CSE 484 / CSE M 584: Web Security

Winter 2022

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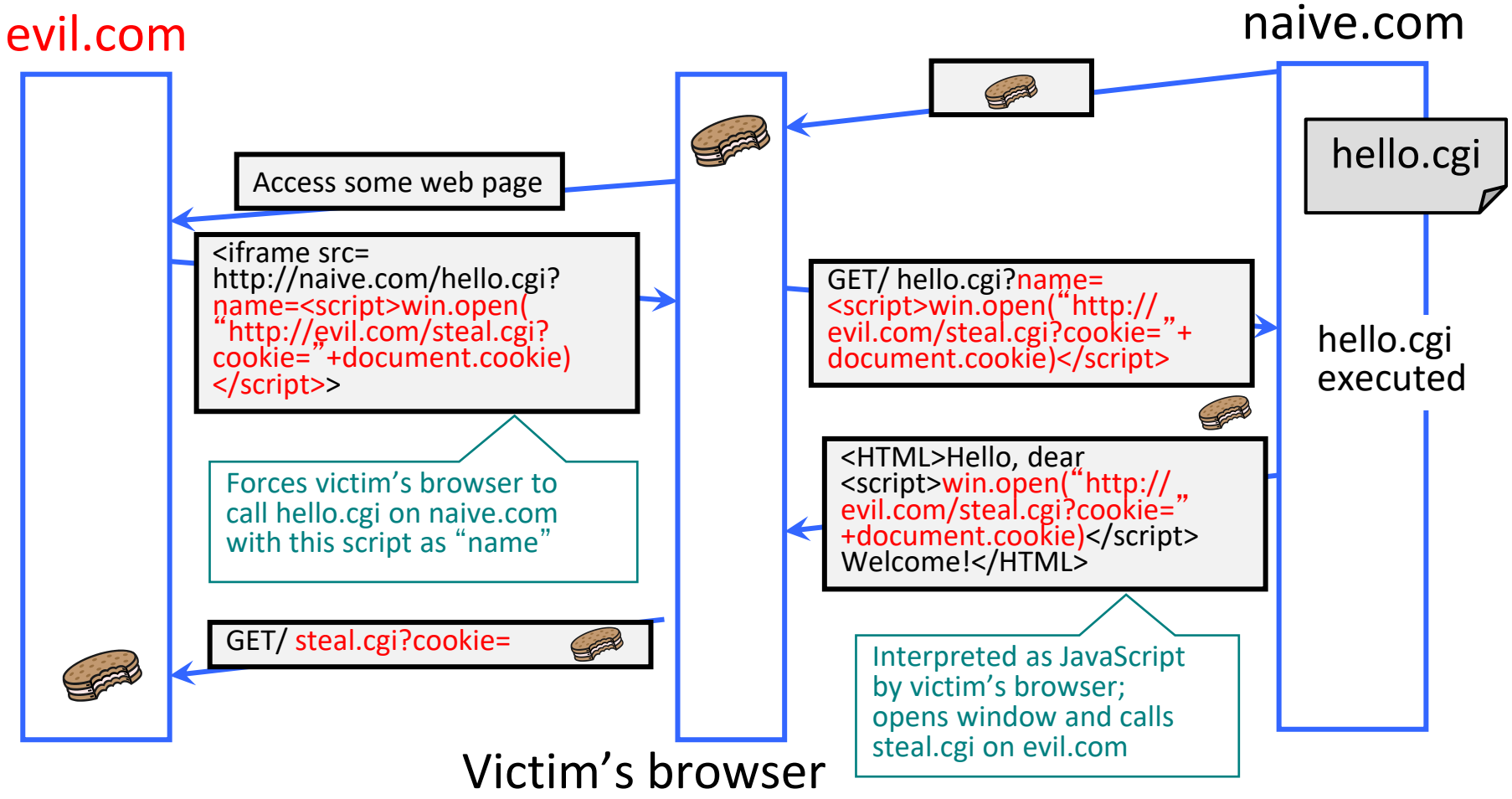
Announcements

- Homework 2s: Wow, so impressive!!
- Lab 2: Out
- Lab 3 will be extra credit
  - Designed to be a fun lab (IoT security)
  - I encourage everyone to try it!
  - But if your schedule is too complicated right now, it is extra credit

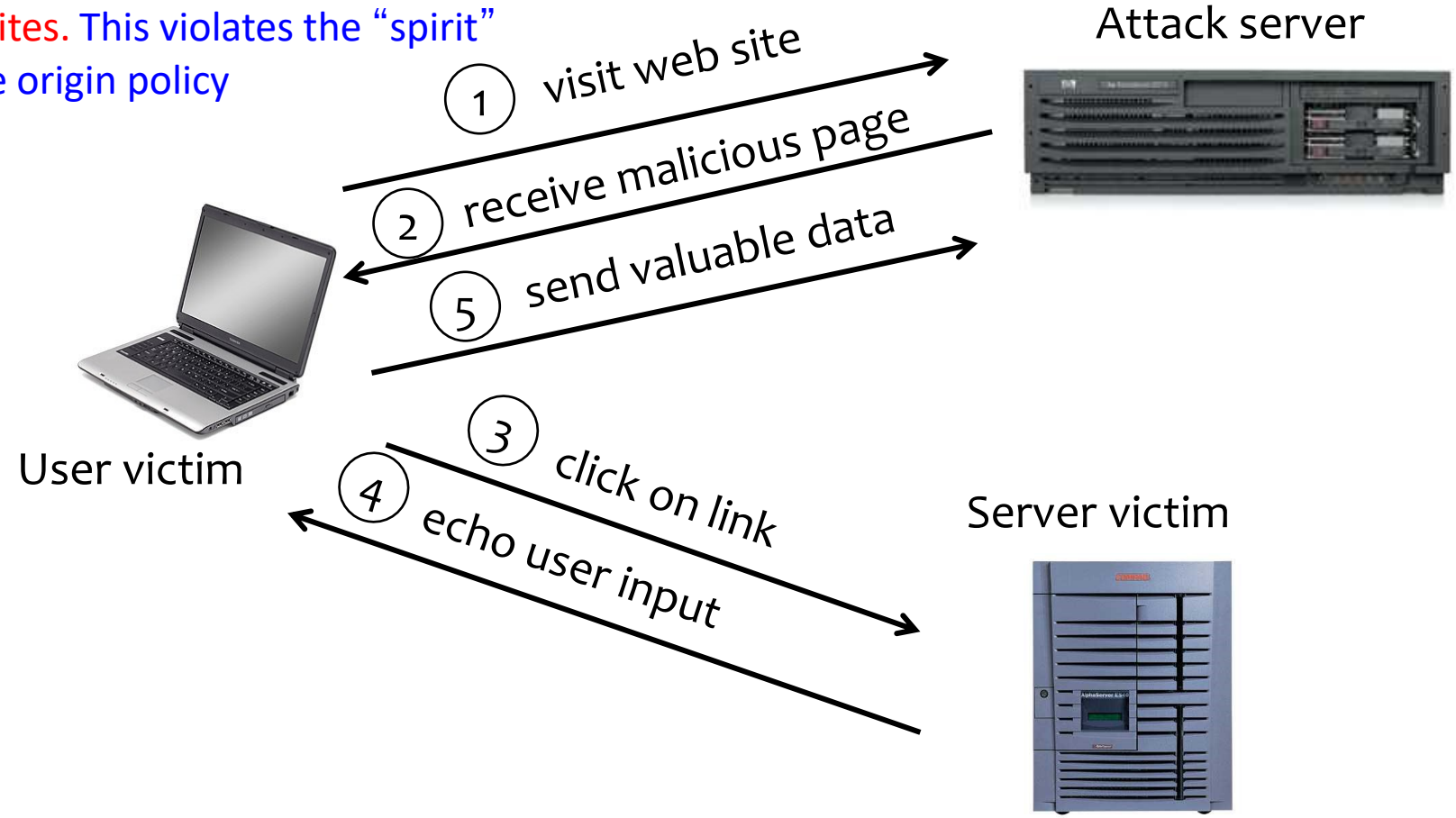
Begin Review Slides

Cross-Site Scripting (XSS)

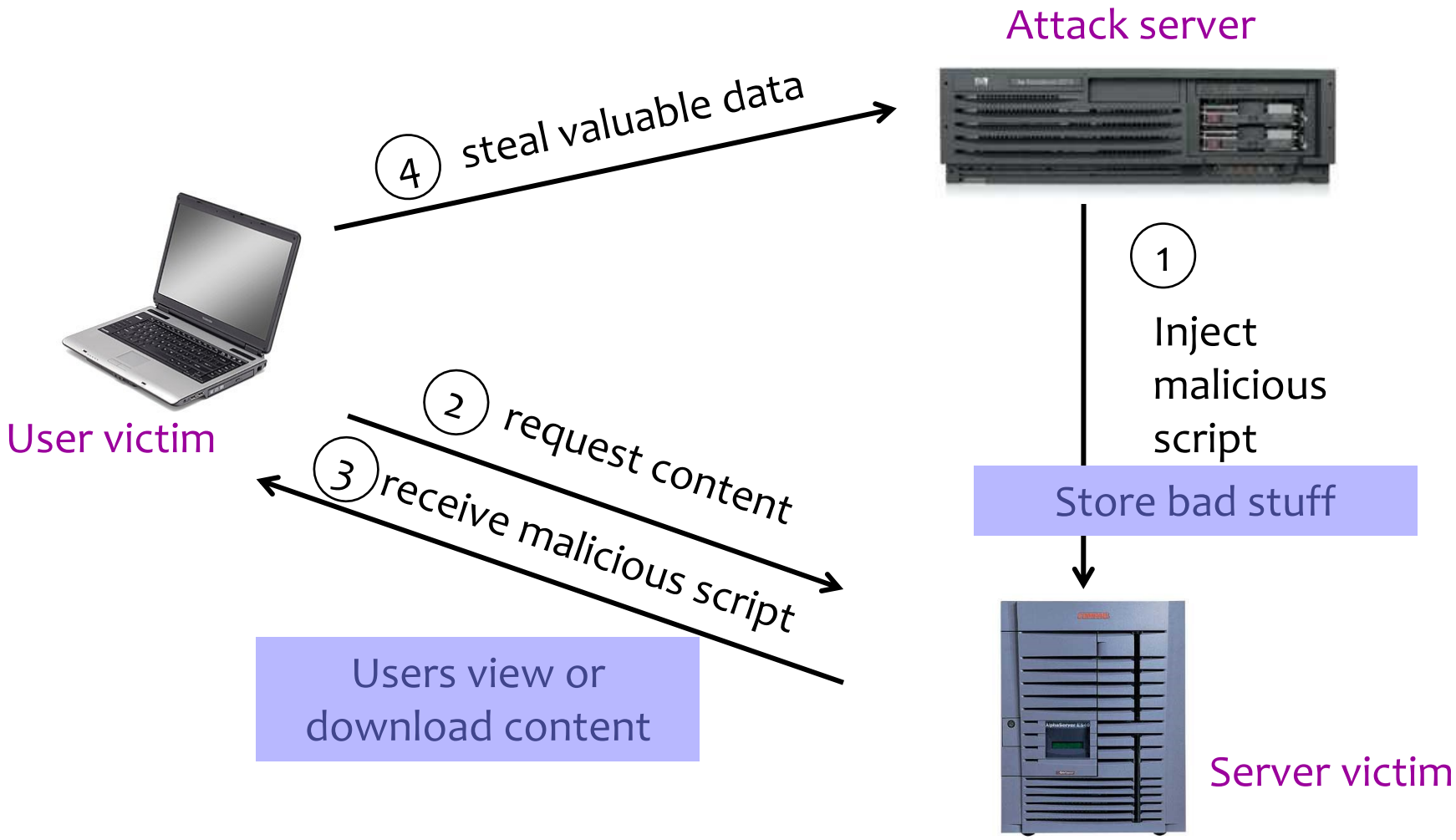


Basic Pattern for Reflected XSS

Injected script can manipulate website to show bogus information, leak sensitive data, cause user's browser to attack other websites. This violates the "spirit" of the same origin policy



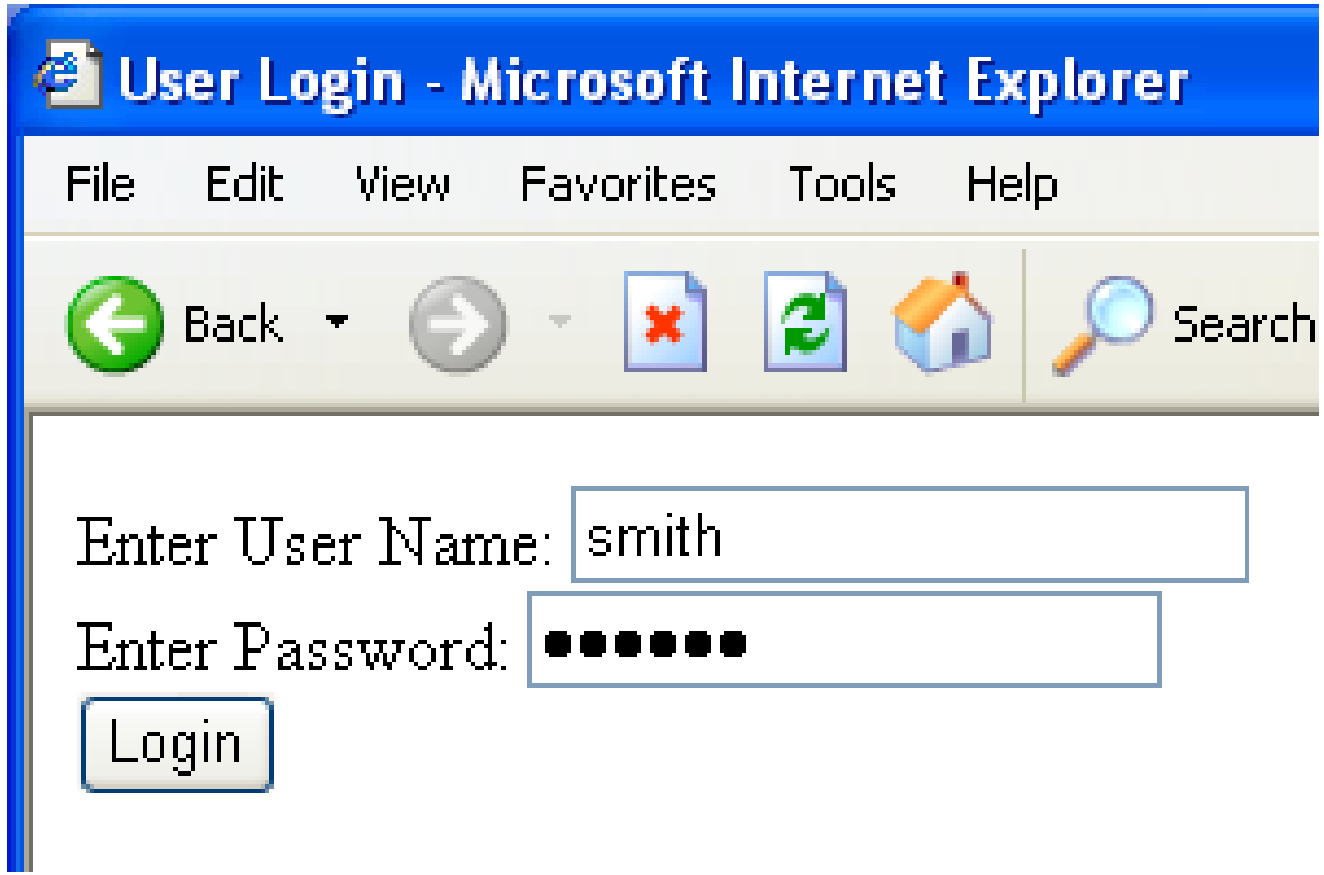
Stored XSS


Attack server
4 steal valuable data
1
Inject malicious script
2 request content
3 receive malicious script
User victim
Store bad stuff
Users view or download content
Server victim

End Review Slides

SQL Injection

Typical Login Prompt

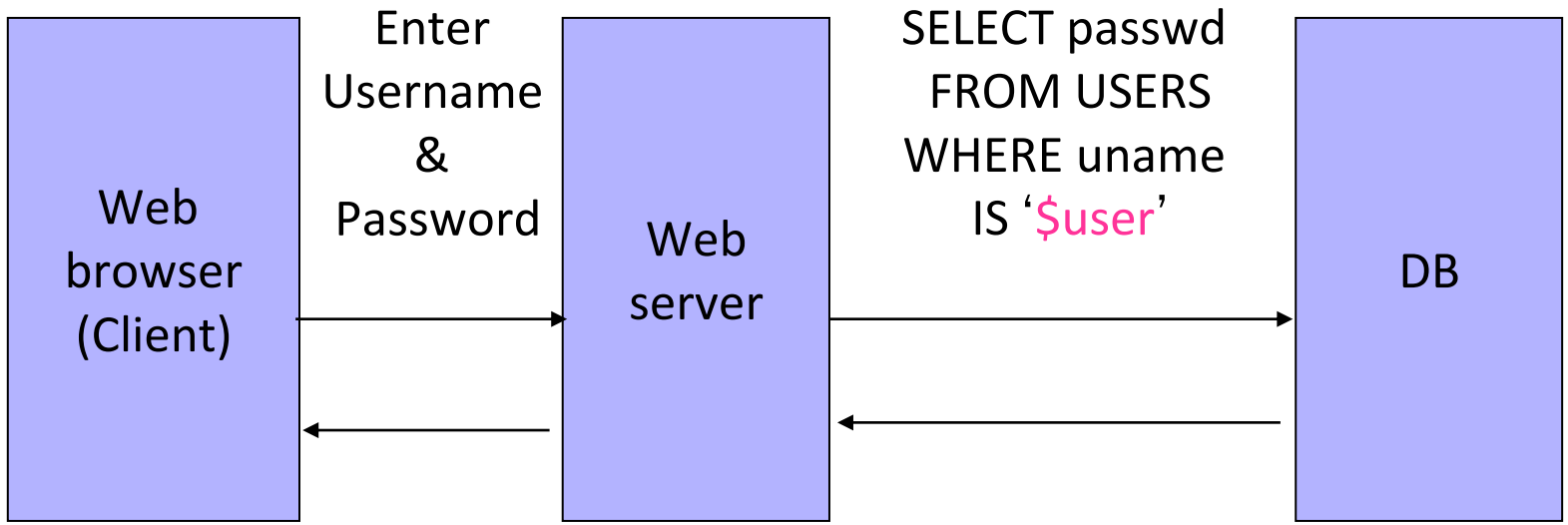


Typical Query Generation Code

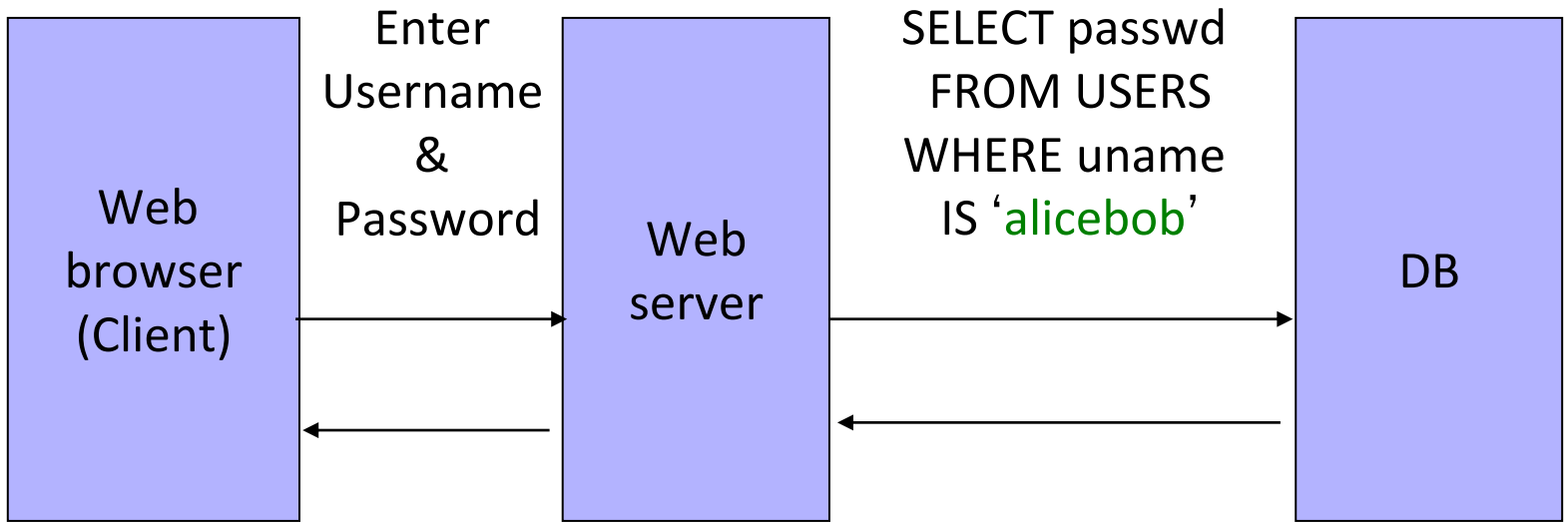
```
$selecteduser = $_GET['user'];
$sql = "SELECT Username, Key FROM Key " .
        "WHERE Username='$selecteduser'";
$rs = $db->executeQuery($sql);
```

What if **‘user’** is a malicious string that changes the meaning of the query?

User Input Becomes Part of Query

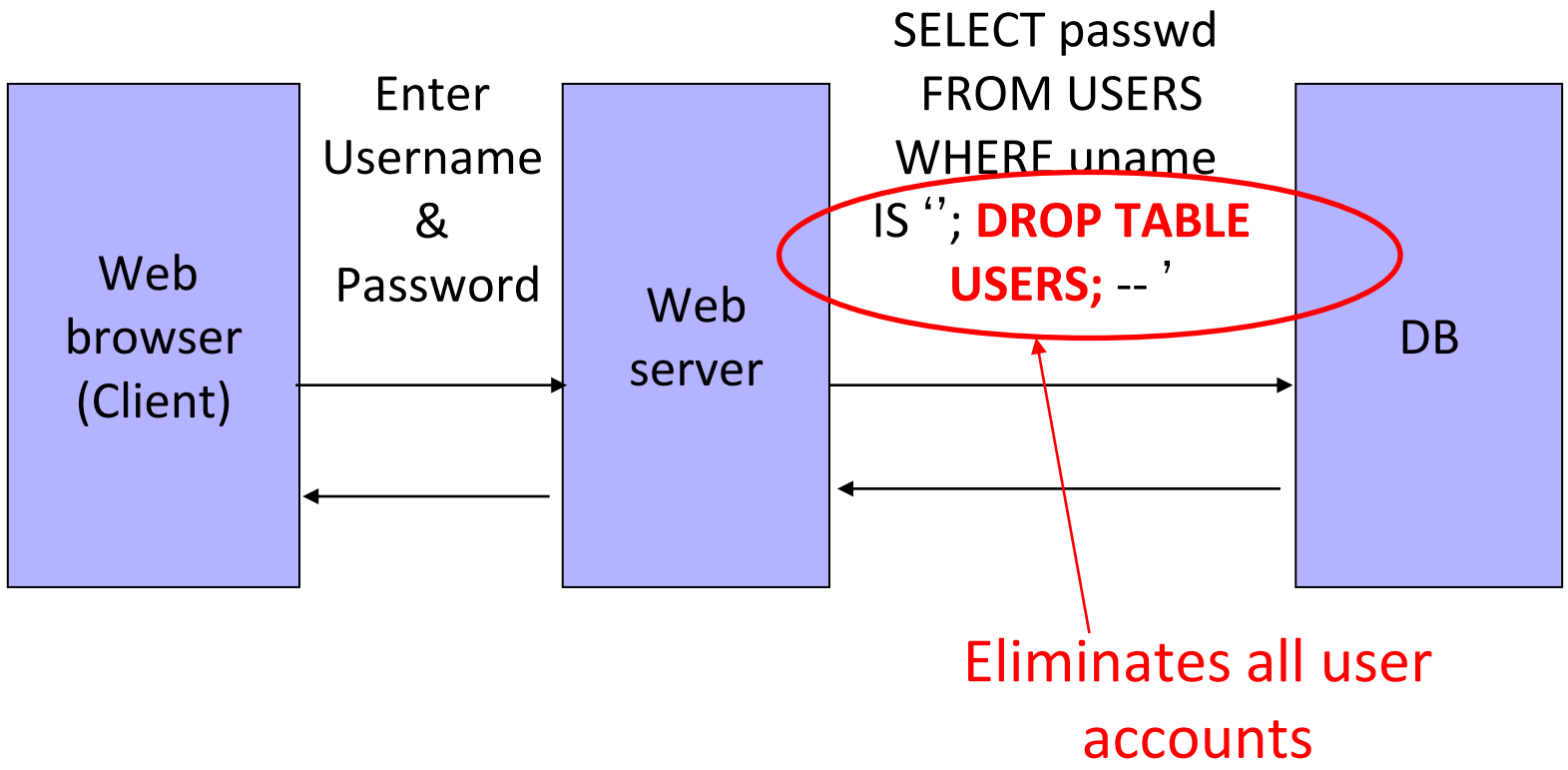


Normal Login

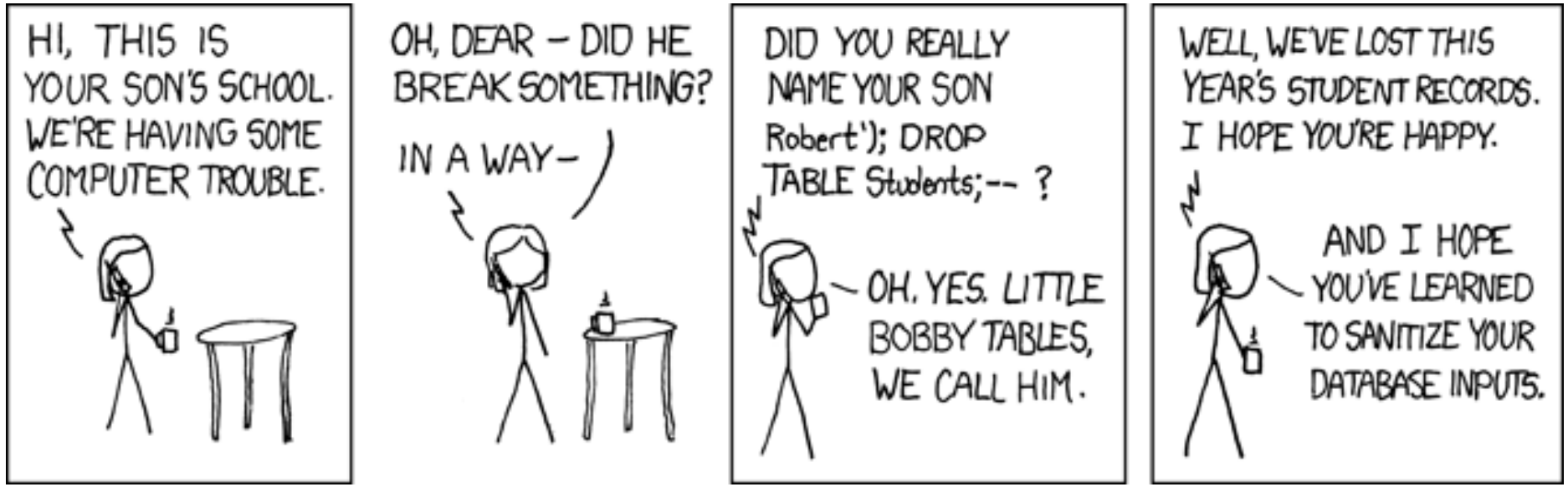


Malicious User Input

SQL Injection Attack

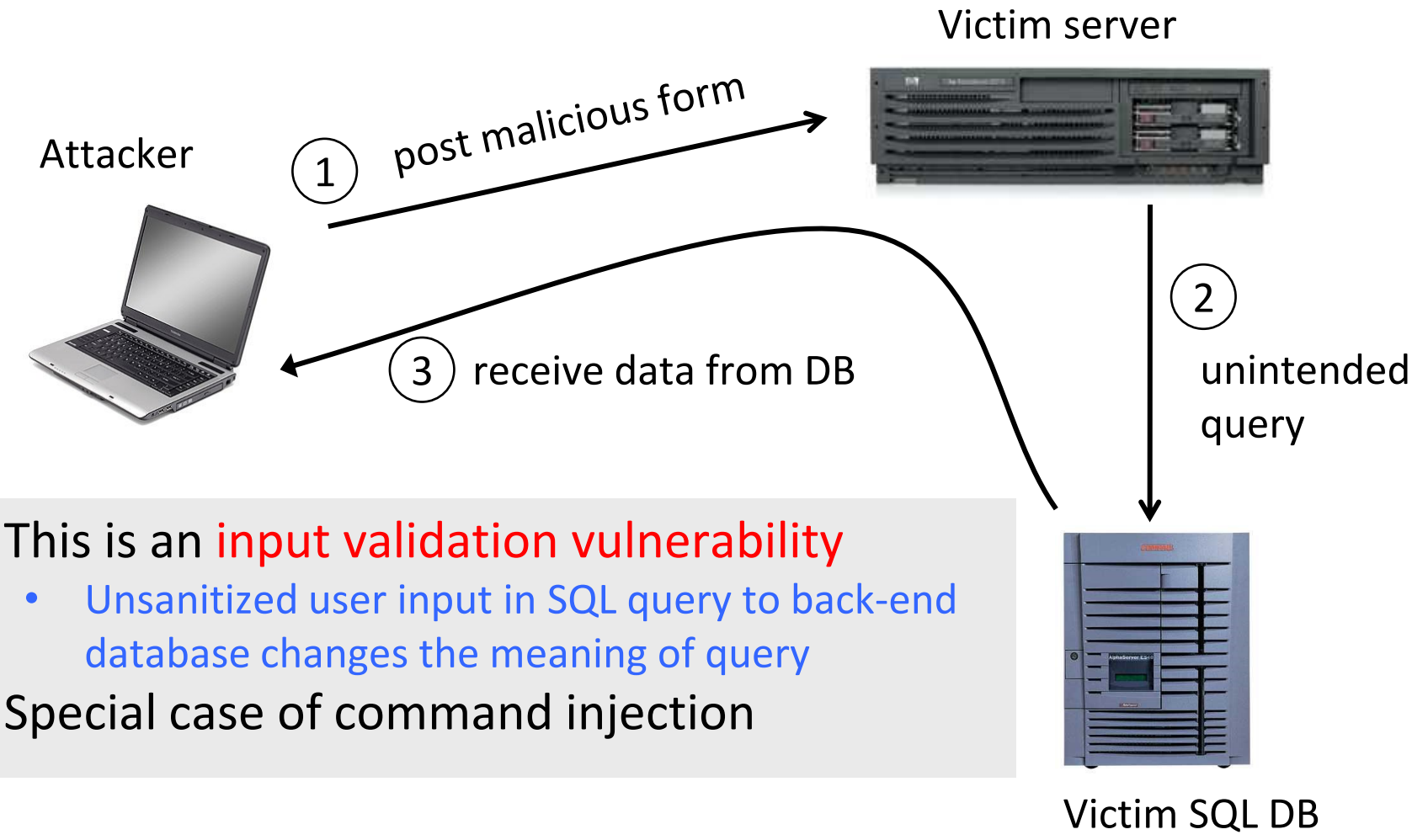


XKCD



http://xkcd.com/327/

SQL Injection: Basic Idea

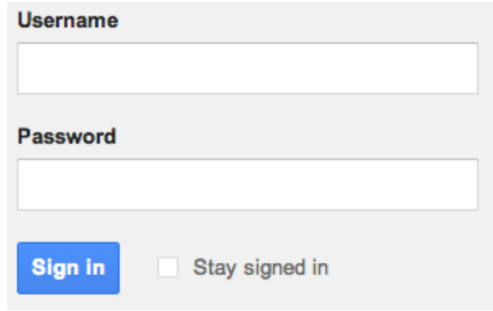


- This is an input validation vulnerability
  - Unsanitized user input in SQL query to back-end database changes the meaning of query
- Special case of command injection

Authentication with Backend DB

(*) remember to hash passwords for real authentication scheme

```
set UserFound = execute(
    "SELECT * FROM UserTable WHERE
    username= ' " & form("user") & " ' AND
    password= ' " & form("pwd") & " ' ");
```



User supplies username and password, this SQL query checks if user/password combination is in the database

```
If not UserFound.EOF
    Authentication correct
  else Fail
```

Only true if the result of SQL query is not empty, i.e., user/pwd is in the database

Breakout

Using SQL Injection to Log In

- User gives username **’ OR 1=1 --**
- Web server executes query

```
set UserFound=execute(
    SELECT * FROM UserTable WHERE
    username= ‘ ’ OR 1=1 -- … );
```

Always true!

Everything after -- is ignored!

- Now all records match the query, so the result is not empty ⇒ correct “authentication”!

“Blind SQL Injection” https://owasp.org/www-community/attacks/Blind_SQL_Injection

- SQL injection attack where attacker asks database series of true or false questions
- Used when
  - the database does not output data to the web page
  - the web shows generic error messages, but has not mitigated the code that is vulnerable to SQL injection.
- SQL Injection vulnerability more difficult to exploit, but not impossible.

Preventing SQL Injection

- Validate all inputs
  - Filter out any character that has special meaning
    - Apostrophes, semicolons, percent, hyphens, underscores, …
    - Use escape characters to prevent special characters form becoming part of the query code
      - E.g.: escape(O'Connor) = O\'Connor
  - Check the data type (e.g., input must be an integer)
- Same issue as with XSS: is there anything accidentally not checked / escaped?

Prepared Statements

```
PreparedStatement ps =
    db.prepareStatement("SELECT pizza, toppings, quantity, order_day "
                + "FROM orders WHERE userid=? AND order_month=?");
ps.setInt(1, session.getCurrentUserId());
ps.setInt(2, Integer.parseInt(request.getParamenter("month")));
ResultSet res = ps.executeQuery();
```

- Bind variables: placeholders guaranteed to be data (not code)
- Query is parsed without data parameters
- Bind variables are typed (int, string, …)

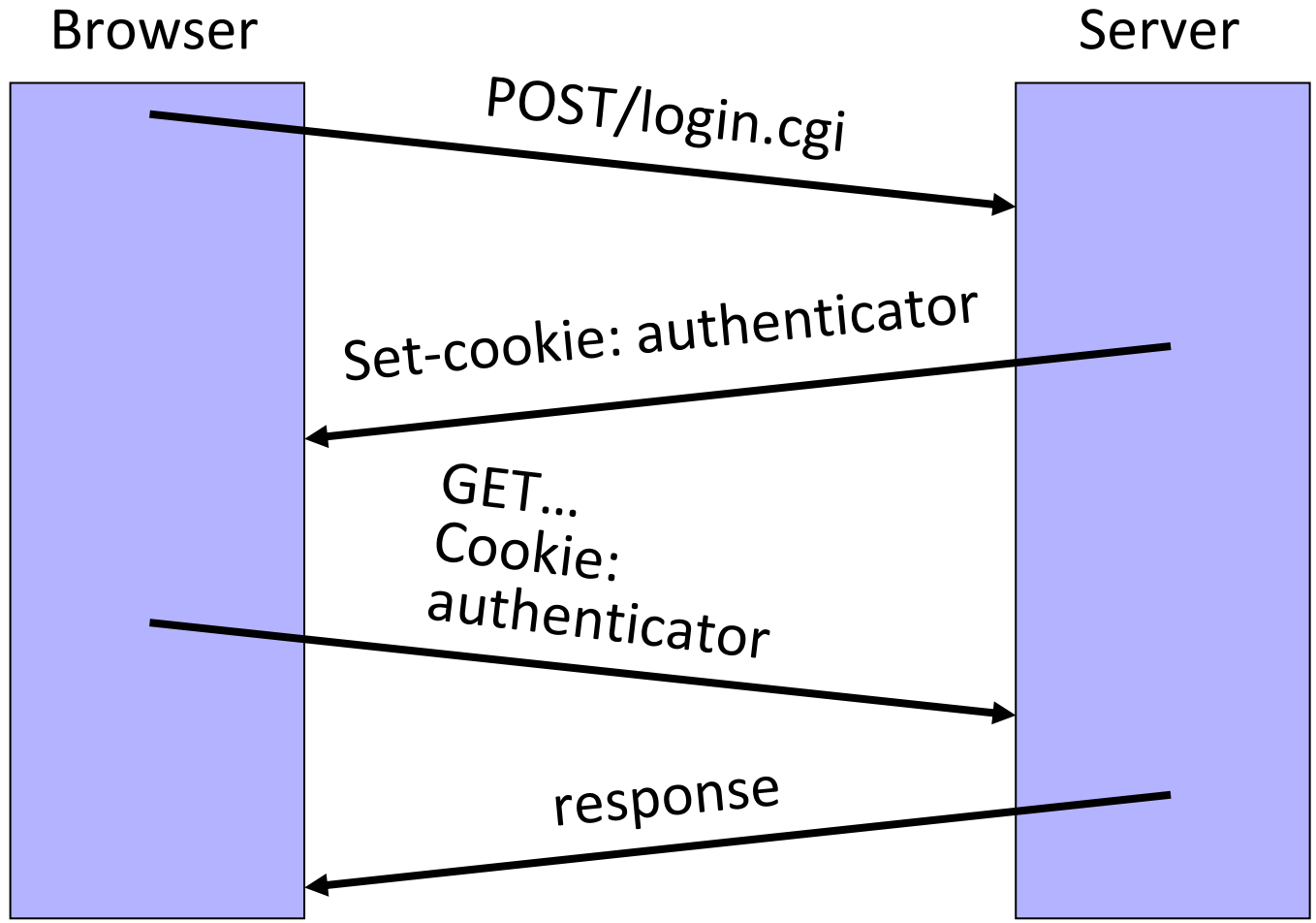
http://java.sun.com/docs/books/tutorial/jdbc/basics/prepared.html

Data-as-code

- XSS
- SQL Injection
- (Like buffer overflows)

Cross-Site Request Forgery (CSRF/XSRF)

Cookie-Based Authentication Review



Browser Sandbox Review

- Based on the same origin policy (SOP)
- Active content (scripts) can send anywhere!
  - For example, can submit a POST request
  - Some ports inaccessible -- e.g., SMTP (email)
- Can only *read* response from the *same origin*
  - … but you can do a lot with just sending!

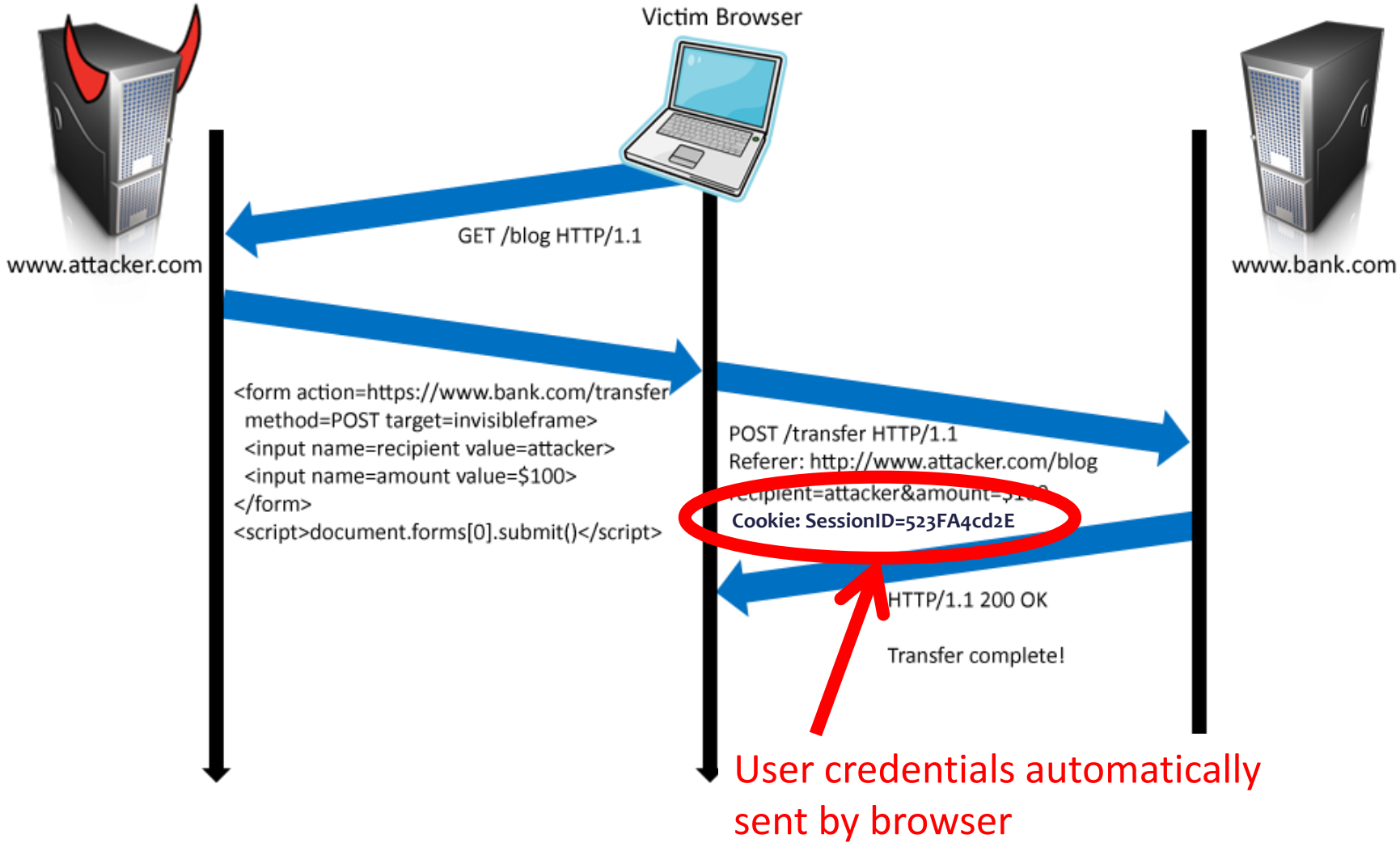
Cross-Site Request Forgery

- Users logs into bank.com, forgets to sign off
  - Session cookie remains in browser state
- User then visits a malicious website containing

```
<form  name=BillPayForm
action=http://bank.com/BillPay.php>
<input  name=recipient  value=attacker> …
<script> document.BillPayForm.submit(); </script>
```

- Browser sends cookie, payment request fulfilled!
- Lesson: cookie authentication is not sufficient when side effects can happen

Cookies in Forged Requests

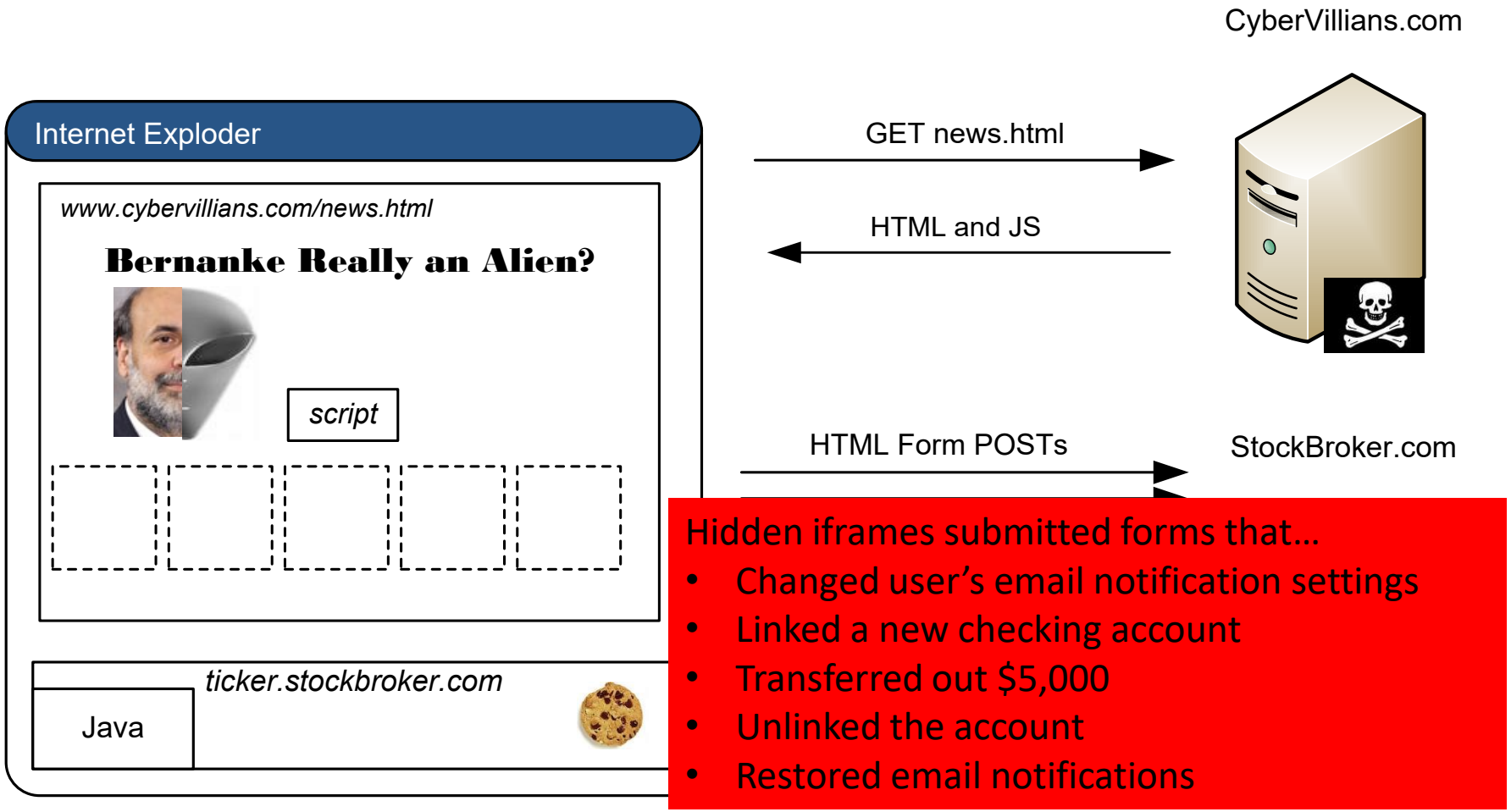


Impact

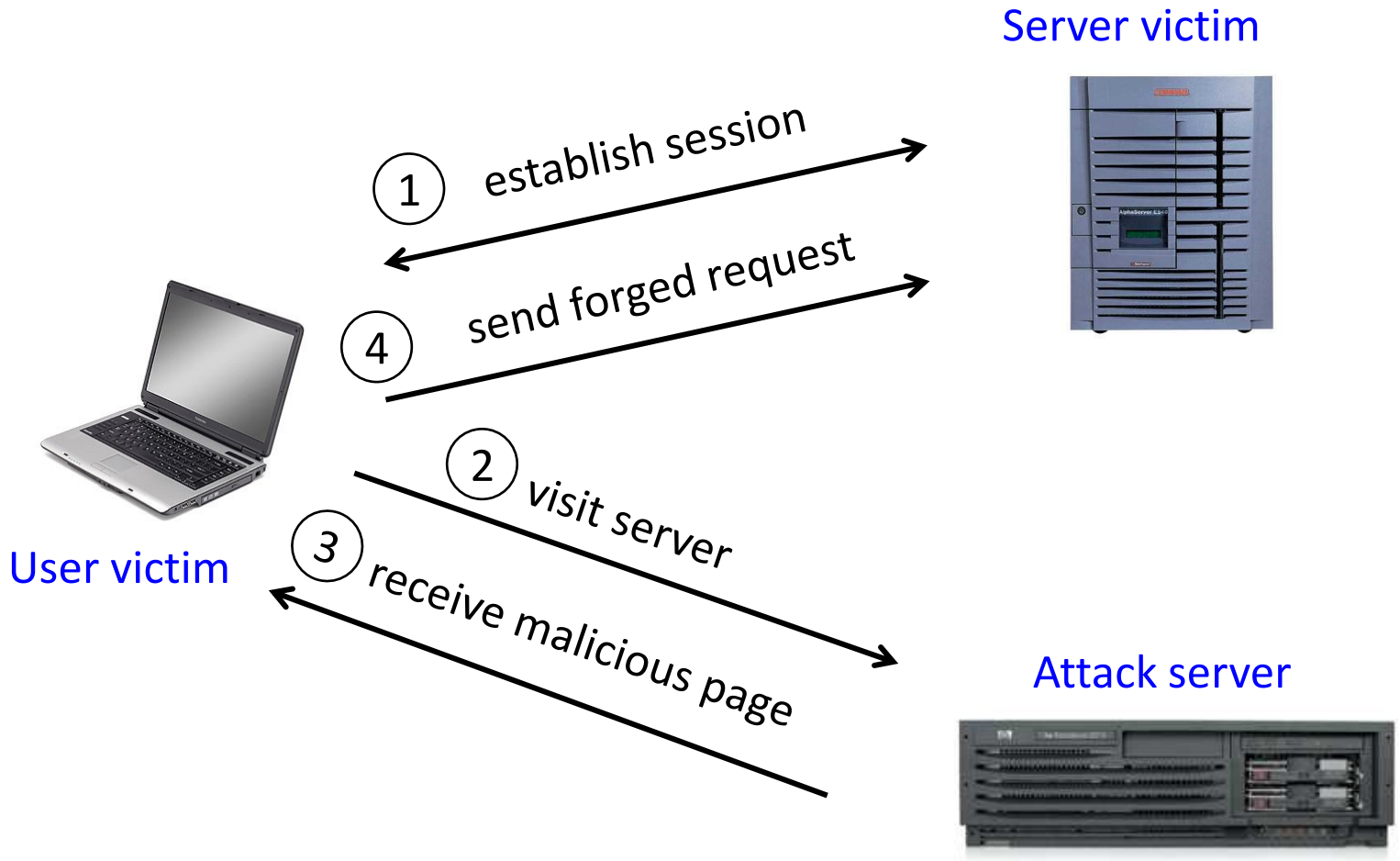
- Hijack any ongoing session (if no protection)
  - Netflix: change account settings, Gmail: steal contacts, Amazon: one-click purchase
- Reprogram the user's home router
- Login to the *attacker's* account
  - Why?

XSRF True Story

[Alex Stamos]



XSRF (aka CSRF): Summary



Q: how long do you stay logged on to Gmail? Financial sites?

Broader View of XSRF

- Abuse of cross-site data export
  - SOP does not control data export
  - Malicious webpage can initiates requests from the user's browser to an honest server
  - Server thinks requests are part of the established session between the browser and the server (automatically sends cookies)

XSRF Defenses

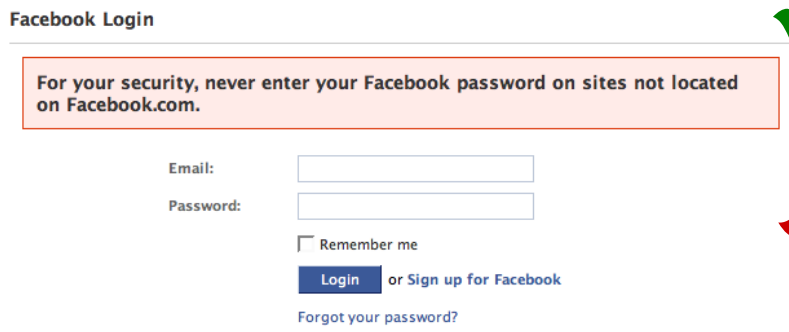
- Secret validation token

<input type=hidden value=23a3af01b>

- Referer validation

Referer:
http://www.facebook.com/home.php

Referer Validation



Referer:
http://www.facebook.com/home.php

Referer:
http://www.evil.com/attack.html

Referer:

- Lenient referer checking – header is optional
- Strict referer checking – header is required

Why Not Always Strict Checking?

- Why might the referer header be suppressed?
  - Stripped by the organization's network filter
  - Stripped by the local machine
  - Stripped by the browser for HTTPS → HTTP transitions
  - User preference in browser
  - Buggy browser
- Web applications can't afford to block these users
- **Many web application frameworks include CSRF defenses today**

Add Secret Token to Forms

```
<input type=hidden value=23a3af01b>
```

- "Synchronizer Token Pattern"
- Include a secret challenge token as a hidden input in forms
  - Token often based on user's session ID
  - Server must verify correctness of token before executing sensitive operations
- Why does this work?
  - **Same-origin policy:** attacker can't read token out of legitimate forms loaded in user's browser, so can't create fake forms with correct token