Web Application Security

Security, XSS, SQL Injection, CSRF, Parameter Tampering, CORS

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Common Web App Security Problems

XSS, SQL Injection, CSRF, Parameter Tampering

Most Common Web Security Problems

- **SQL** Injection
- Cross-site Scripting (**XSS**)
- URL/HTTP manipulation attacks (**Parameter Tampering**)
- Cross-site Request Forgery (**CSRF**)
- **DoS**, **DDoS** and **Brute Force attacks**
- Too much **information** in Errors

```
Fatal error: Uncaught exception 'Exception' with message 'Lost connection to
MySQL server during query' in /home/www/bdz.bg/www/m/db/database.inc.php:44
Stack trace: #0 /home/www/bdz.bg/www/m/db/mysql_database.inc.php(31): Database-
>ThrowException('Lost connection...') #1 /home/www/bdz.bg/www/m/commit.php(26):
MySqlDatabase->Connect('213.222.56.138', 'new', 'mobile_guide', 'mobile%BDZ')
#2 {main} thrown in /home/www/bdz.bg/www/m/db/database.inc.php on line 44
```

- Security flows in other software we use

https://owasp.org/Top10
https://www.exploit-db.com

Other Security Threats

- Semantic **URL/HTTP attacks** (URL/HTTP manipulation)
  - Always validate the data on the server-side
- **Man in the Middle** (Always use SSL)
- **Insufficient Access Control**
- Other types of **data injection** (Always sanitize data)
- **Phishing** and **Social Engineering** (Educate your users)
- **Security flows** in other software we use (Use latest versions)

Security Fundamentals

- There is a wide range of known types of threats and attacks

Category	Threats / Attacks
Input Validation	Buffer overflow, cross-site scripting, SQL injection, canonicalization
Parameter Tampering	Query string manipulation, form field manipulation, cookie manipulation, HTTP header manipulation
Session Management	Session hijacking, session replay, man-in-the-middle
Cryptography	Poor key generation or key management, weak or custom encryption
Sensitive Information	Access sensitive code or data in storage, network eavesdropping, code/data tampering, **Admin password in exceptions**
Exception Management	Information disclosure, denial of service

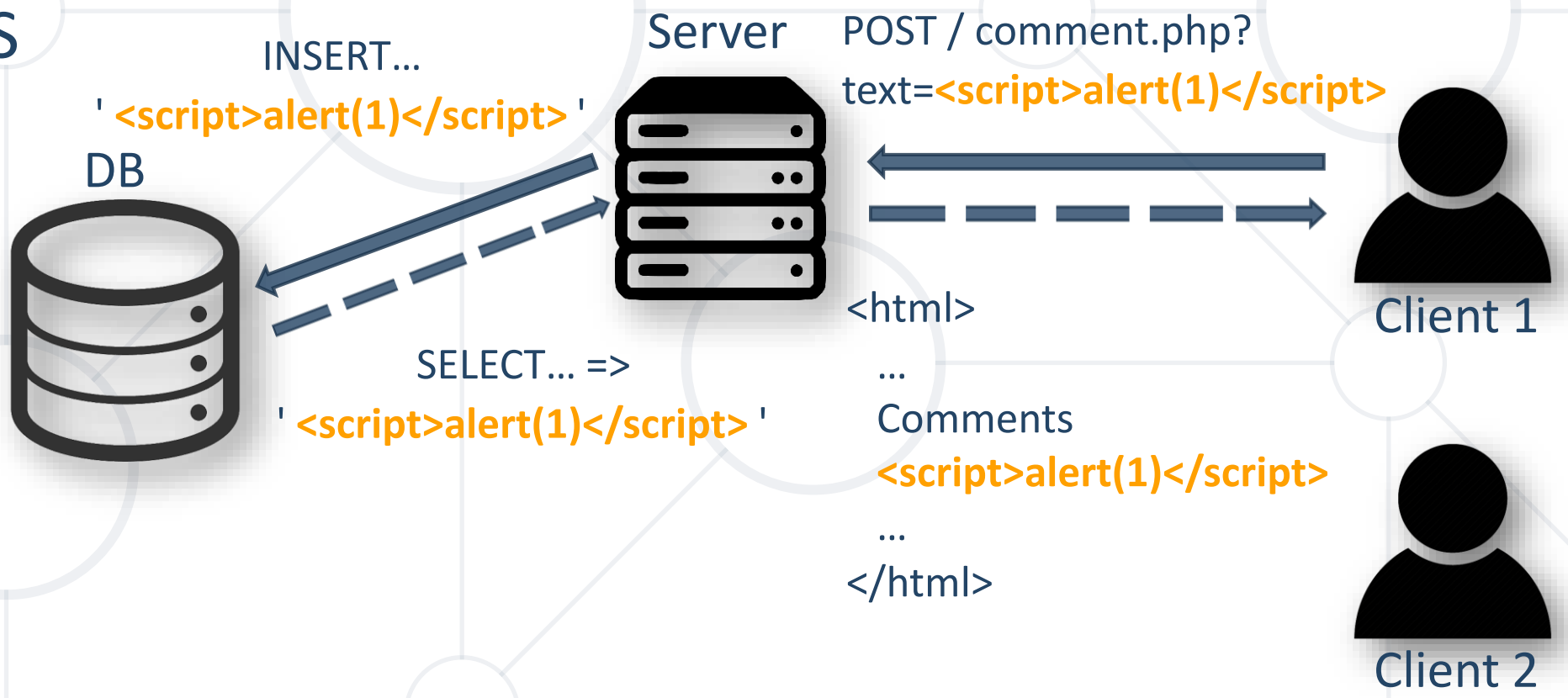
- There is an even wider range of unknown threats and attacks…

Cross Site Scripting (XSS)

Injecting Unsafe HTML Code (with Scripts)

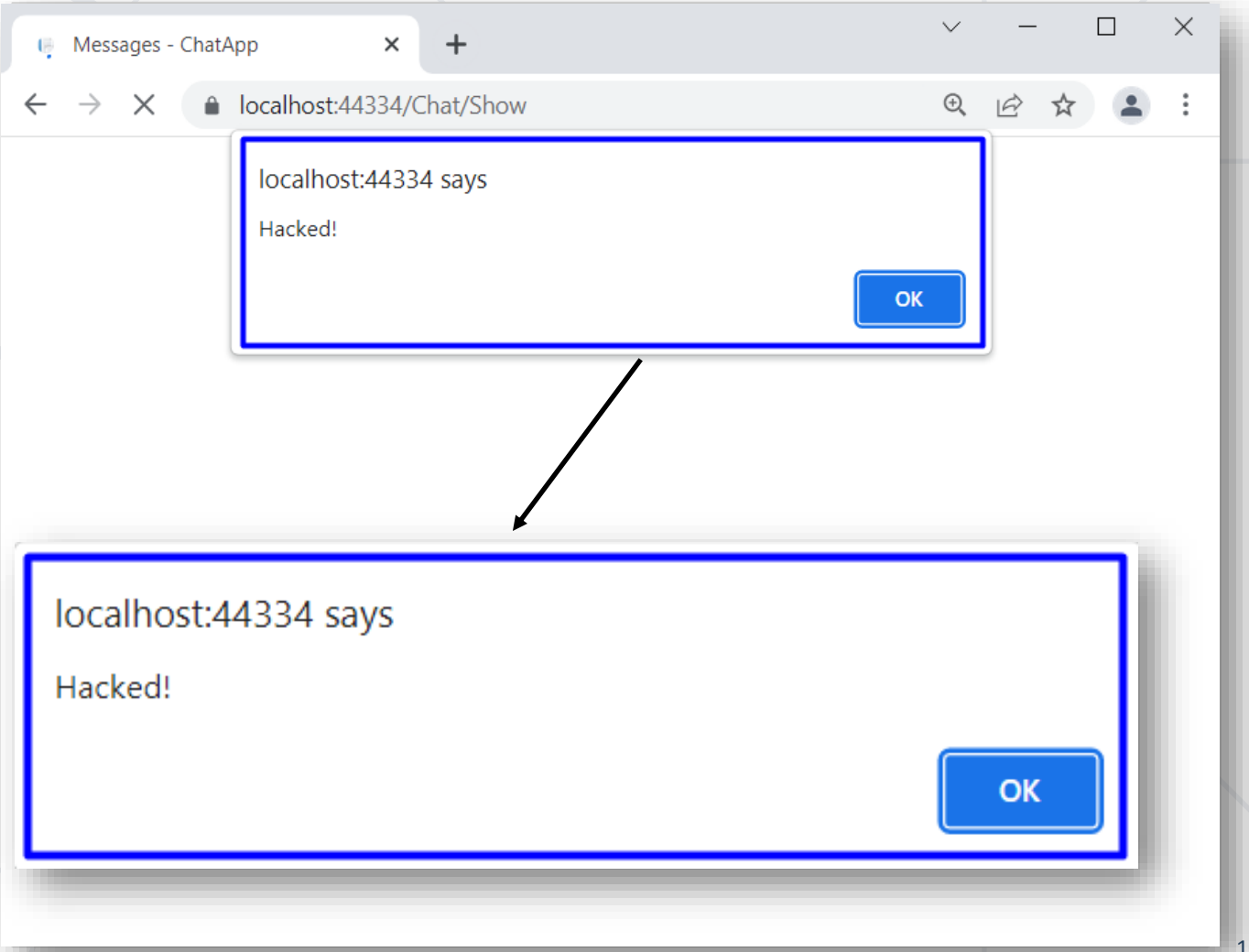
What is Cross Site Scripting (XSS)?

- **XSS** attacks enable attackers to inject **client-side scripts** into **web pages** viewed by users
  - Server XSS
  - Client XSS



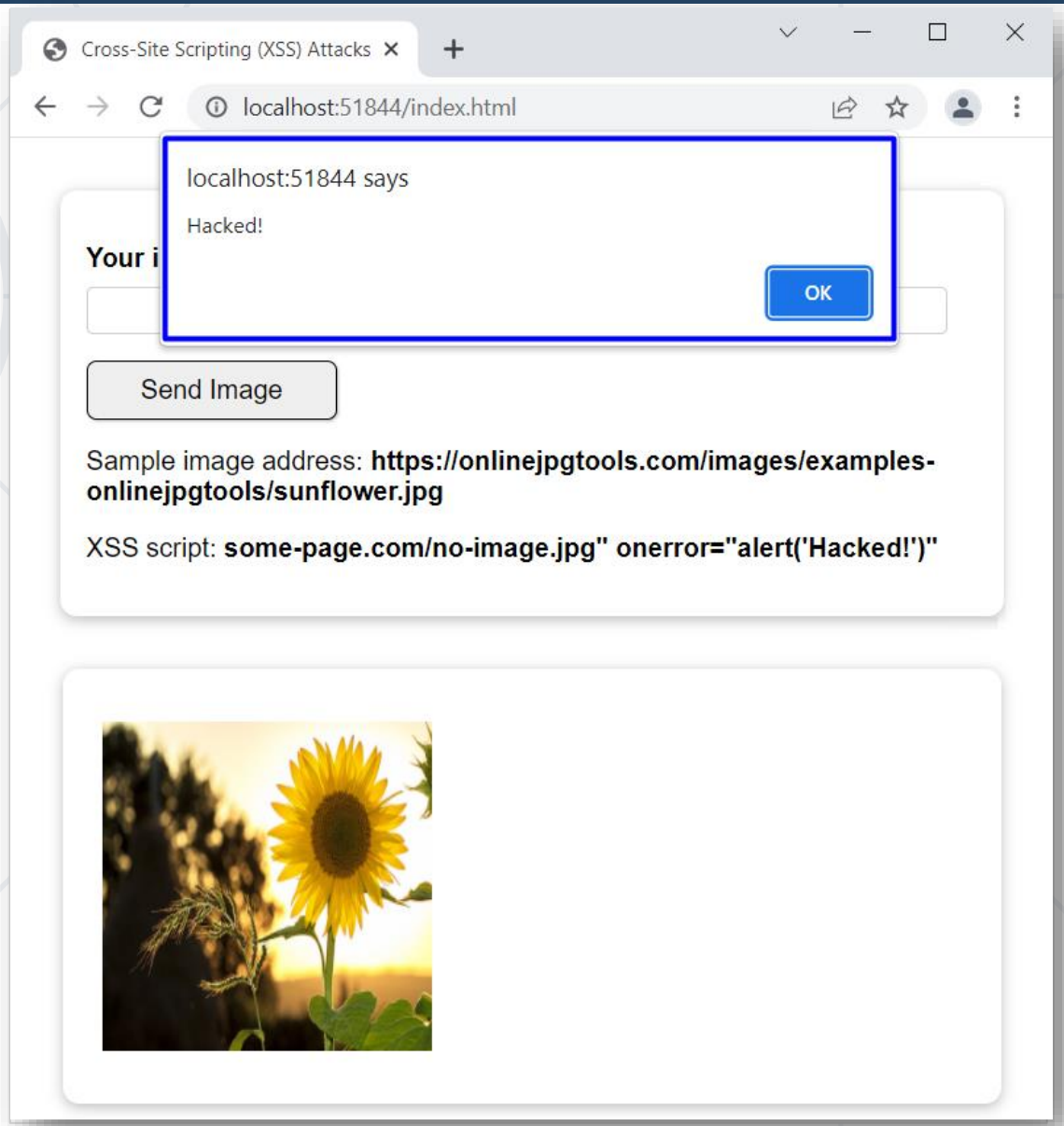
Cross Site Scripting (XSS) – Demo

- We have a **vulnerable** ASP.NET Core chat app
  - User adds "`<script>alert('Hacked!')</script>`"
  - Then, a JS popup appears
- Demo code: see the resources



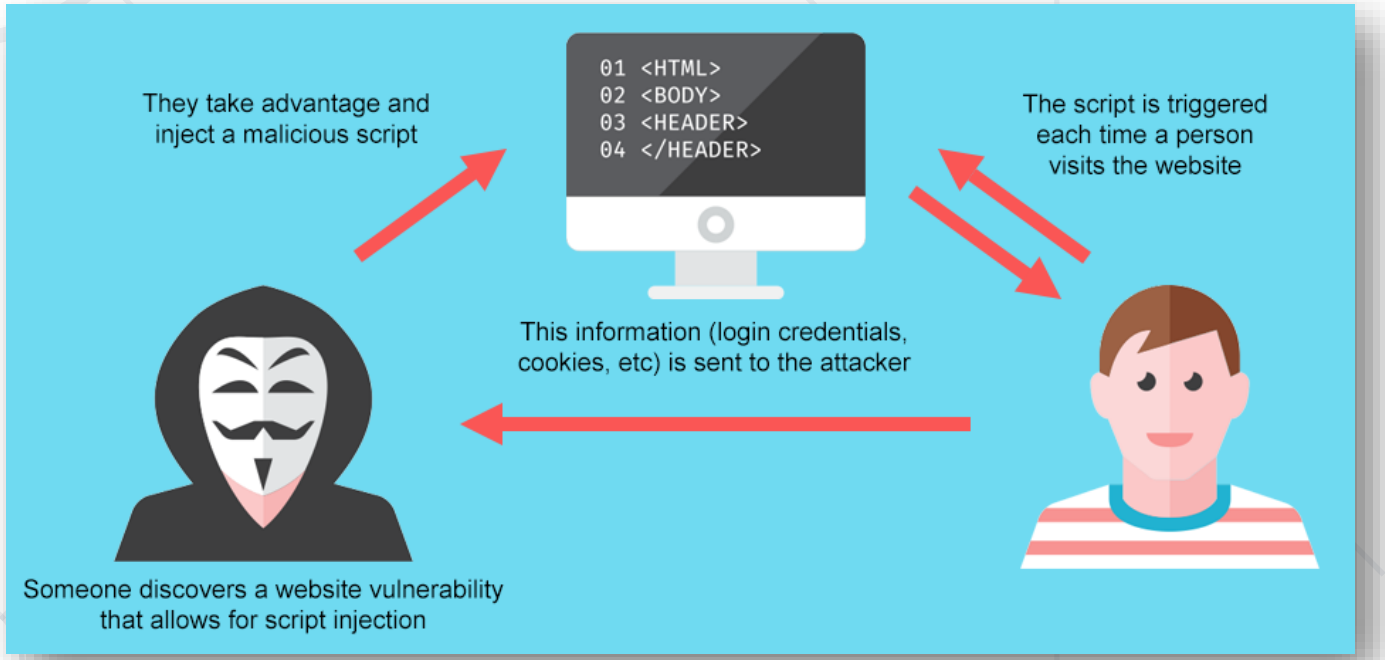
Cross Site Scripting (XSS) with Image – Demo

- We have a vulnerable JS images app
  - User adds an invalid image URL and an **onclick event with a JS script**
  - Then, a JS popup appears
- Demo code: see the resources



Why is XSS a Big Security Problem?

- Attackers can
  - **Steal cookies**, **session storage**, local storage, etc.
  - **Impersonate you**, e. g. "create a new admin user"
  - Perform **actions** on behalf of the user
  - Gain access to the **user's sensitive data**
  - Etc.



Protecting from XSS in ASP.NET MVC

- **The Razor view engine** secures you against **XSS** by default
  - If you decide to break it – **`@Html.Raw(…)`**

```
<td>
    @Html.Raw(item.Address)
    @*@Htm
</td>
```

IHtmlString HtmlHelper.Raw(string value)
Returns markup that is not HTML encoded.

- There are several **rules** you must follow to be secured
  - Never put **untrusted data** into your HTML output
  - Before putting untrusted data somewhere, ensure it is **secured**
    - Encoded, parsed, validated, checked for malicious contents
  - Untrusted data can be inputted anywhere in the application
    - URLs, HTML Elements, HTML Attributes, JavaScript code etc.

Protecting from XSS in ASP.NET MVC

- **ASP.NET Core** provides you with anything to secure your app
  - **Razor** automatically encodes all output sourced from variables

```
@{ var untrustedInput = "<\"script\">"; }

@untrustedInput
```

```
&lt;&quot;script&quot;&gt;
```

  - You can inject **Encoders** directly to your Views and use them

```
@using System.Text.Encodings.Web;
@inject JavaScriptEncoder encoder;

@{ var untrustedInput = "<\"123\">"; }

<script> document.write("@encoder.Encode(untrustedInput)"); </script>
```

```
<script> document.write("\u003C\u0022123\u0022\u003E"); </script>
```

Protecting from XSS in ASP.NET MVC

- You can also use ASP.NET Core **Encoder Services**
  - HtmlEncoder `<"123">` ➡ `<"123">`
  - JavaScriptEncoder `<"123">` ➡ `u003C\u0022123\u0022\u003E`
  - UrlEncoder `<"123">` ➡ `%3C%22123%22%3E`
- Alternatively, you can use the static methods
  - `WebUtility.HtmlEncode` and `WebUtility.HtmlDecode`
  - `WebUtility.UrlEncode` and `WebUtility.UrlDecode`

HtmlSanitizer

- **HtmlSanitizer** is a .NET library for cleaning HTML fragments and documents from constructs that can lead to XSS attacks
  - https://github.com/mganss/HtmlSanitizer
- Install the HtmlSanitizer NuGet package, then

```
var sanitizer = new HtmlSanitizer();
var html = @"<script>alert('xss')</script><div onload=""alert('xss')"""
    + @"style=""background-color: test"">Test<img src=""test.gif"""
    + @"style=""background-image:
            url(javascript:alert('xss')); margin: 10px""></div>";
var sanitized = sanitizer.Sanitize(html, "http://www.example.com");
Assert.That(sanitized, Is.EqualTo(@"<div style=""background-color: test"">"
    + @"Test<img style=""margin: 10px""
            src=""http://www.example.com/test.gif""></div>"));
```

SQL Injection

Inject SQL Code in Unsafe Database Query

SQL Injection

- The following SQL commands are executed
  - Usual search (**no SQL injection**)

```
SELECT * FROM Messages WHERE MessageText LIKE ‘%JohnSnow%'"
```

  - SQL-injected search (matches **all records**)

```
SELECT * FROM Messages WHERE MessageText LIKE '%%%%'"
```

```
SELECT * FROM Messages WHERE MessageText LIKE '%' or 1=1 --%'"
```

  - SQL-injected **INSERT** command

```
SELECT * FROM Messages WHERE MessageText
LIKE '%'; INSERT INTO Messages(MessageText, MessageDate) VALUES
('Hacked!!!', '1.1.1980') --%'"
```

SQL Injection

- The following SQL commands are executed
  - Usual search (**no SQL injection**)

```
SELECT * FROM Messages WHERE MessageText LIKE ‘%JohnSnow%'"
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  - SQL-injected search (matches **all records**)

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SELECT * FROM Messages WHERE MessageText LIKE '%%%%'"
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```
SELECT * FROM Messages WHERE MessageText LIKE '%' or 1=1 --%'"
```

  - SQL-injected **INSERT** command

```
SELECT * FROM Messages WHERE MessageText
LIKE '%'; INSERT INTO Messages(MessageText, MessageDate)
VALUES ('Hacked!!!', '1.1.1980') --%'"
```

SQL Injection

- Original **SQL Query**

```
String sqlQuery = "SELECT * FROM user WHERE name = '" + username + "'
AND pass='" + password + "'";
```

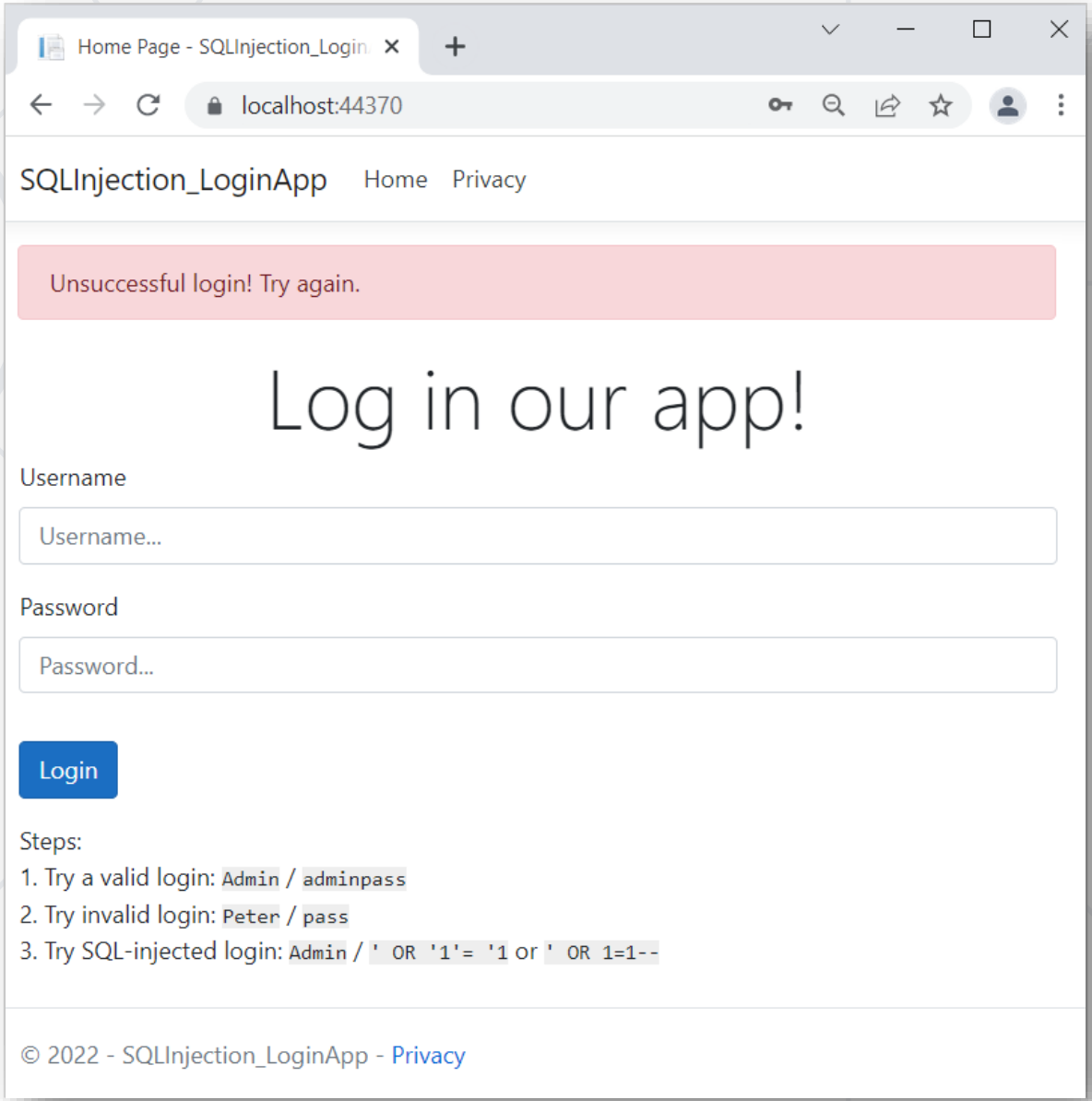
- Setting username to **Admin** & password to **' OR '1'= '1** produces

```
String sqlQuery = SELECT * FROM user WHERE name = 'Admin' AND
pass='' OR '1'='1'
```

- The result
  - The user with **username** – "**Admin**" will login **WITHOUT** password
  - The **pass query** will turn into a **bool** expression which is **always true**

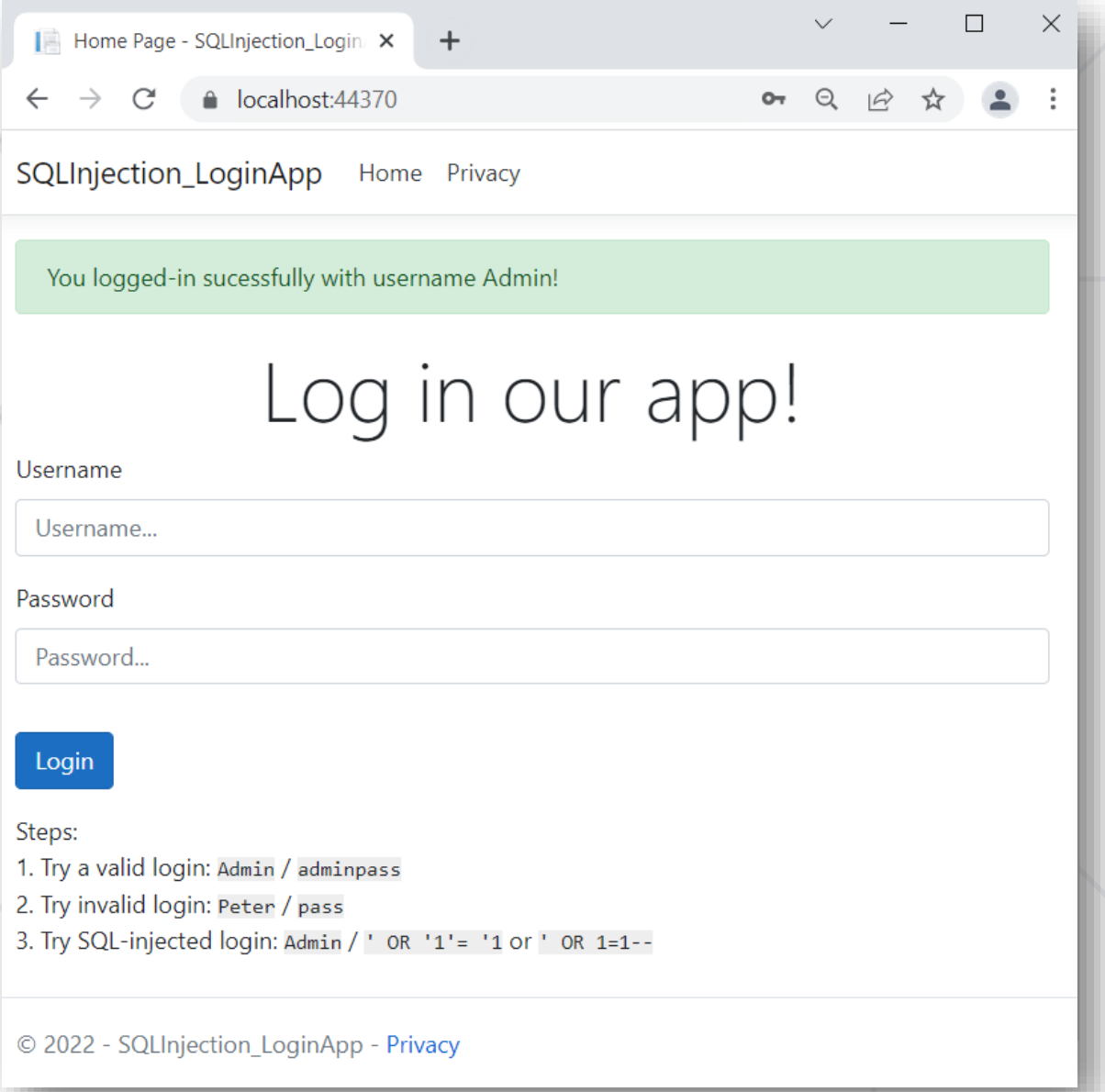
SQL Injection – Demo (Normal Workflow)

- We have a simple app with an SQL-injectable login form
  - You can log in with "**Admin**" / "**adminpass**"
    - A success message appears
  - Other credentials are invalid
    - An error message appears



SQL Injection – Demo

- Use **SQL Injection** to log in with the "Admin" username and **no password**
  - Write **' OR '1'= '1** in the password field
  - Now you are successfully logged-in
- Demo code: see the resources



SQL Injection – How to Protect?

- Don't concatenate SQL with "+"
  - Use **parameterized SQL** queries or **stored procedures**
- Escape and sanitize all **user input**
- Never connect to a database with an **admin-level account**
- Don't store **secrets** in plain text
- **Exceptions** should reveal minimal information

Protect from SQL Injection – Sample Code

- SQL-injection **vulnerable code**

```
string sqlQuery = "SELECT * FROM Users WHERE username = '"
       + user.Username
       + "' AND Password = '"
       + user.Password + "'";

var userExists = this.data.Users.FromSqlRaw(sqlQuery).Any();

if(userExists) …
else …
```

- The same code, rewritten correctly, with **parameterized query**

```
var userExists = this.data.Users
       .Any(u => u.Username == user.Username && u.Password == user.Password);

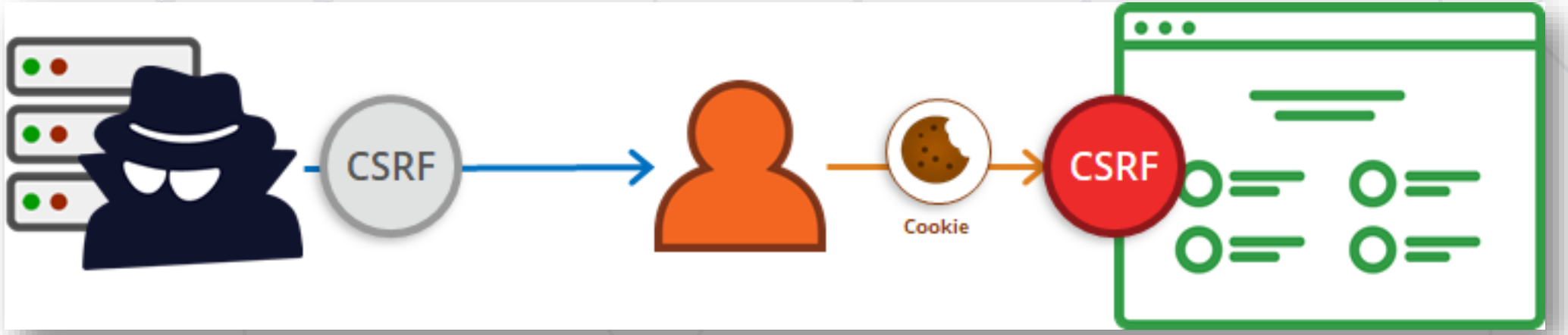
if(userExists) …
else …
```

Cross-Site Request Forgery

Submit a Form on Behalf of Unsuspecting User

Cross-Site Request Forgery

- **Cross-Site Request Forgery** (**CSRF** / **XSRF**) is a web security attack over the HTTP protocol
  - Allows **executing unauthorized commands** on behalf of some user
    - By using his cookies stored in the browser
  - The user has valid permissions to execute the requested command
  - The attacker uses these permissions maliciously, unbeknownst to the user



Cross-Site Request Forgery

- What **Cross-Site Request Forgery** actually is

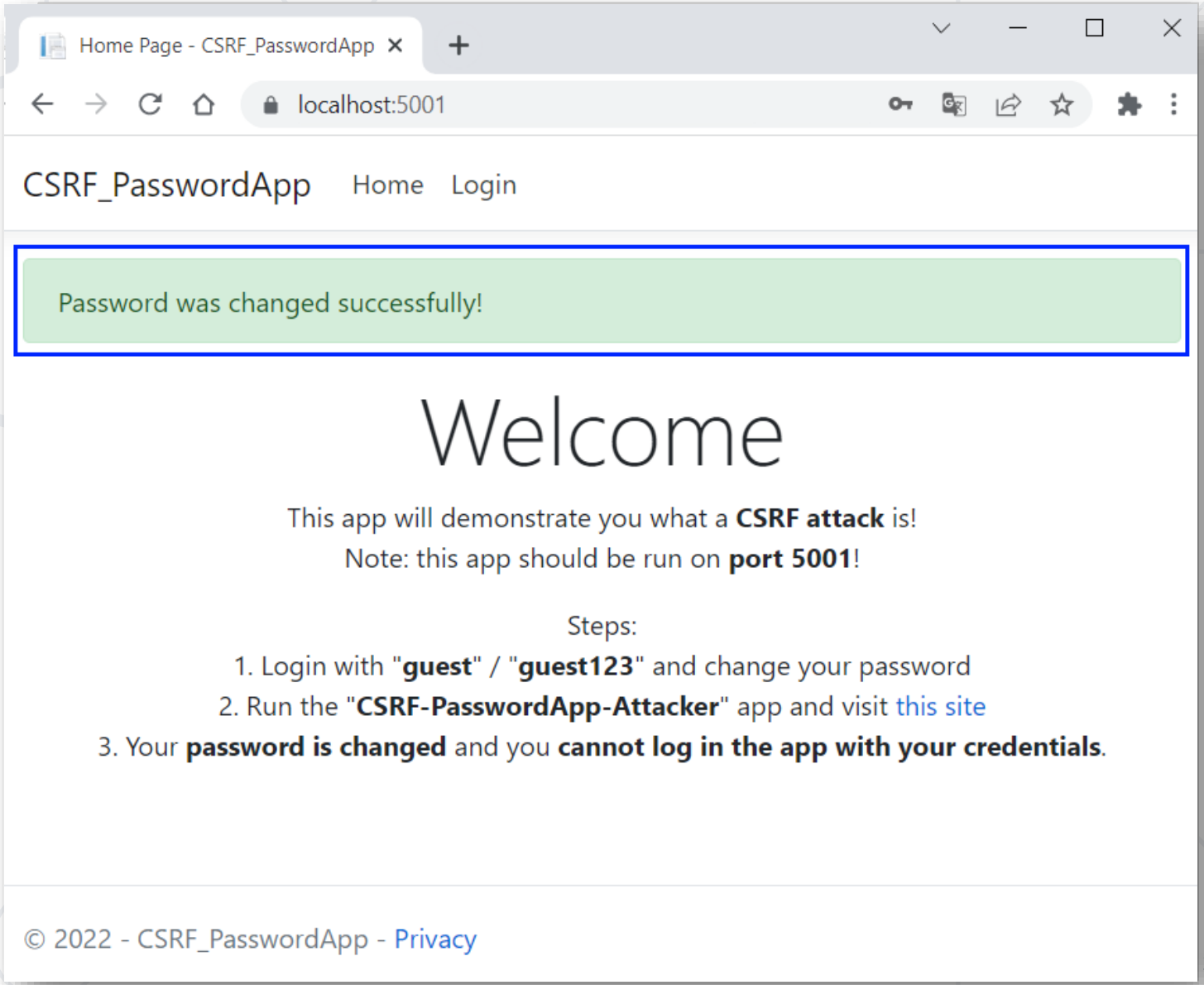
```
<!-- SOME MULTI-COLOR USELESS CLICKBAIT CONTENT -->

<form action="http://good-banking-site.com/api/account" method="post">
    <input type="hidden" name="Transaction" value="withdraw">
    <input type="hidden" name="Amount" value="1000000">
    <input type="submit" value="Click to collect your prize!">
</form>
```

- The user can even **misclick** the button accidentally
  - This will still trigger the attack
  - Security against such attacks is necessary
    - It protects both **your app** and **your clients**

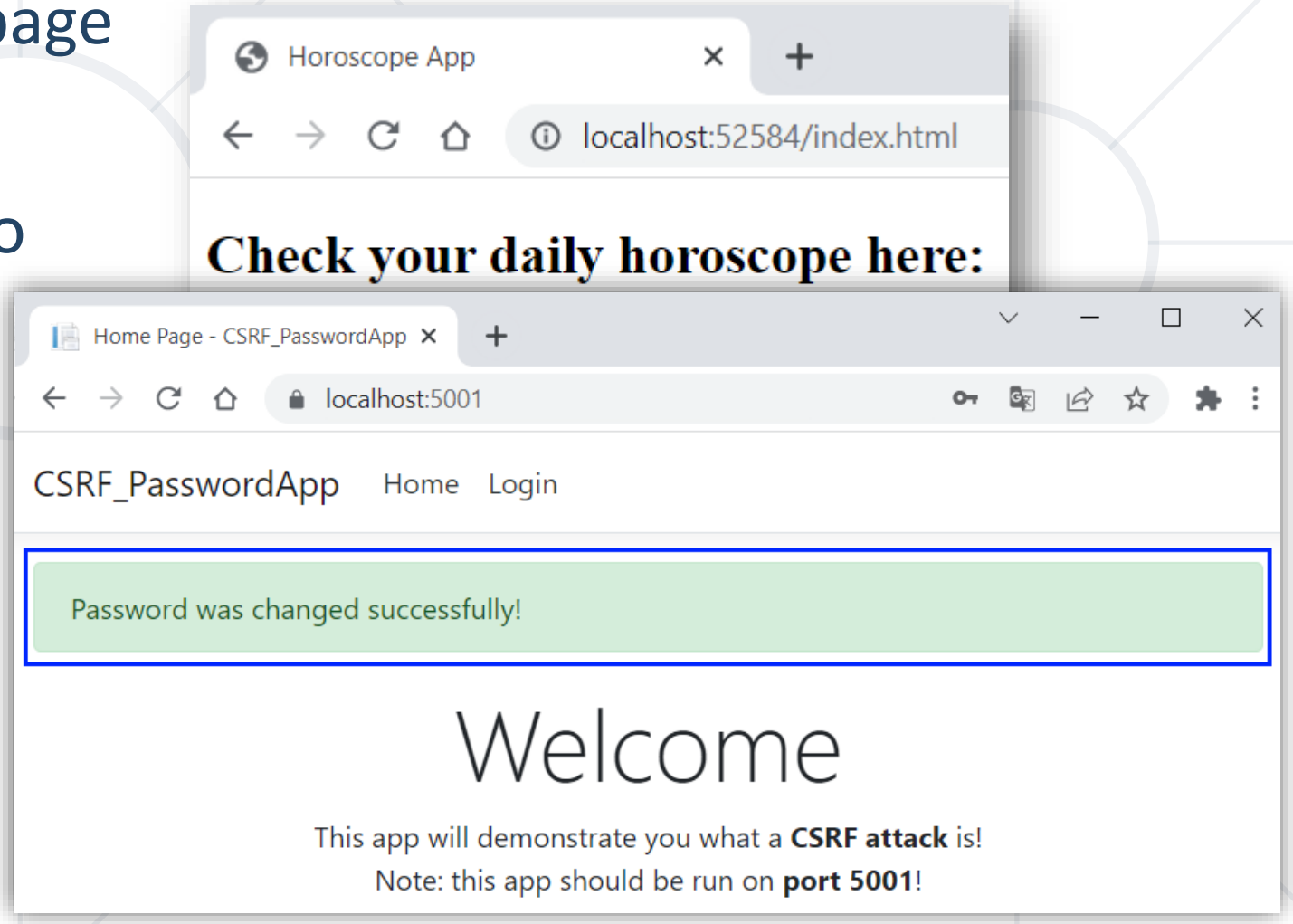
CSRF – Demo (Normal Workflow)

- We have a very simple app, where users can **login and change their password**
  - Without protection for CSRF
  - Access the app on **port 5001**
- Login with default user "**guest**" / "**guest123**"
- Change the password
- You will see a success message on the "Home" page
- Now you can log in with your new password



CSRF – Demo (Attack Workflow)

- Visit the **link** on the "Home" page
  - It accesses a **malicious site**
- Click on the [`Click`] button to **trigger the attack**
- The malicious app **changed your password** through **CSRF**
  - Now you cannot log in with your credentials
  - Your password has changed to "**hacked!**"
- Demo code: see the resources



AutoValidateAntiforgeryToken

- The **<form>** tag helper in ASP.NET Core automatically adds a special hidden field to the form
  - It has a random value called **anti-forgery token**
- Then you should **require this token** to be send
  - For a specific action

```
[AutoValidateAntiforgeryToken]
public IActionResult SendMoney(…) { … }
```

  - For all actions in given controller

```
[AutoValidateAntiforgeryToken]
public class ManageController : Controller
```

  - Globally for the whole application

```
services.AddMvc(options =>
    options.Filters.Add(new AutoValidateAntiforgeryTokenAttribute()));
```

The Anti-Forgery Token in ASP.NET MVC

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Log in

Use a local account to log in.

Email

Password

☐ Remember me?

Log in

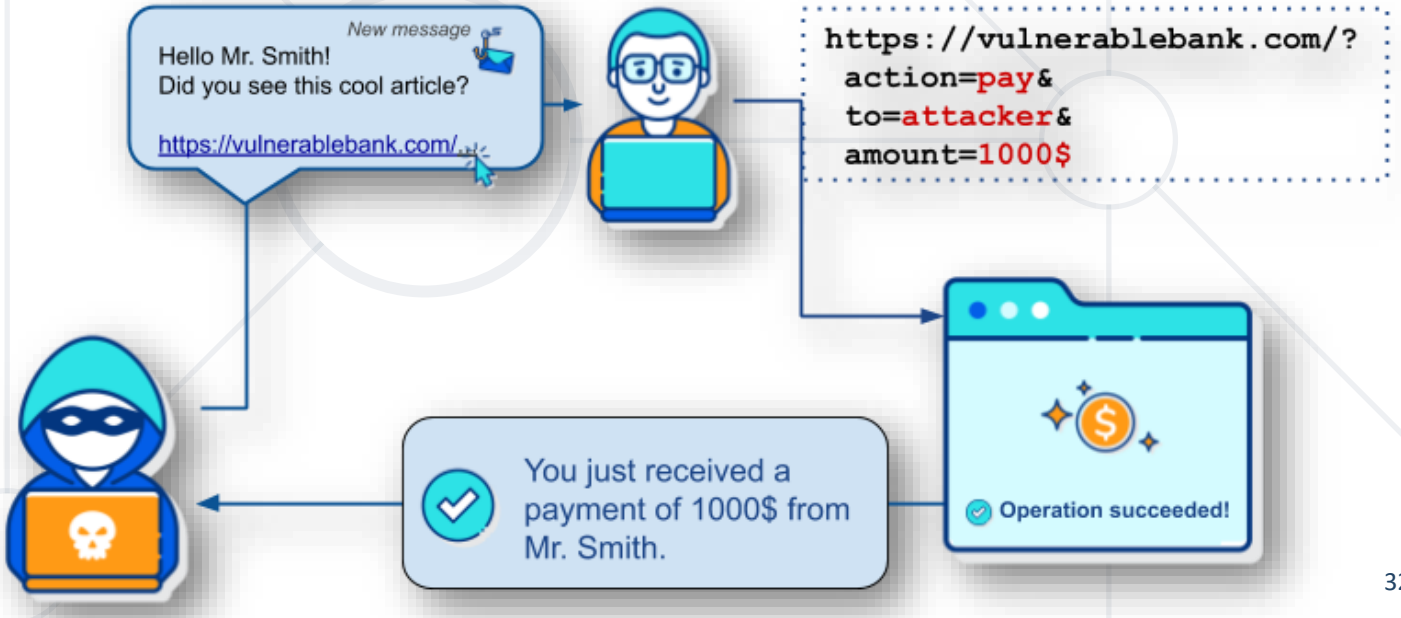
```
▼<form id="account" method="post" novalidate="novalidate">
  <h4>Use a local account to log in.</h4>
  <hr>
  ▶<div class="form-group">…</div>
  ▶<div class="form-group">…</div>
  ▶<div class="form-group">…</div>
  ▶<div class="form-group">…</div>
  ▶<div class="form-group">…</div>
  <input name="__RequestVerificationToken" type="hidden" value=
  "CfDJ8Fksy1R6YXZMqcQ_RDpbjf_9rfRkNZDzbJEuV9iu1gGQEl75WG3KLrozo
  BNQiQZgUMaJ6VC7RBC-TkVBim_TXEvWgm72AF-sYJhd2_euEmTYSkNSPqRsr4e
  21BXkLPOrmbW1Fh4hBcUEiR19gP_5JYY"> == $0
  <input name="Input.RememberMe" type="hidden" value="false">
</form>
```

CSRF: How to Protect?

- Use **anti-forgery token**
- Include **additional authentication** for sensitive actions
- Use the **SameSite** flag in cookies

```
Set-Cookie: CookieName=CookieValue; SameSite=Strict;
```

- Following a **RESTful design**
- Enabling **CORS protection**

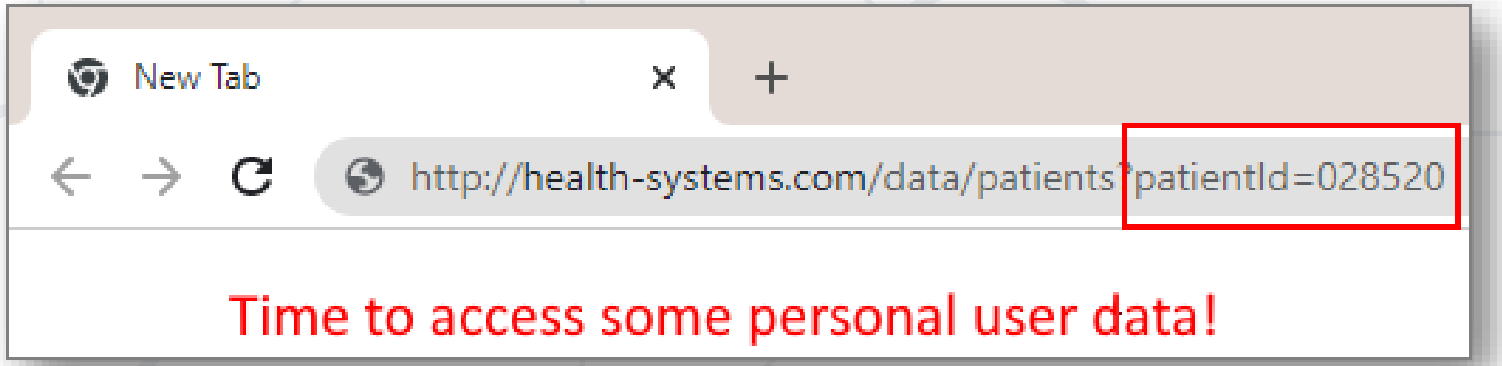


Parameter Tampering

Changing Input Parameters at the Client Side

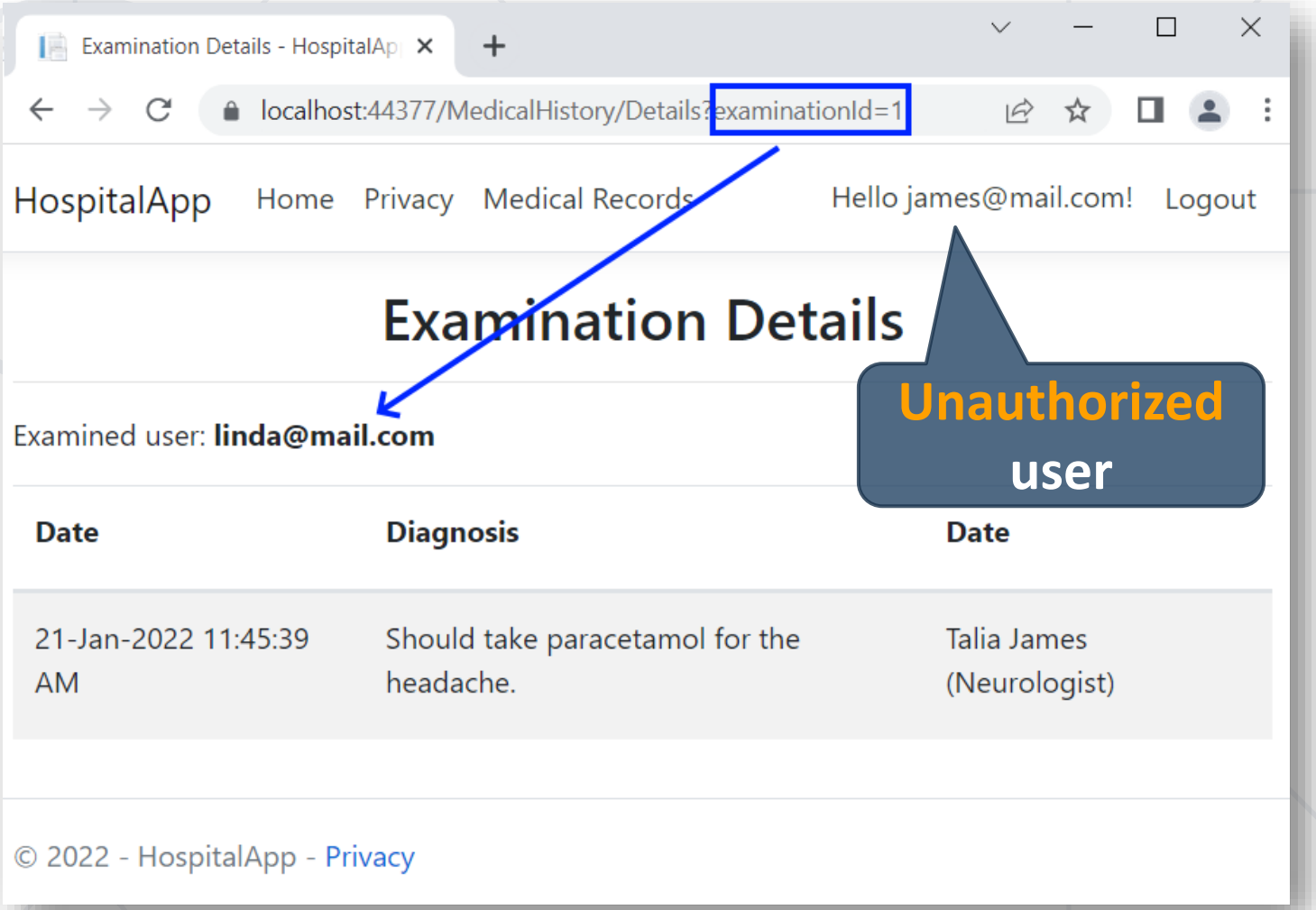
Parameter Tampering

- **Parameter Tampering** is the manipulation of **parameters** exchanged between **client** and **server**
  - Altered query strings, request bodies, cookies
  - Skipped data validations, injected additional parameters



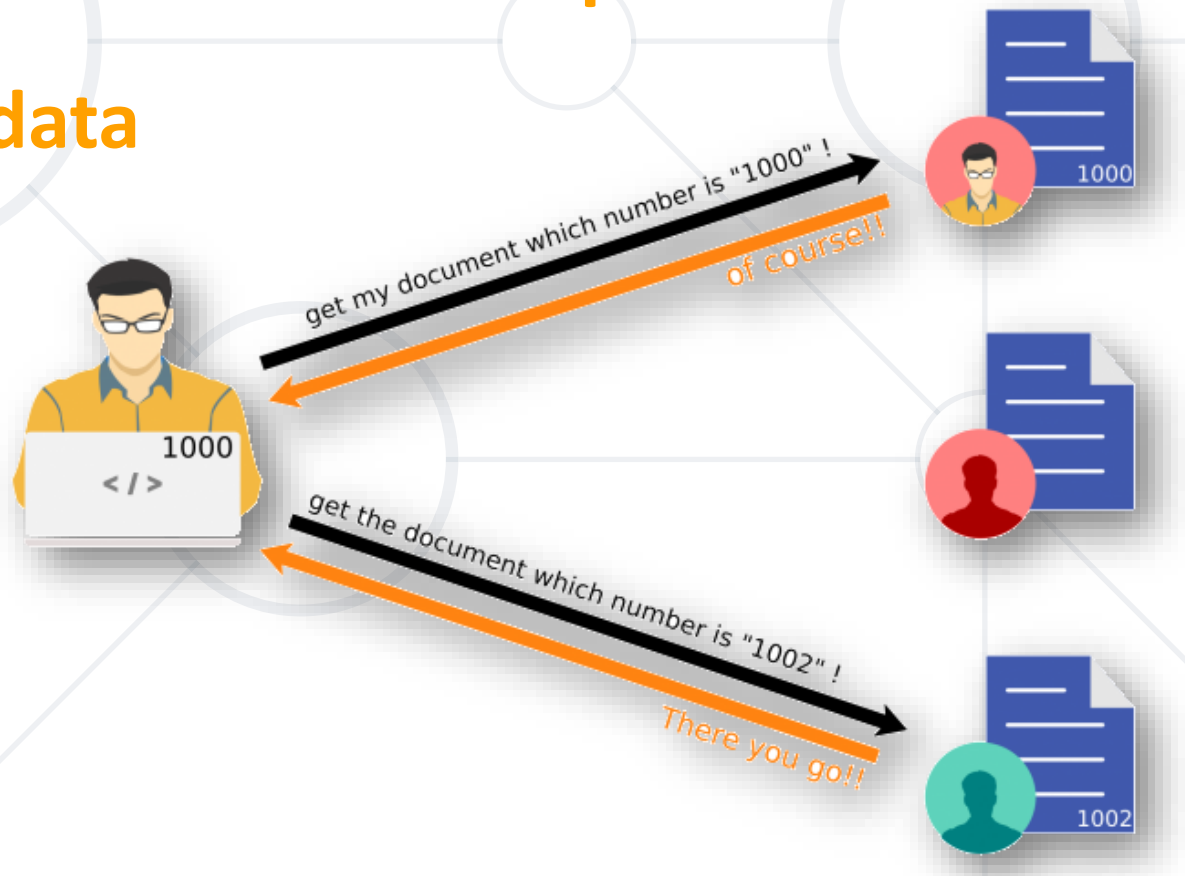
Parameter Tampering – Demo

- We have a simple app, which displays data by ID
  - Without checking the permissions
- A hacker can **change the examination ID** in the URL
  - And **access other users' data**
- Demo code: see the resources



Parameter Tampering: How to Protect?

- Check the **input parameters** before accessing the database
- The **forms** on the site should have some **built-in protection**
- Using regex to limit or **validate data**
- Avoid unwanted or hidden data
- **Encrypt** the session cookies



Protect from Parameter Tampering – Sample Code

- Code, **vulnerable to parameter tampering**

```
var examination = this.data.Examinations.Include(ex => ex.Patient)
   .FirstOrDefault(ex => ex.Id == examinationId);

if(examination == null) return RedirectToAction("Summary");

var currentLoggedUserId = this.User
       .FindFirstValue(ClaimTypes.NameIdentifier);

if (examination.PatientId != currentLoggedUserId) return Unauthorized();

var model = new ExaminationRecord() { … };
return View(model);
```

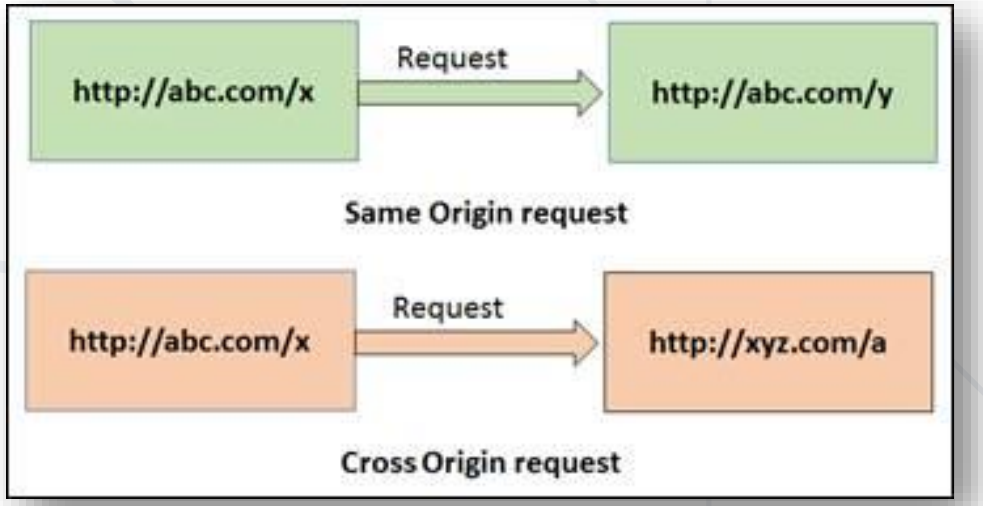
- Add **explicit checks** to secure the code

Cross Origin Resource Sharing

CORS

CORS

- Browser security prevents a web page from making requests to a **domain**, different from the one that served the web page (its **origin**)
  - This restriction is called **S**ame-**O**rigin **P**olicy (**SOP**)
  - This policy also prevents malicious sites from reading data from your site
- Sometimes you might want to allow other sites to bypass this restriction
  - **Cross-origin requests** to your app may become necessary, at some point
  - That's where **C**ross **O**rigin **R**esource **S**haring (**CORS**) comes to the rescue



CORS

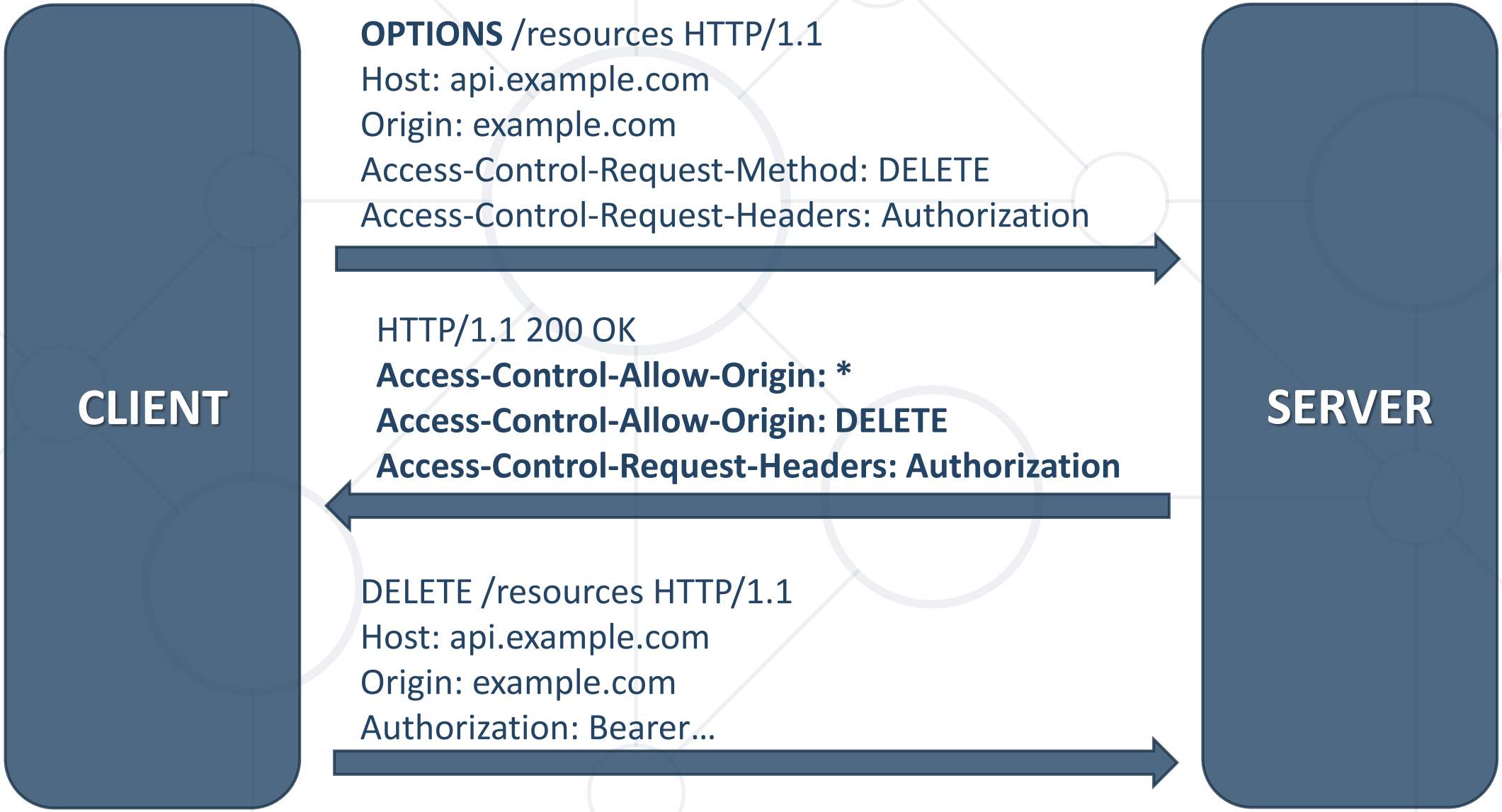
- **CORS** is a **W3C** standard that allows a server to "relax" the **SOP**
  - Using **CORS**, a server can **explicitly** allow some cross-origin requests
  - That doesn't mean all cross-origin requests will be allowed
- Two URLs have the **same origin** if they have
  - Identical **Schemes**, **Hosts** and **Ports** (RFC 6454)

Same-origin URLs

```
https://example.com/foo.html
https://example.com/bar.html
```

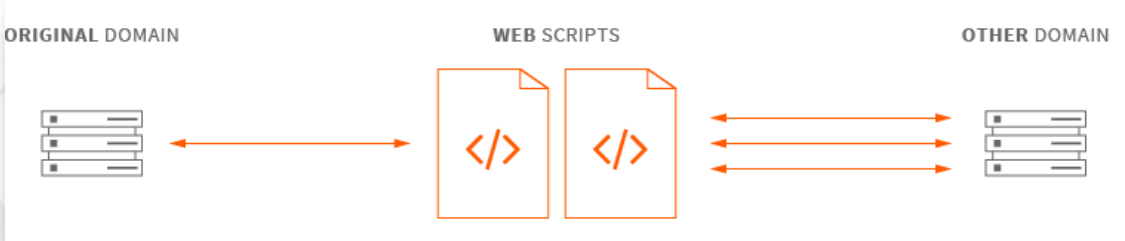
`https://example.net`	Different **domain**
`https://www.example.com/foo.html`	Different **subdomain**
`http://example.com/foo.html`	Different **scheme**
`https://example.com:9000/foo.html`	Different **port**

CORS Example



CORS in ASP.NET Core

- **CORS**, in ASP.NET Core, is setup
  - **Globally**, via a **middleware**
  - Per **Action** or per **Controller** via an **Attribute**




```
builder.Services.AddCors();
```

```
app.UseCors(builder =>
        builder.WithOrigins("http://example.com"));
```

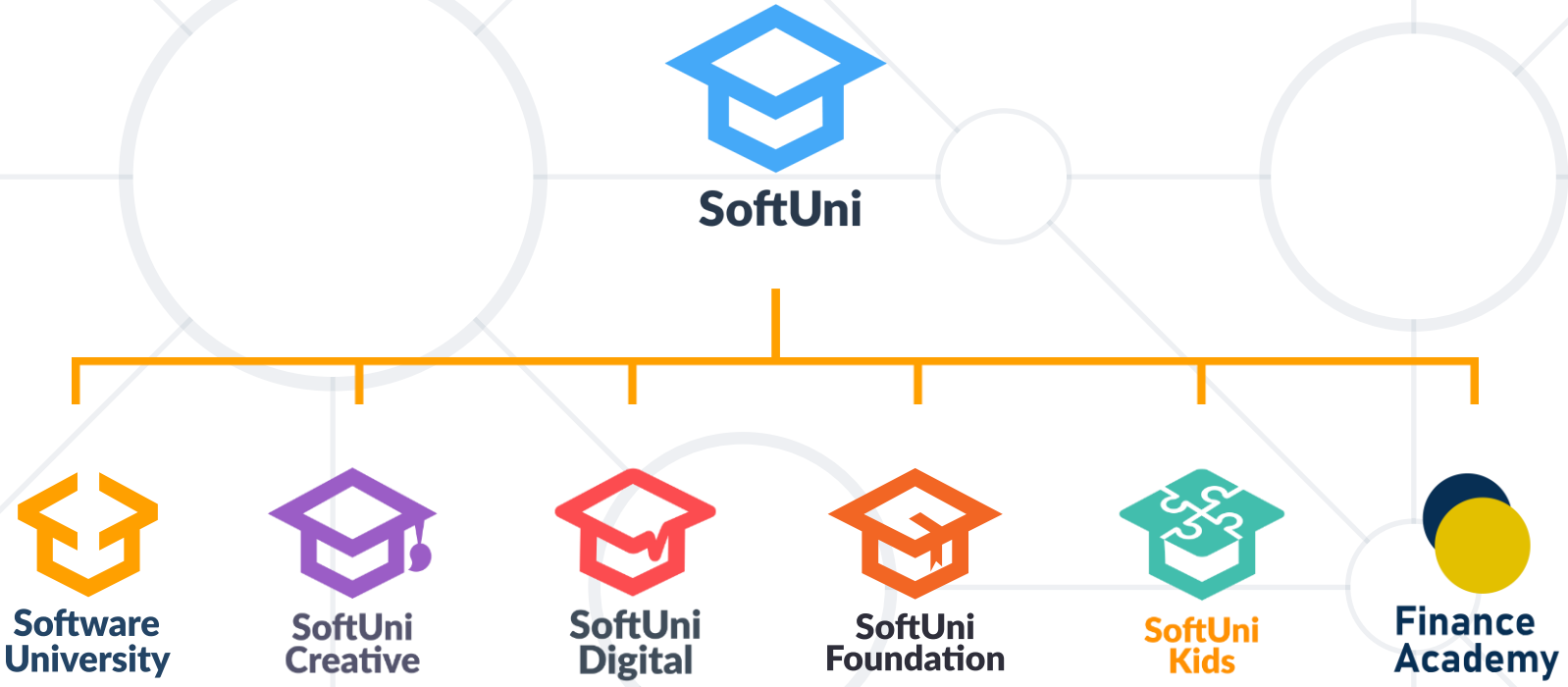
```
[HttpGet]
[EnableCors("AllowSpecificOrigin")]
public ContentResult GetTest()
{
    return Content("test");
}
```

```
[HttpGet]
[DisableCors]
public string Version()
{
    return "1.0.0";
}
```

Summary

- Common security problems
- Cross-Site Scripting – attackers inject malicious scripts
- SQL Injection – attackers interfere with app queries to the db
- Cross-Site Request Forgery – attackers force users to execute unwanted actions on web apps that they are logged-in
- Parameter Tampering – attackers manipulate parameters, exchanged between client and server
- CORS allows you to bypass the browser's same-origin policy

Questions?



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