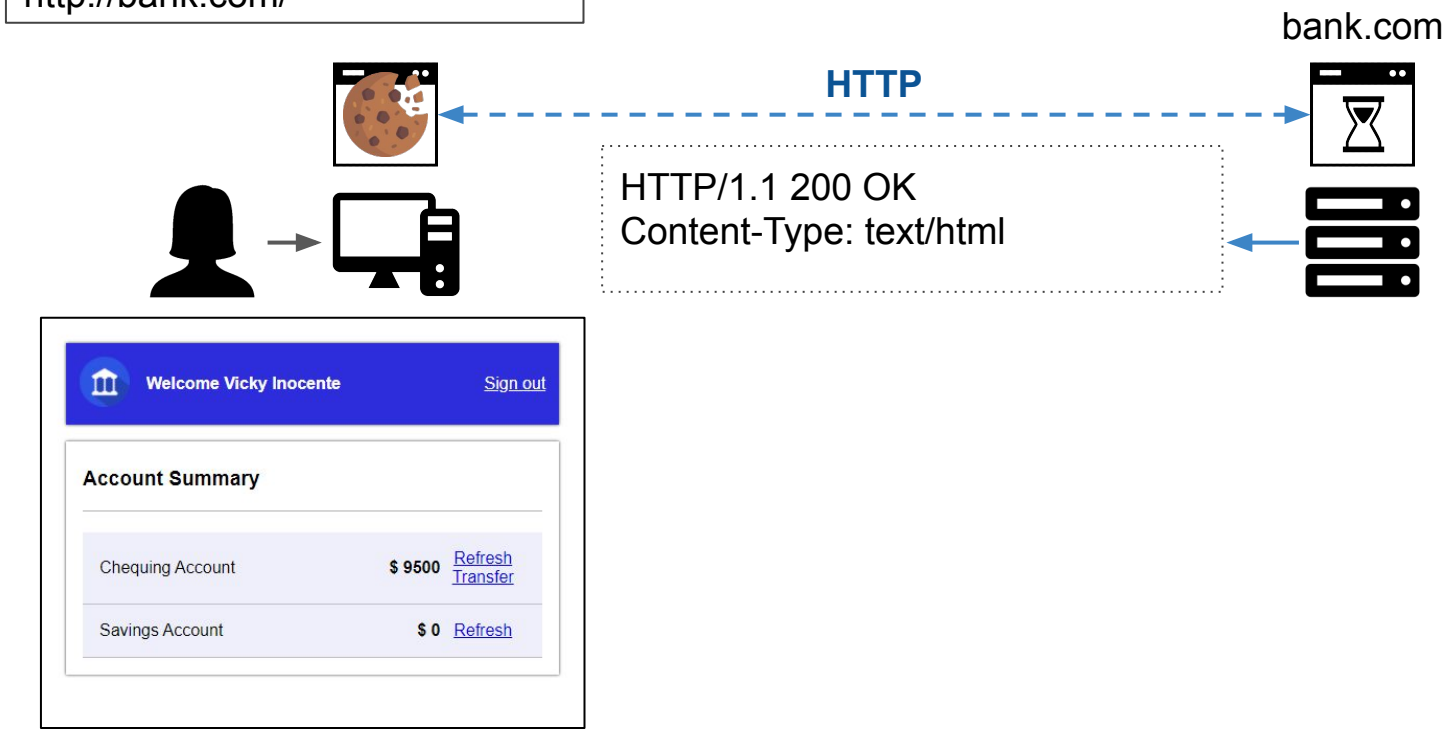

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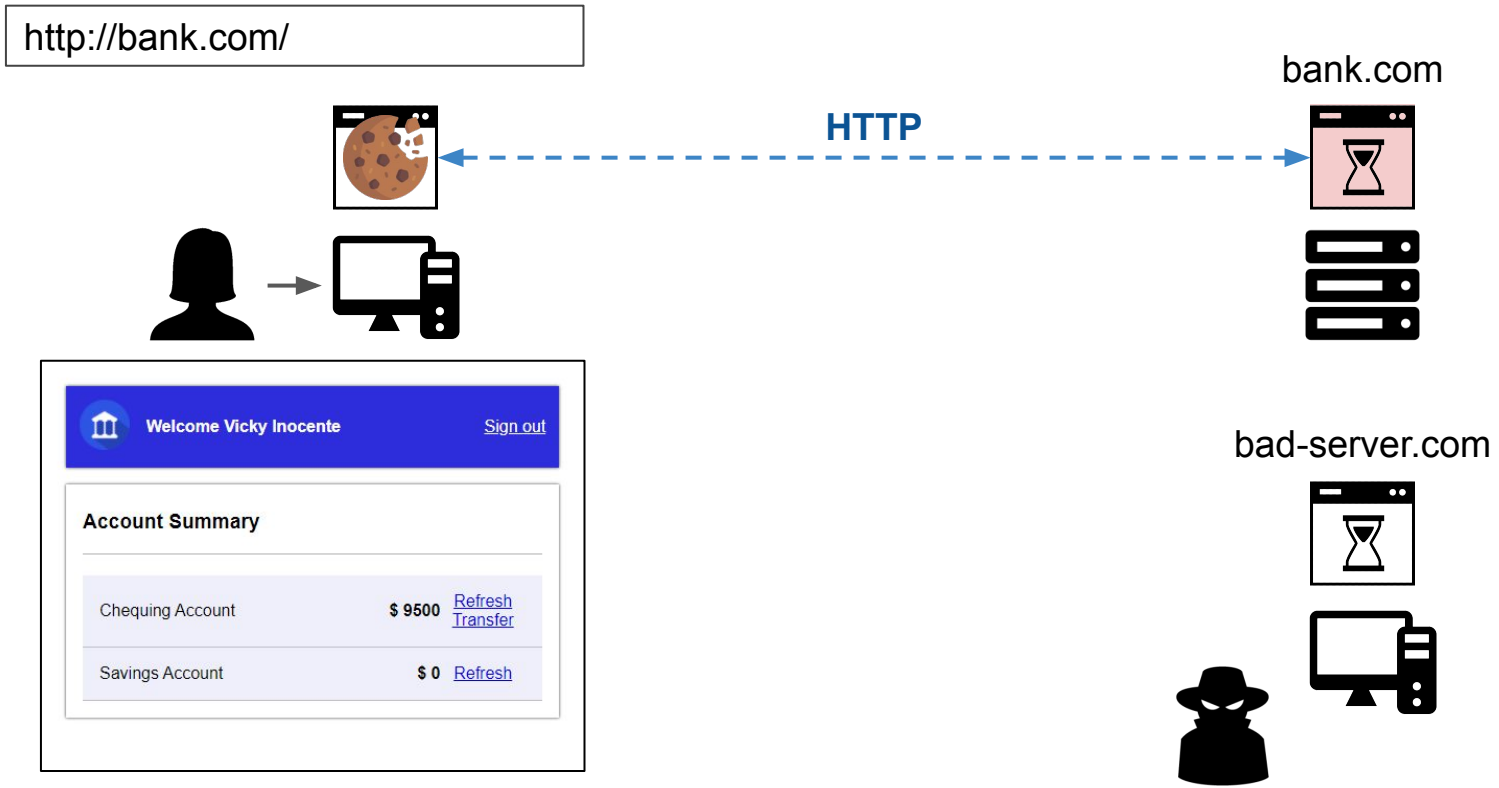

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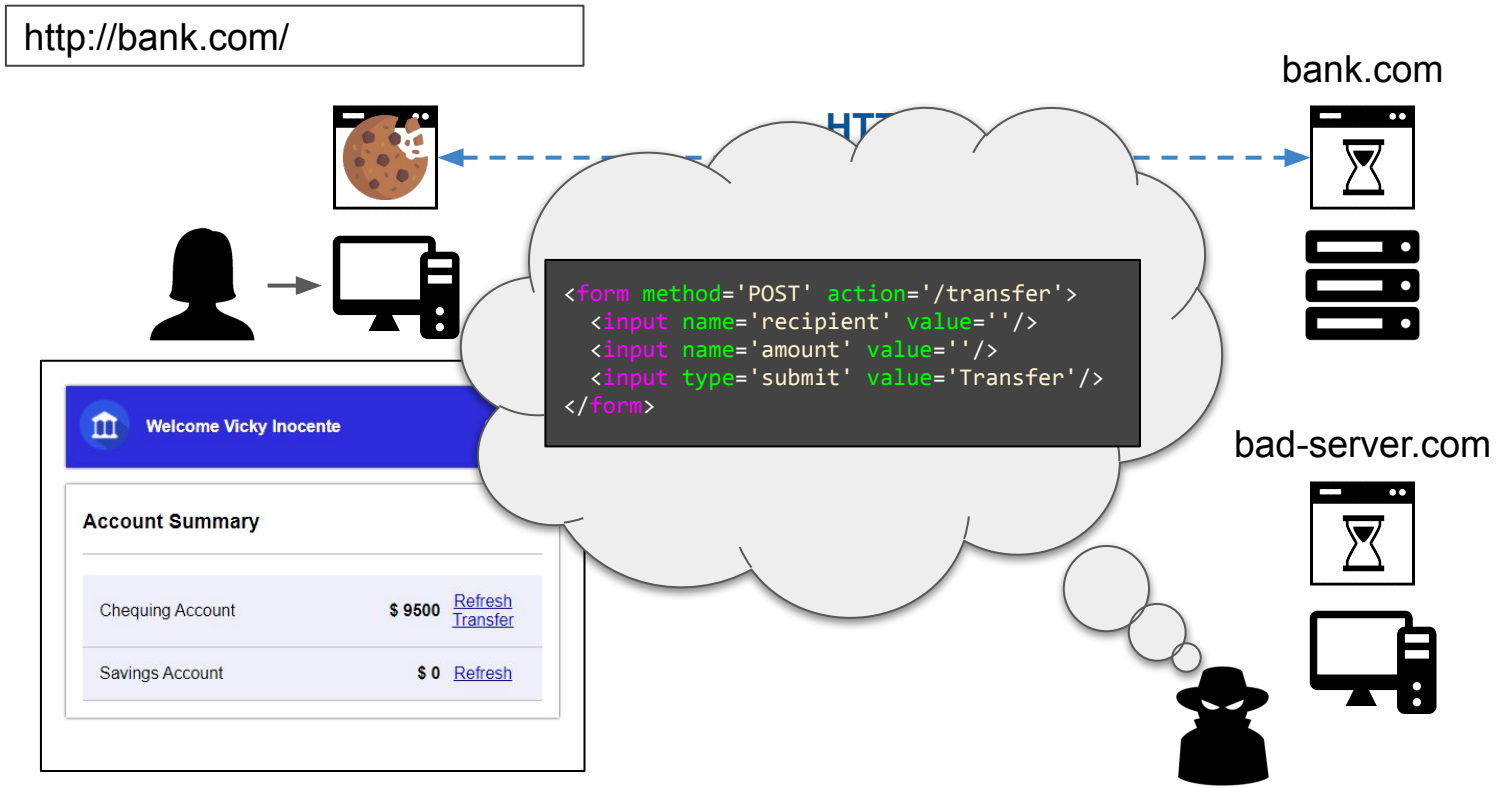

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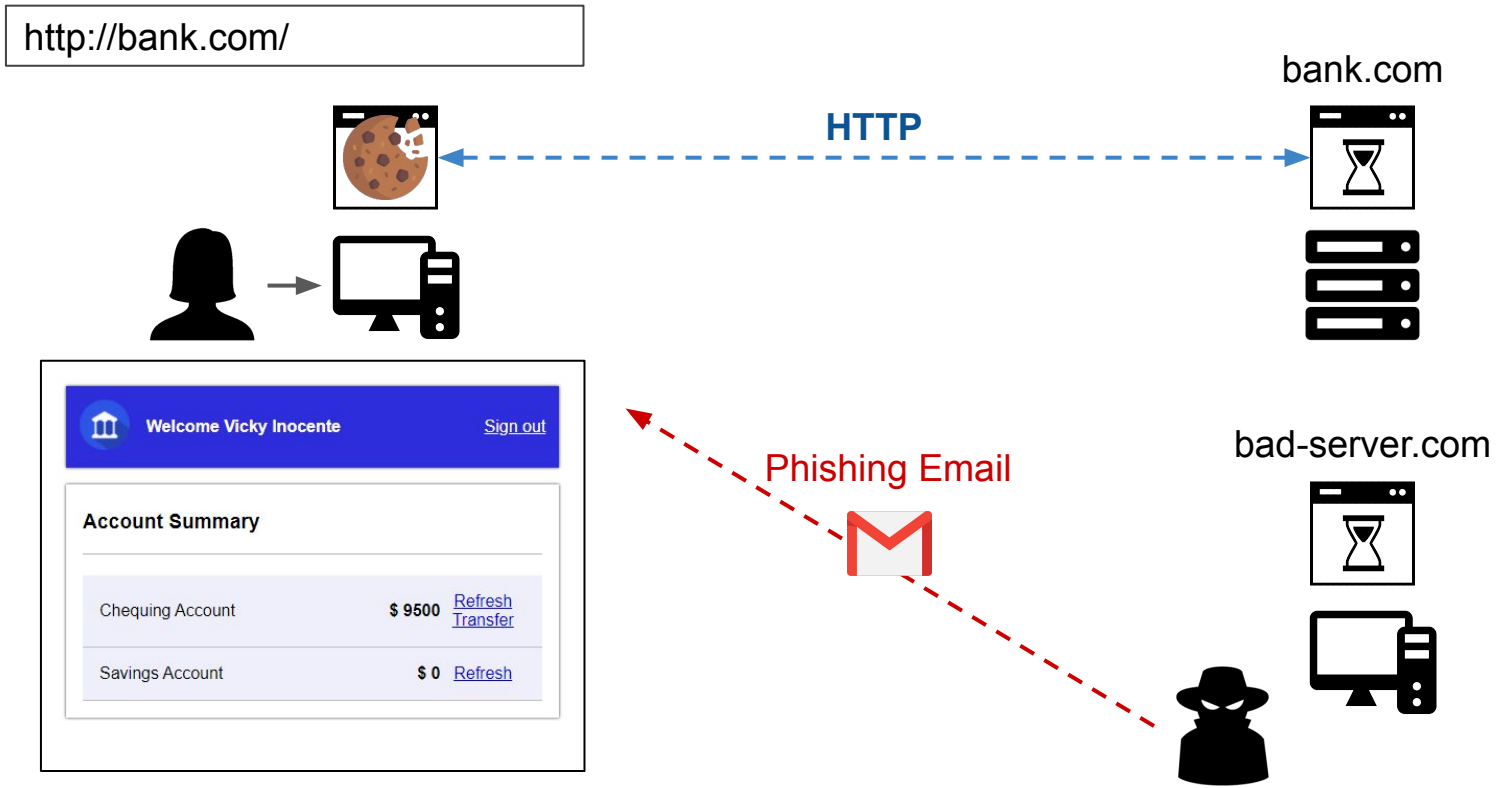

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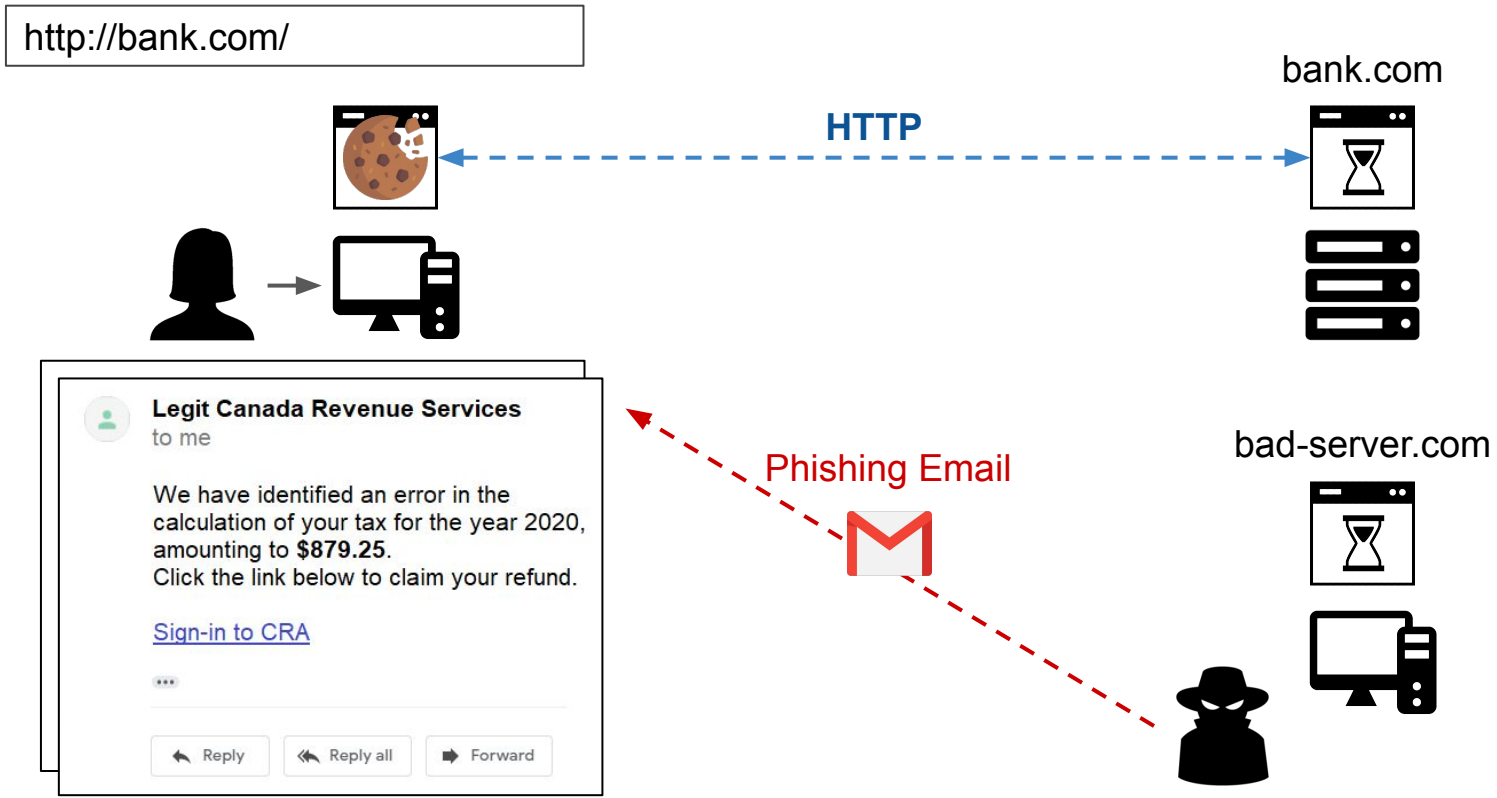

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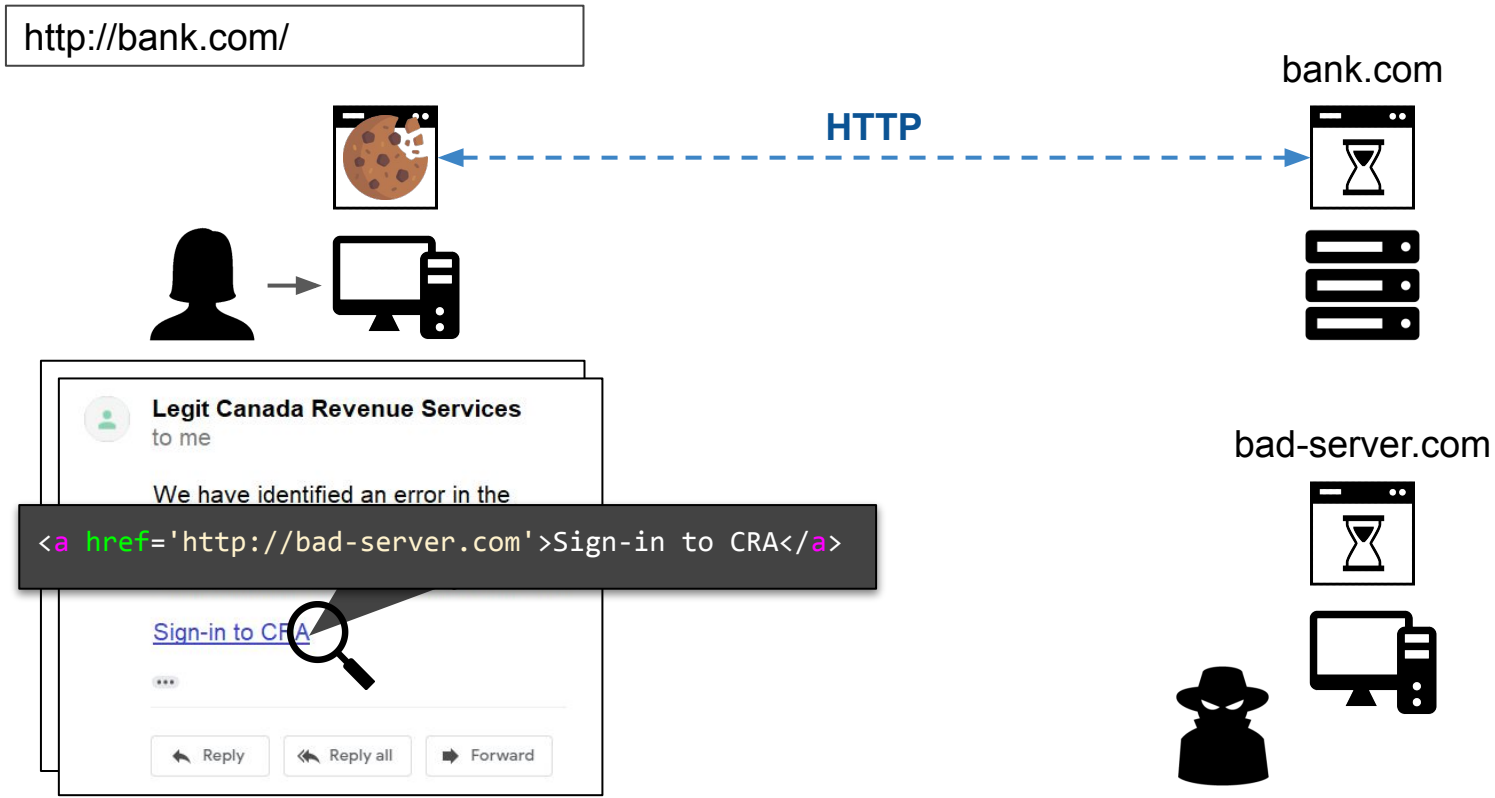

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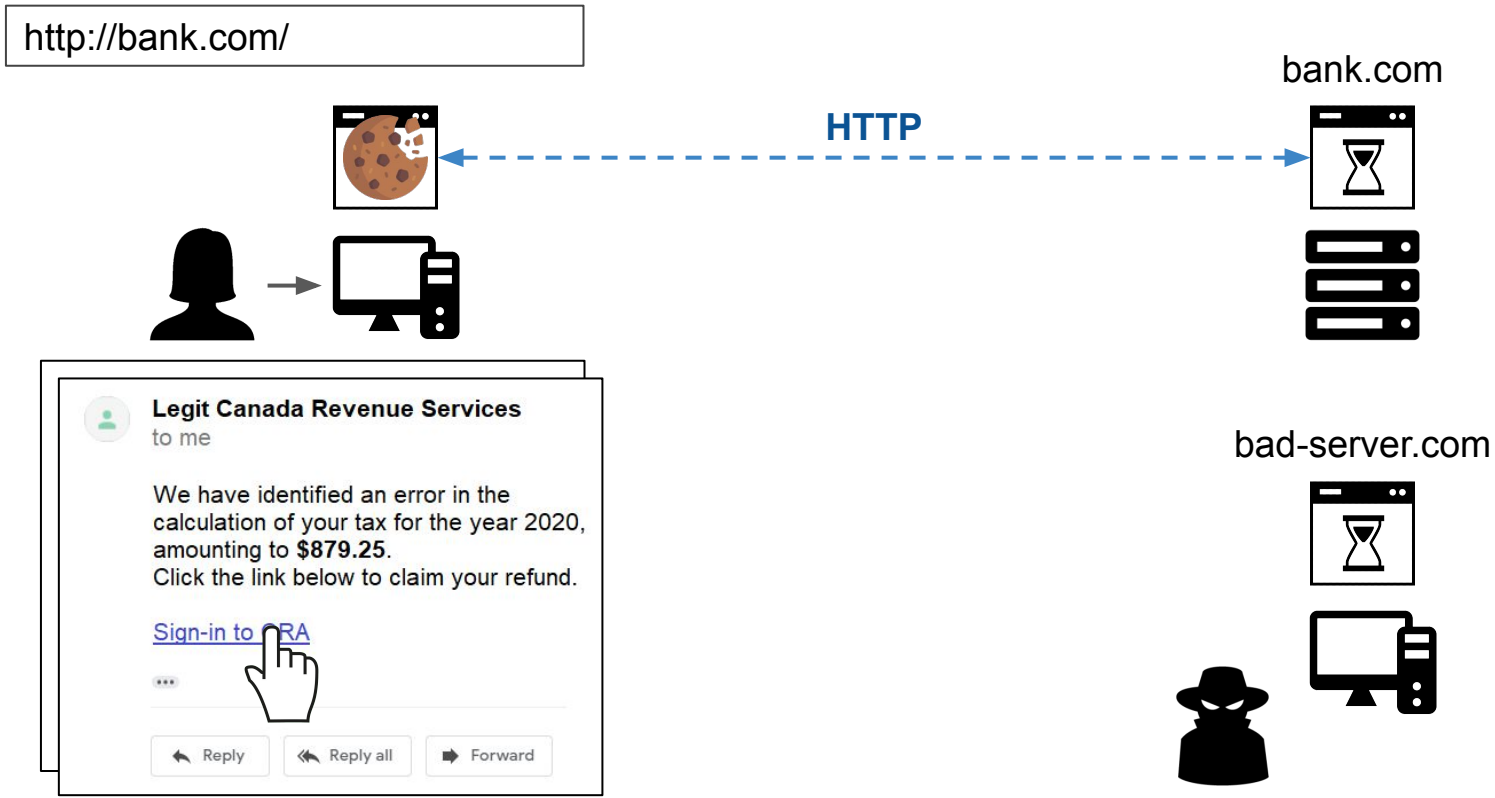
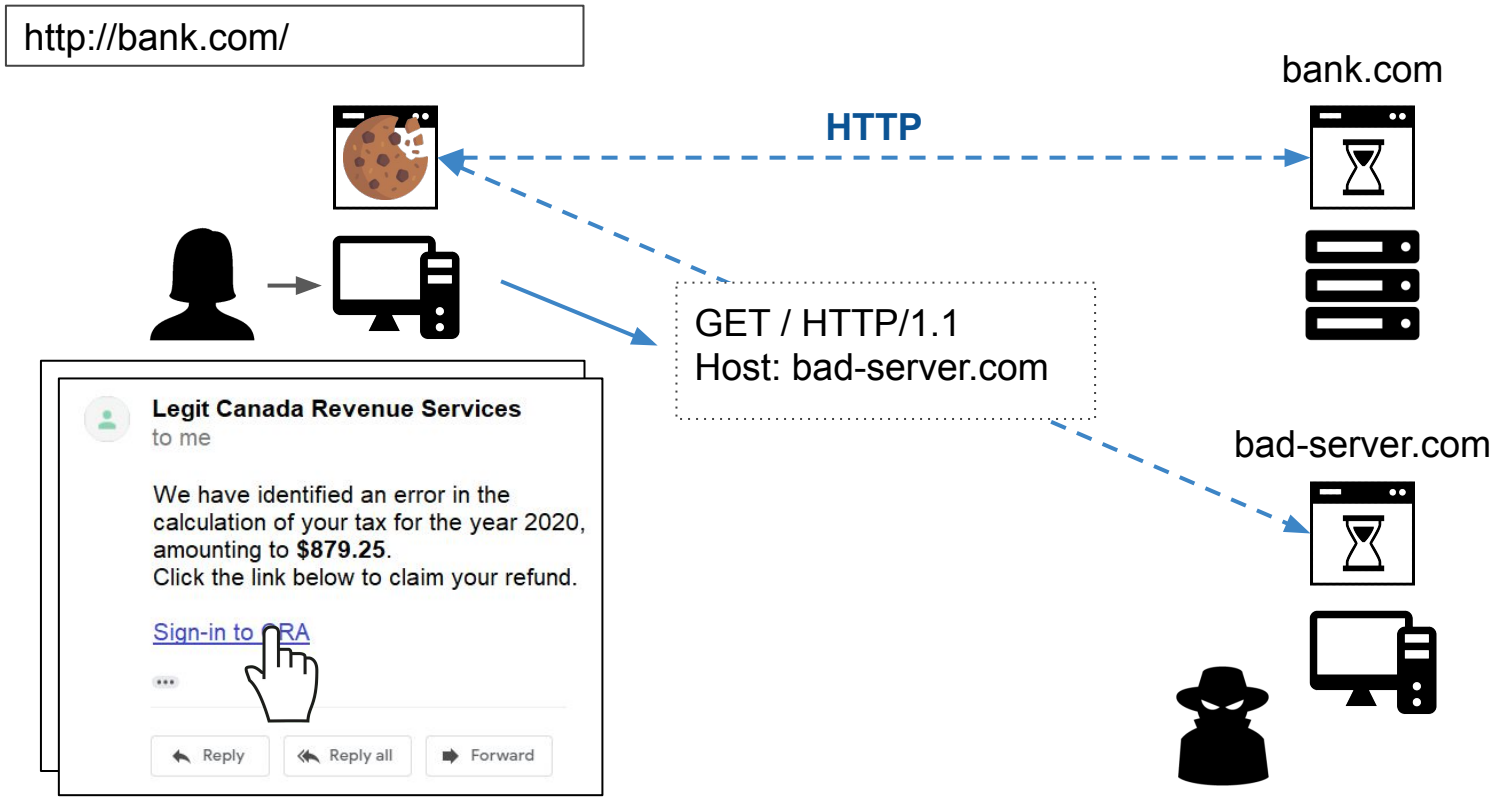
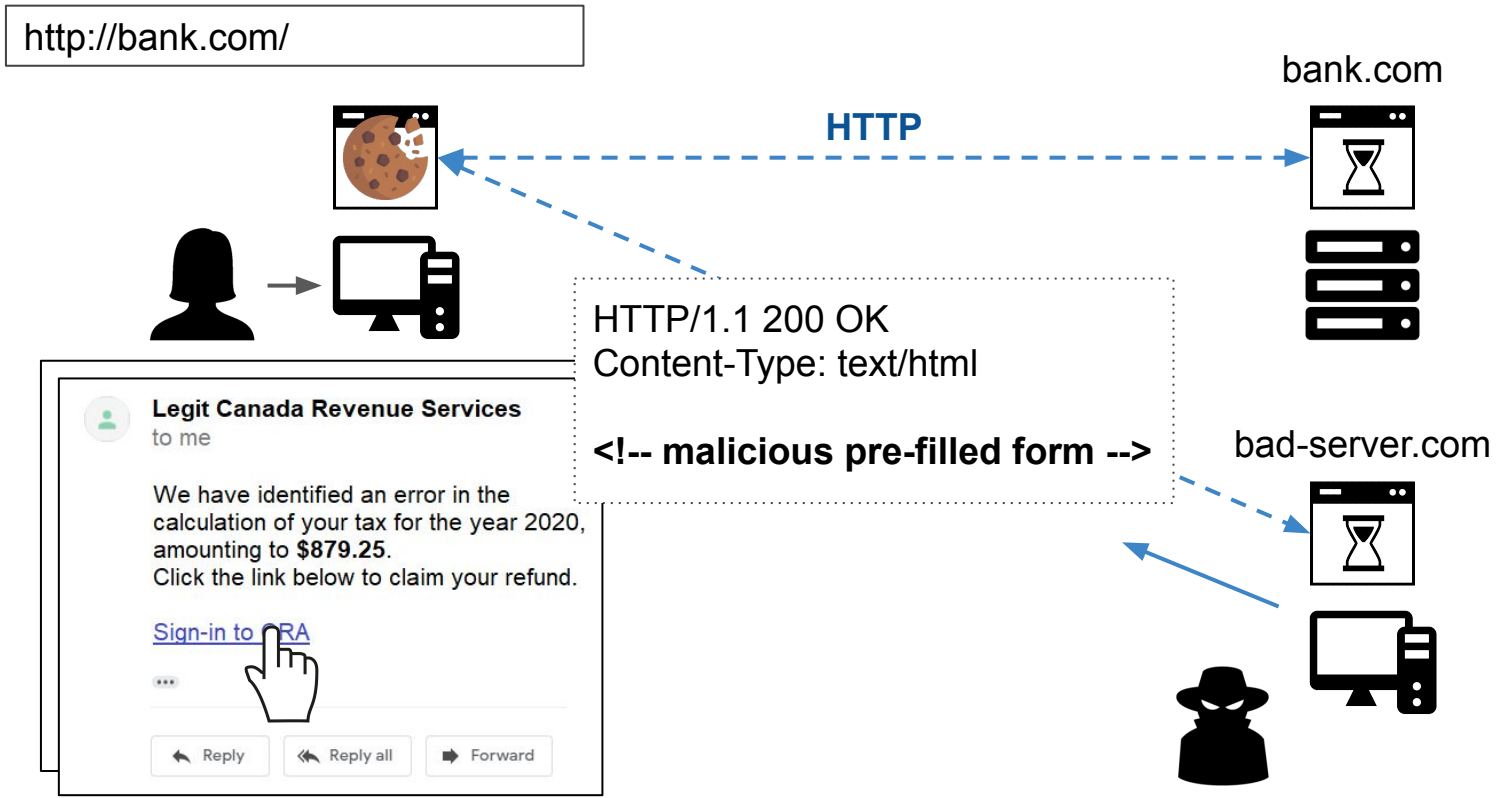


Web Security: Cross-site Request Forgery

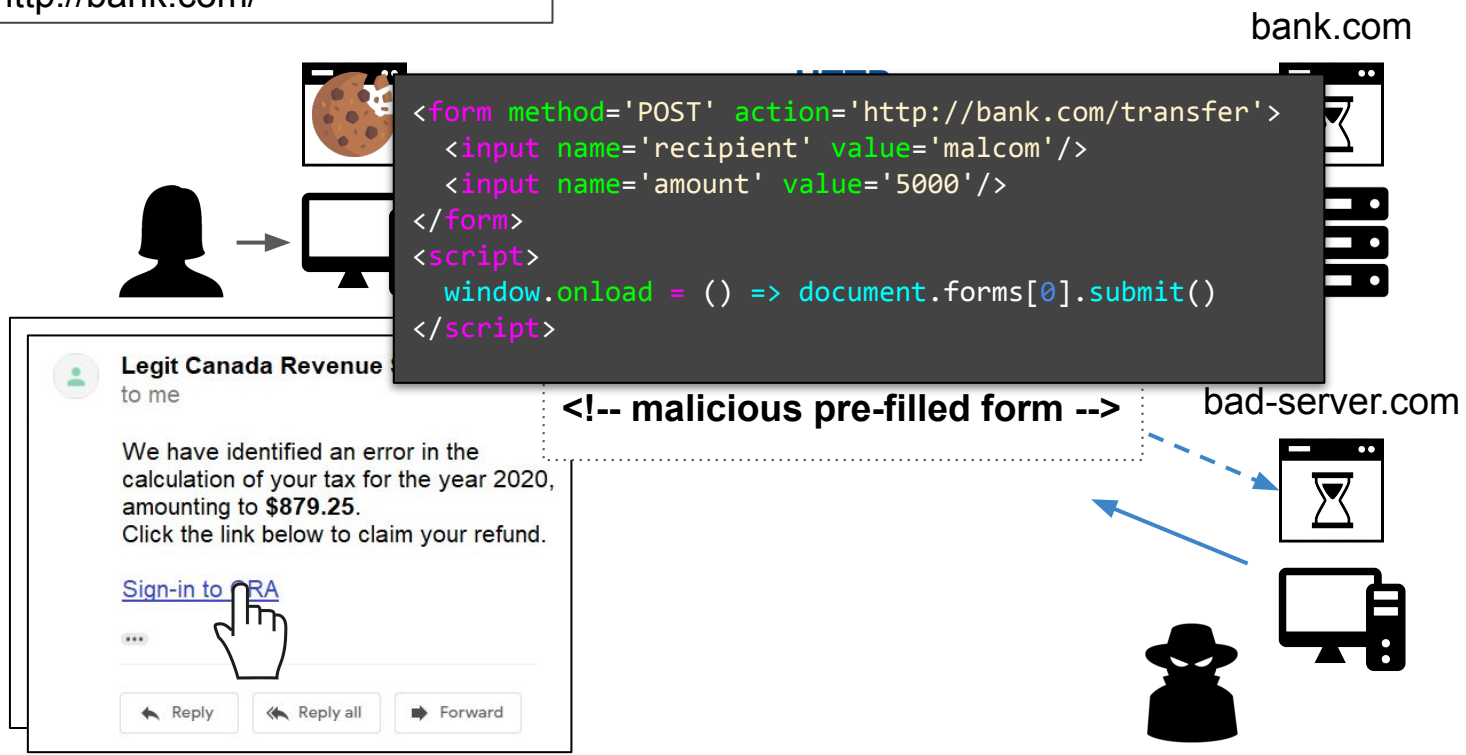


Web Security: Cross-site Request Forgery

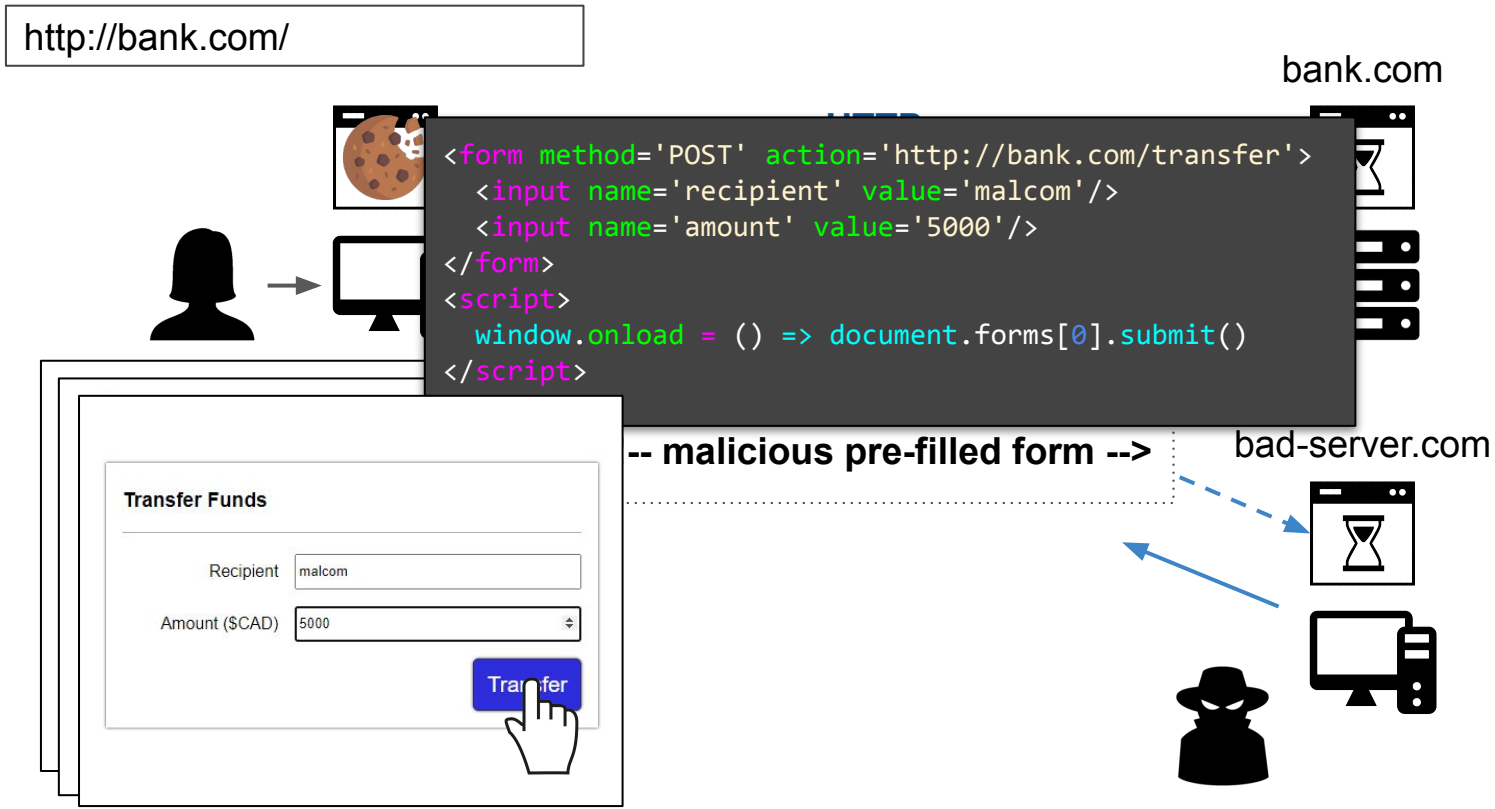


Web Security: Cross-site Request Forgery

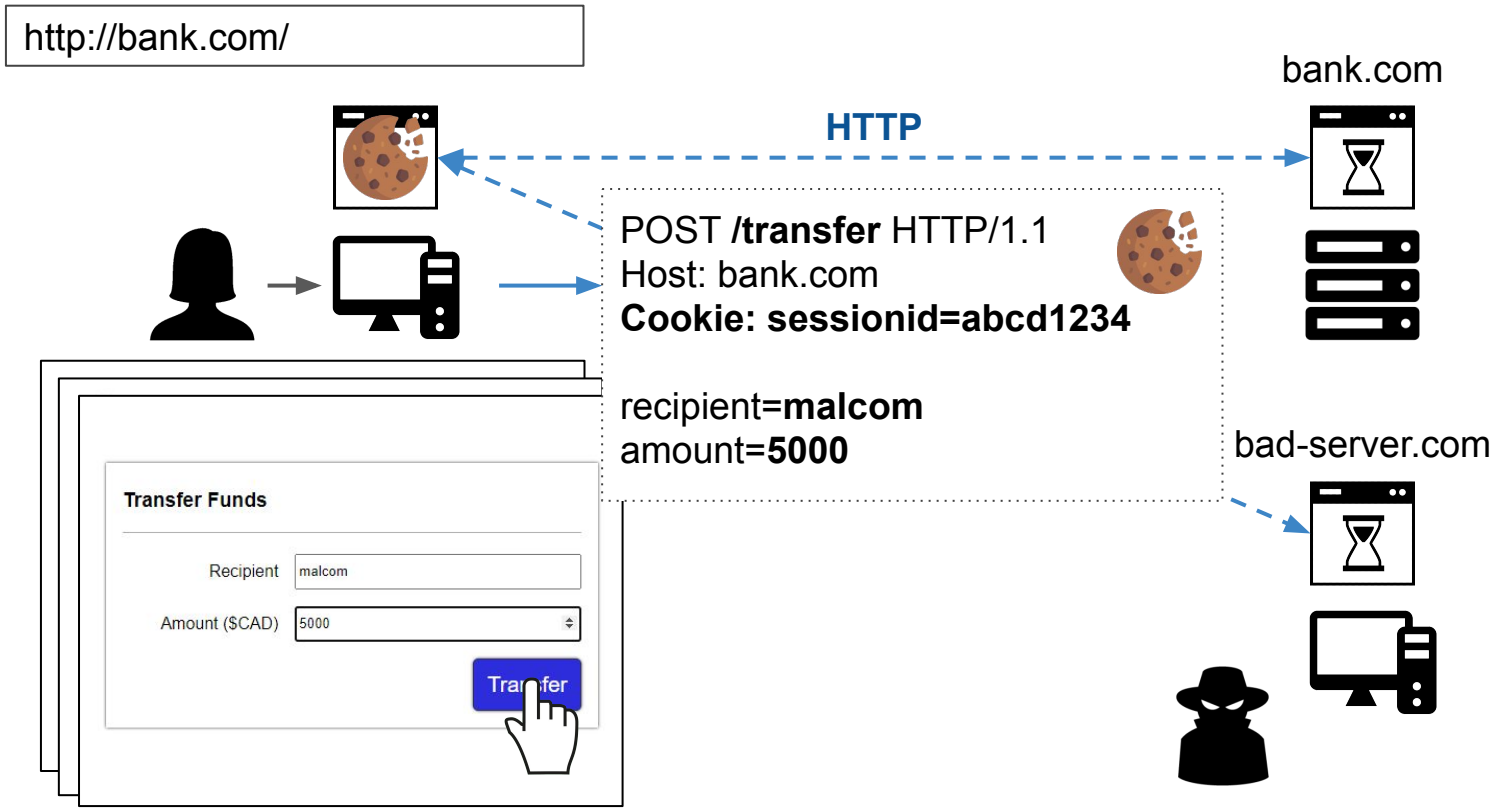
http://bank.com/



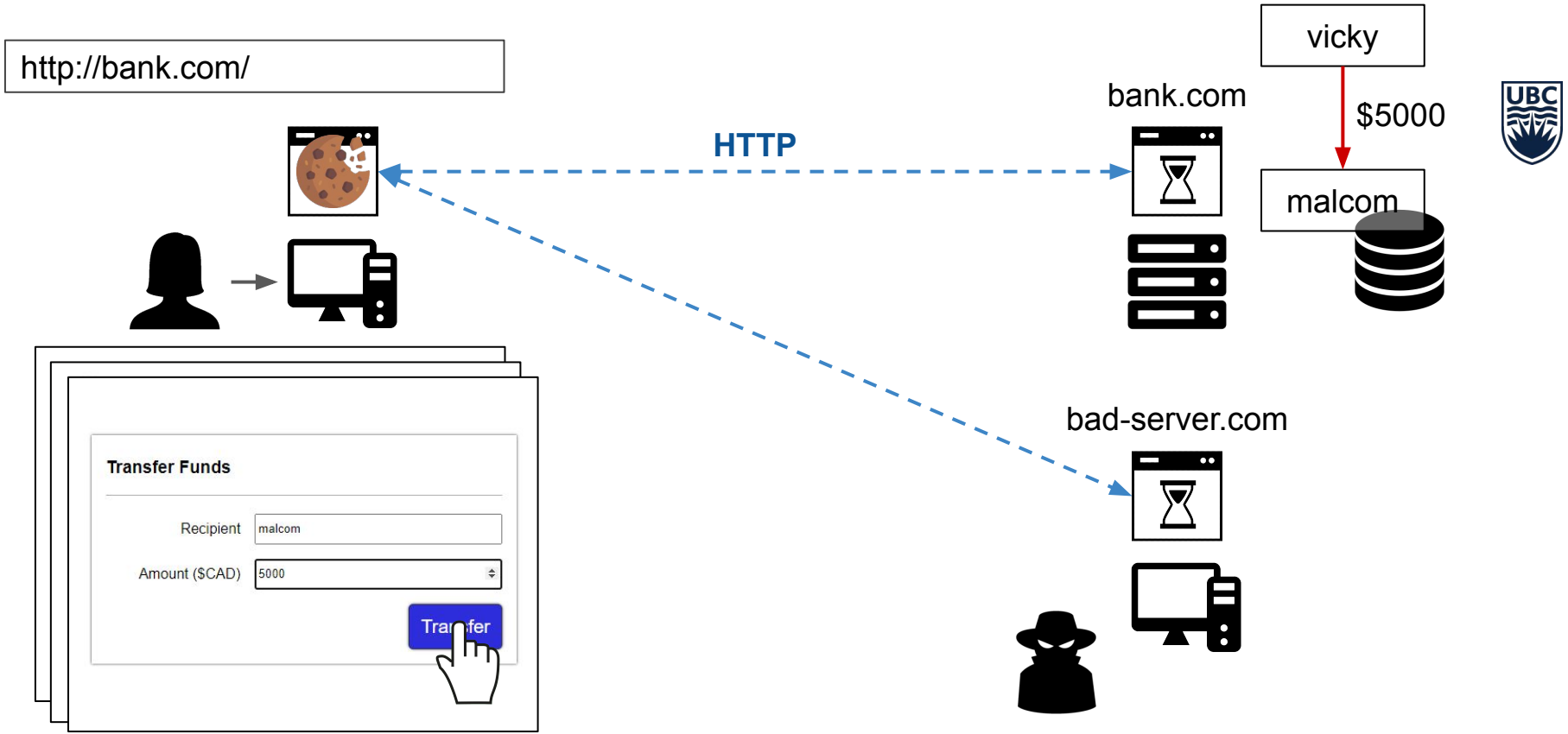
Web Security: Cross-site Request Forgery



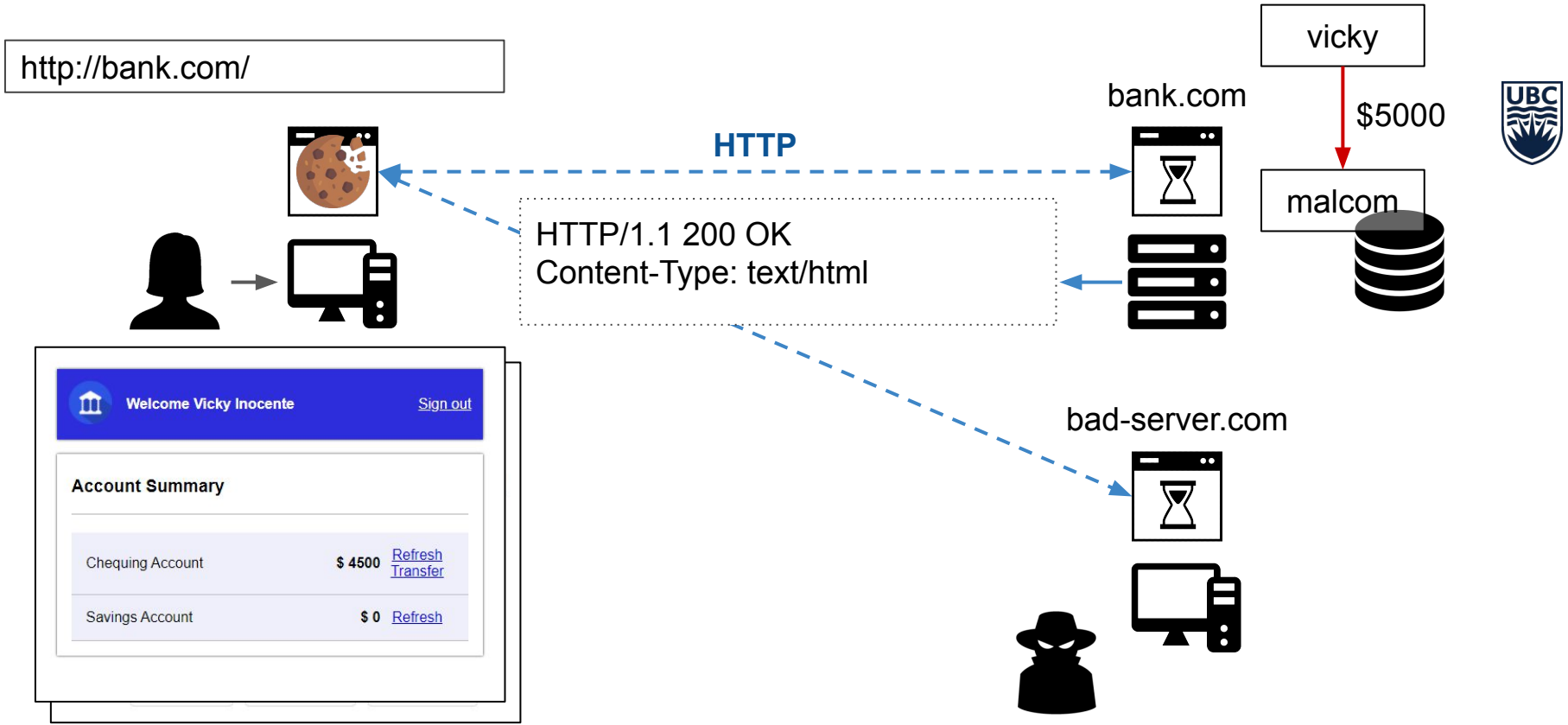
Web Security: Cross-site Request Forgery



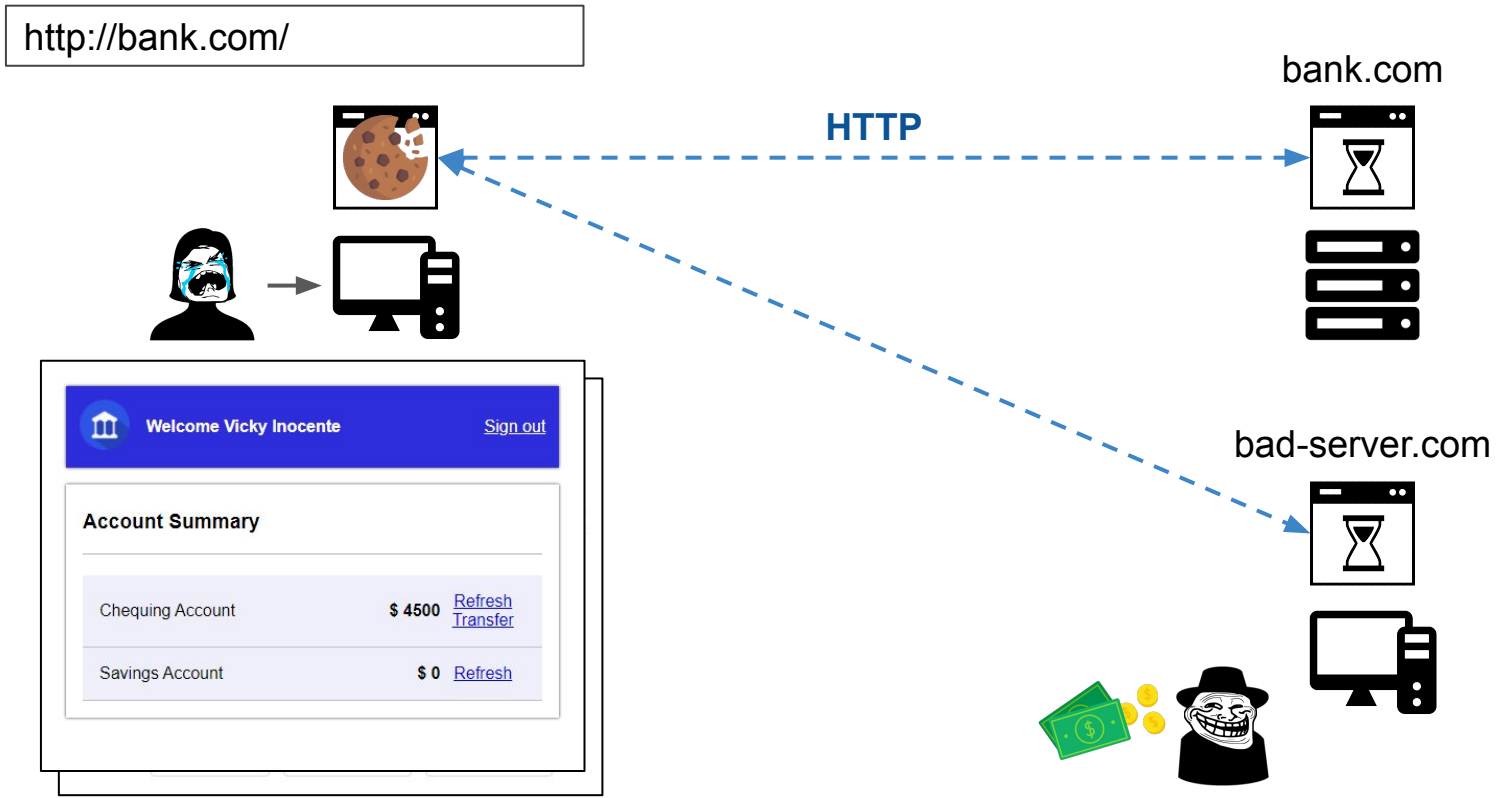
Web Security: Cross-site Request Forgery



Web Security: Cross-site Request Forgery



Web Security: Cross-site Request Forgery



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 CPEN322 Bank App. You want to phish a victim into clicking a link, so that it transfers her money to your account.

CPEN322 Bank is at: http://99.79.38.47:5000

Your personal storage is at: http://99.79.38.47:8000/USERNAME

To create a malicious form, go to: http://99.79.38.47:8000/USERNAME/form/edit

To view your malicious form, go to: http://99.79.38.47:8000/USERNAME/form

To phish a victim, go to: http://99.79.38.47:4000

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)