

# Middleware Architectures 2

## Lecture 2: Browser Networking

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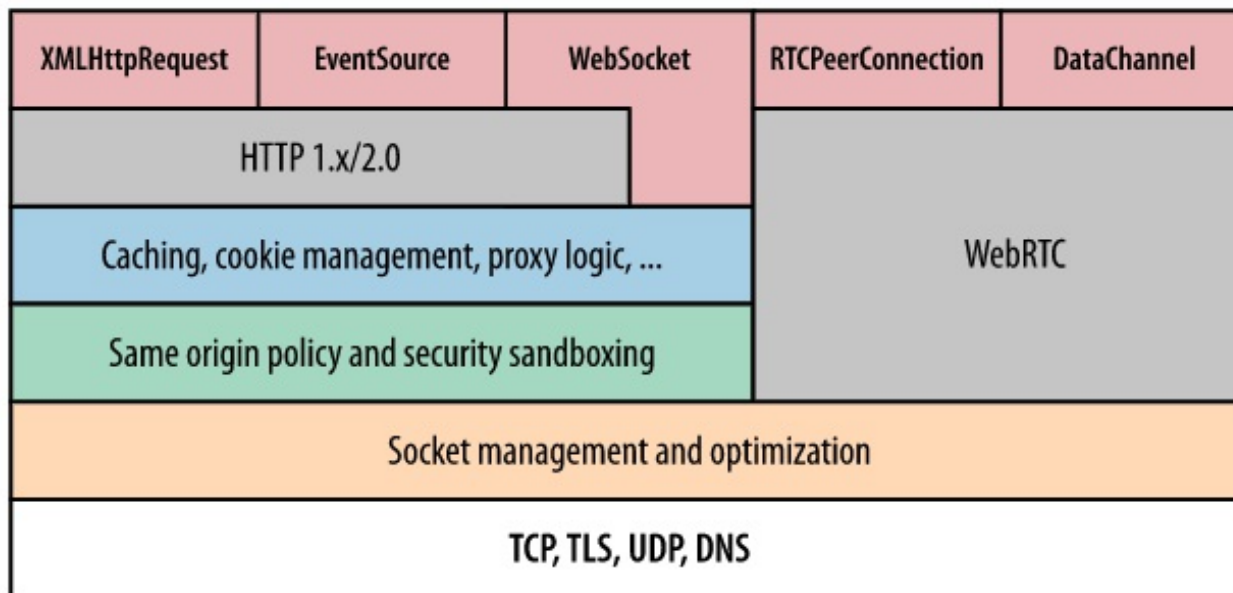
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# Overview

- Browser Networking
  - *XHR*
  - *Fetch API*
- Security Mechanisms
- JSON and JSONP

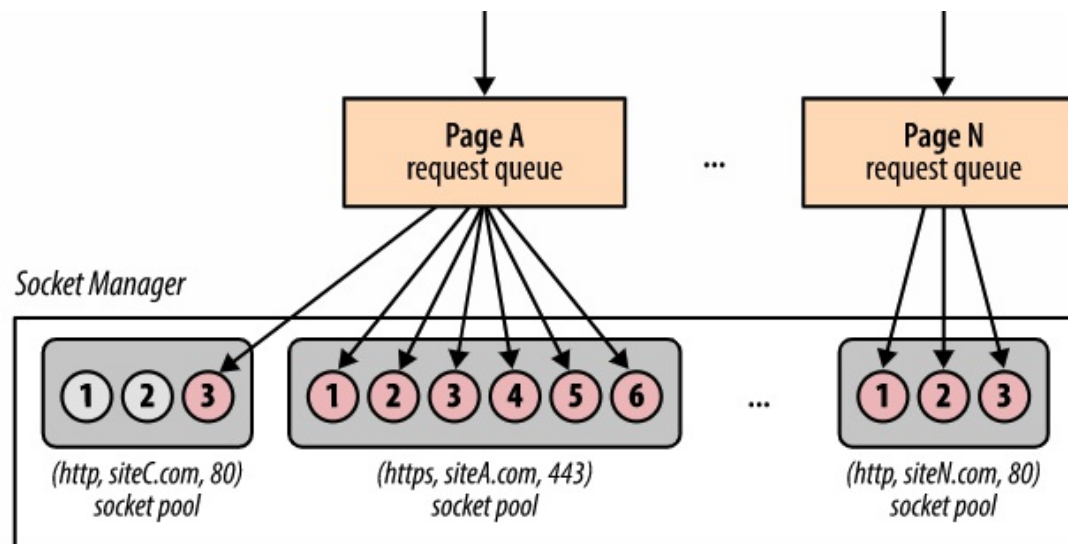
# Browser Networking

- Browser
  - Platform for fast, efficient and secure delivery of Web apps
  - Many components
    - parsing, layout, style calculation of HTML and CSS, JavaScript execution speed, rendering pipelines, and **networking stack**
  - When network is slow, e.g. waiting for a resource to arrive
    - all other steps are blocked



# Connection Management

- Network socket management and optimization
  - *Socket reuse*
  - *Request prioritization*
  - *Protocol negotiation*
  - *Enforcing connection limits*
- Socket manager
  - *Sockets organized in pools (connection limits and security constraints)*
  - *origin = (protocol, domain, port number)*



# Network Security

- No raw socket access for app code
  - *Prevents apps from initiating any connection to host*
  - *For example port scan, connect to mail server, etc.*
- Network security
  - **Connection limits**
    - *protect both client and server from resource exhaustion*
  - **Request formatting and response processing**
    - *Enforcing well-formed protocol semantics of outgoing requests*
    - *Response decoding to protect user from malicious servers*
  - **TLS negotiation**
    - *TLS handshake and verification checks on certificates*
    - *User is warned when verification fails, e.g. self-signed cert is used*
  - **Same-origin policy**
    - *Constraints on requests to be initiated and to which origin*

# Mashups

- Web application hybrid
  - *App uses APIs of two or more applications*
- Types
  - *Data mashup – integration/aggregation of data (read only)*
  - *Service mashup – more sophisticated workflows (read, write)*
  - *Visualization – involves UI*
    - *For example, third-party data displayed on the Google map*
- Client-Server View
  - *client-side mashups (in a browser)*
    - *JavaScript, Dynamic HTML, AJAX, JSON/JSONP*
  - *server-side mashups*
    - *server-side integration of services and data*
    - *Any language*

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# XMLHttpRequest (XHR)

- Interface to utilize HTTP protocol in JavaScript
  - *standardized by Web Applications WG [↗](#) at W3C*
  - *basis for AJAX*
    - *Asynchronous JavaScript and XML*
- Typical usage
  1. *Browser loads a page that includes a script*
  2. *User clicks on a HTML element*
    - *it triggers a JavaScript function*
  3. *The function invokes a service through XHR*
    - *same origin policy, cross-origin resource sharing*
  4. *The function receives data and modifies HTML in the page*

# XHR Interface – Key Methods and Properties

- Method and properties of XHR object
  - **open**, *opens the request, parameters:*
    - method** – *method to be used (e.g. GET, PUT, POST),*
    - url** – *url of the resource,*
    - asynch** – *true to make asynchronous call,*
    - user, pass** – *credentials for authentication.*
  - **onReadyStateChange** – *JavaScript function object, it is called when **readyState** changes (uninitialized, loading, loaded, interactive, completed).*
  - **send, abort** – *sends or aborts the request (for asynchronous calls)*
  - **status, statusText** – *HTTP status code and a corresponding text.*
  - **responseText, responseXML** – *response as text or as a DOM document (if possible).*
  - **onload** – *event listener to support server push.*
- See XMLHttpRequest (W3C) [🔗](#), or XMLHttpRequest (Mozilla reference) [🔗](#) for a complete reference.

# How XHR works

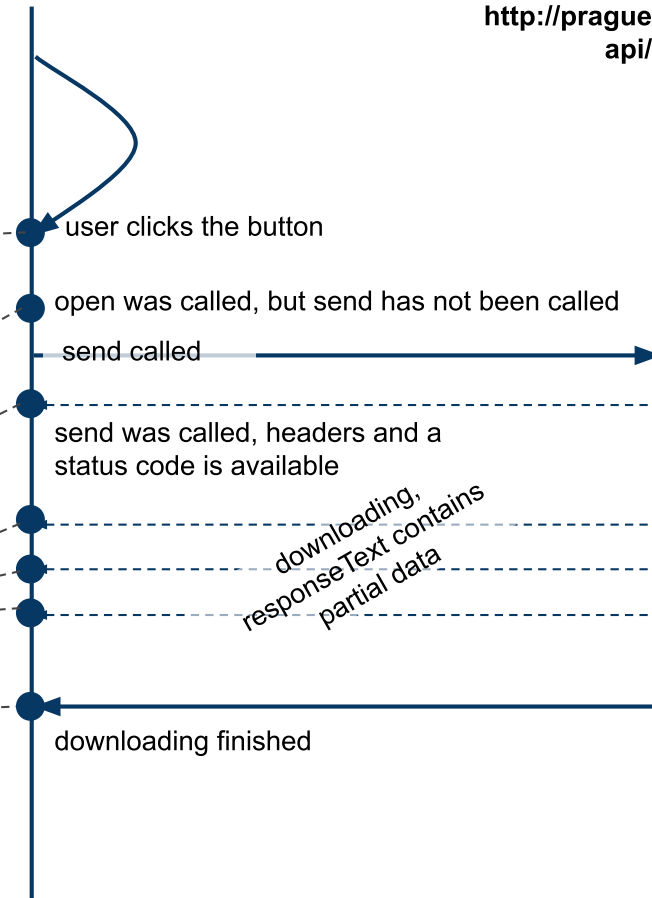
## HTML with JavaScript code

was loaded as a response to `http://prague.example.org/`

```
...  
<input type="button" value="Show Prague!" onclick="click()" />  
  
<script type="text/javascript">  
  
var xhr = new XMLHttpRequest();  
  
function click() {  
  xhr.open("GET", "http://prague.example.org/api/data", true);  
  xhr.onreadystatechange = stateChanged;  
  xhr.send();  
}  
  
function stateChanged() {  
  if (xhr.readyState == 1) { // loading  
    ...  
  }  
  if (xhr.readyState == 2) { // loaded  
    ...  
  }  
  if (xhr.readyState == 3) { // interactive  
    ...  
  }  
  if (xhr.readyState == 4) { // completed  
    ...  
  }  
}  
}  
</script>
```

## Browser

Resource at  
`http://prague.example.org/  
api/data`



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# Fetch API

- XHR is callback-based, Fetch is promise-based
- Interface to accessing requests and responses
  - Provides global **fetch** method to fetch resources asynchronously
  - Can be easily used in service workers
  - Supports CORS and other extensions to HTTP
- Interfaces
  - **Request** – represents a request to be made
  - **Response** – represents a response to a request
  - **Headers** – represents response/request headers
- Basic usage:

```
1  async function logMovies() {  
2      const response = await fetch("http://example.com/movies.json");  
3      const movies = await response.json();  
4      console.log(movies);  
5  }
```

# Making request

- A **fetch** function is available in global **window**
- It takes **path** and returns **Promise**

```
1 fetch('https://api.github.com/users/tomvit')
2   .then(response => response.json())
3   .then(data => console.log(data))
4   .catch(error => console.error('Error:', error));
```

- You can make **no-cors** request
  - *With Fetch, the request will be handled as with putting **src** to **img***

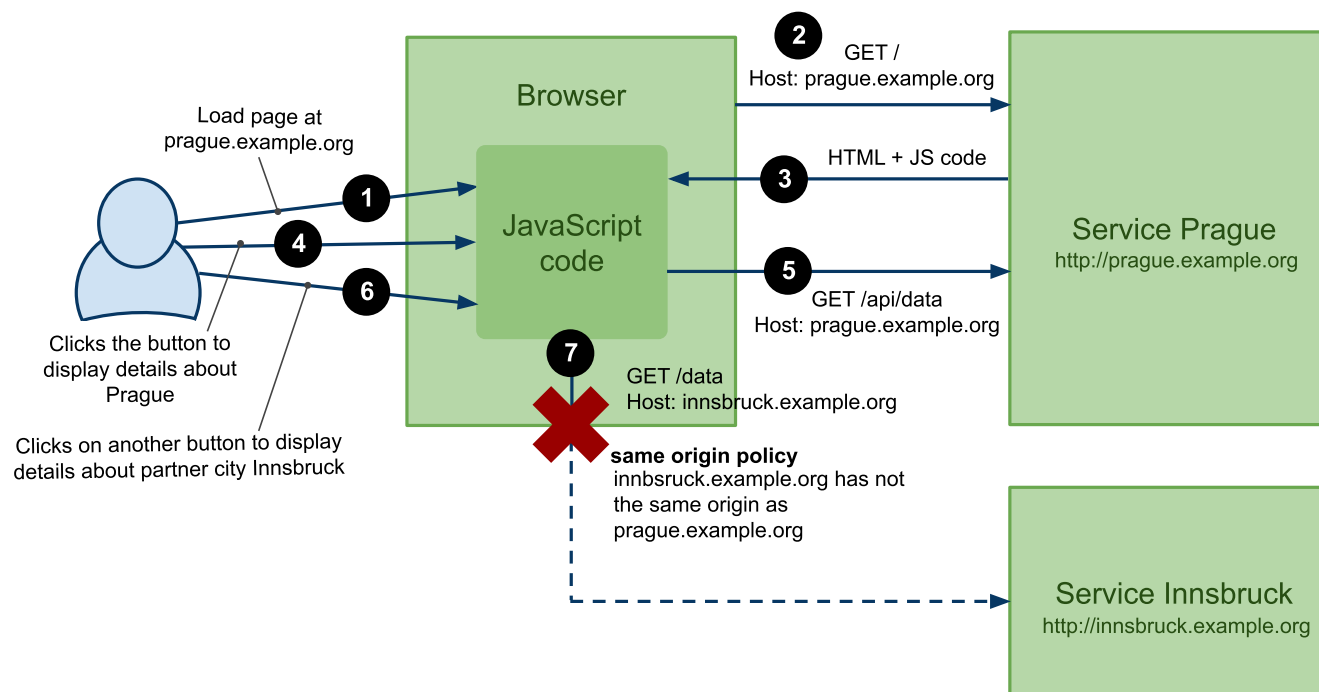
```
1 fetch('https://google.com', {
2   mode: 'no-cors',
3 }).then(function (response) {
4   console.log(response.type);
5 });
```

- You can access low-level body stream
  - *With XHR, the whole **responseText** would be loaded into memory.*
  - *With Fetch, you can read chunks of response and cancel the stream when needed.*

# Overview

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- **Security Mechanisms**
  - *Scripting Attacks*
  - *Cross-origin Resource Sharing Protocol (CORS)*
- JSON and JSONP

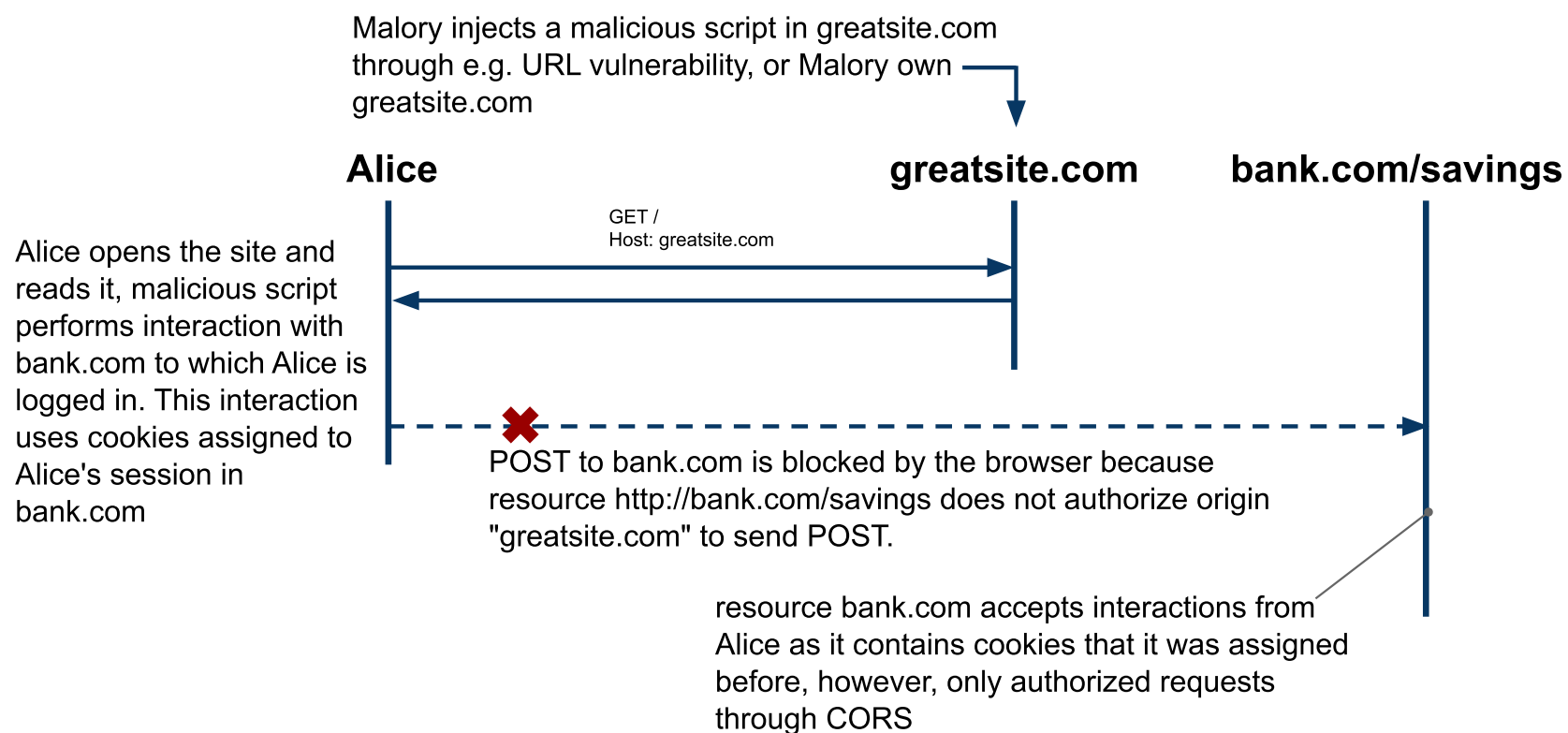
# Same Origin Policy



- JavaScript code can only access resources on the same domain
  - *XHR to GET, POST, PUT, UPDATE, DELETE*
  - Browsers apply **same origin policy**
- Solutions
  - *JSON and JSONP (GET only)*
  - *Cross-origin Resource Sharing Protocol (CORS)*

# Why Same Origin Policy?

- Without the same origin policy, the following POST would be possible



# Overview

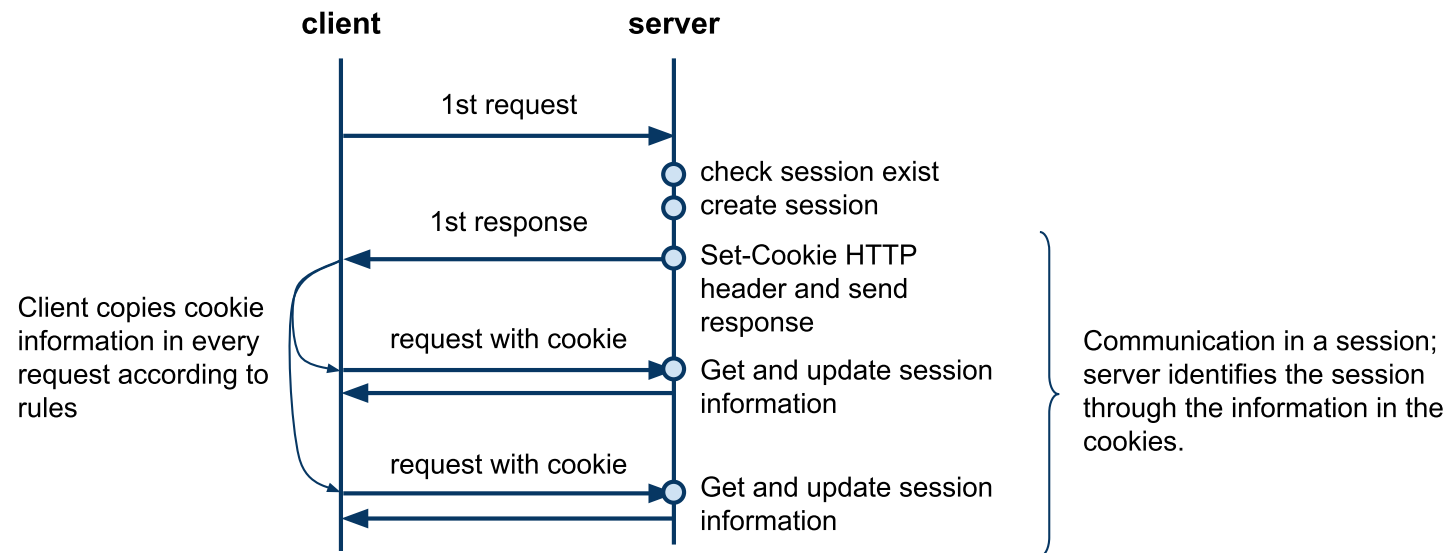
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# Overview

- Scripting Attacks
  - *Intruders make users perform action that has side effects on their resources*
  - *Intruders inject malicious code to Web pages*
- Roles in Security Scenarios
  - *Alice, Bob*
    - *Normal users, usually Alices wants to send a message to Bob or Alice accesses a Bob's site.*
  - *Eve*
    - *A user with bad intentions, usually a passive attacker.*
  - *Mallory*
    - *An active attacker, usually sends a link to a page with malicious code.*

# Recall: State management in HTTP

- Request-response interaction with cookies
  - *Session is a logical channel maintained by the server*



- Stateful Server
  - *Server remembers the session information in a server memory*
  - *Server memory is a non-persistent storage, when server restarts the memory content is lost!*

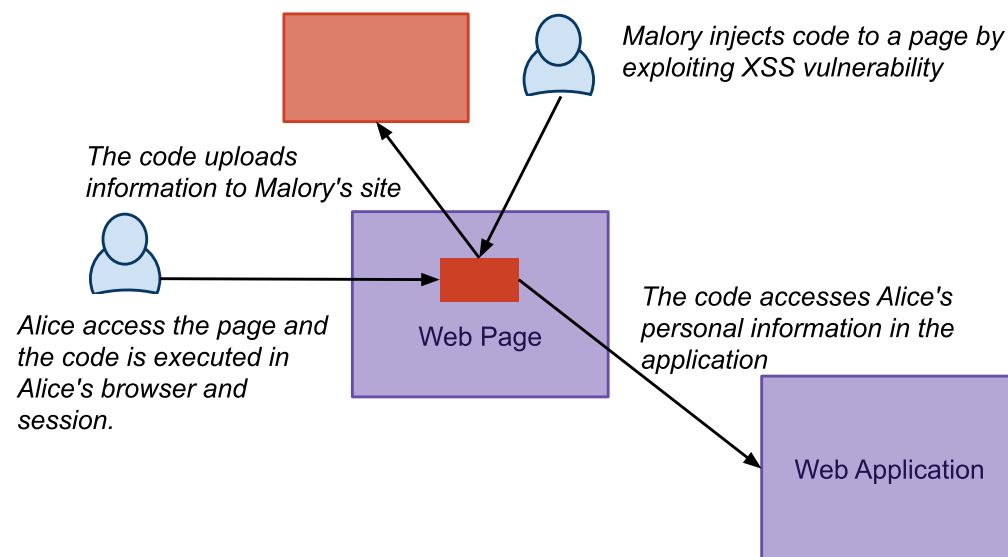
# Cross-site Request Forgery (CSRF)

- Exploits a trust of a website in a user's browser
- Scenario
  1. Mallory sends a link to Alice (in an email, in a chat, etc.)
    - The link points to a page that has HTML code with hrefs to Alice's private resources
    - For example, to perform an action on Alice's account, it is possible to use `img` like this:

```
1 | 
```
  2. Alice loads the page in her browser
    - Alice is authenticated to the bank's website, the browser sends Alice's authentication cookies with the request.
- Issues and Prevention
  - The bank site violates REST, i.e. overloading of GET for making actions
  - The bank should check HTTP `referer` header
  - It is a "blind" attack, Mallory does not see the result
  - To perform POST, current browsers today use *CORS protocol*

# Cross-site Scripting Attack (XSS)

- Exploits a trust of a user in a website



- Example Scenario
  1. An attacker injects a code to a page
  2. A users executes the code in his/her browser's session
  3. The code provides information (cookies) to the attacker
  4. The attacker uses the cookies to access the user's data

# XSS Examples

- Twitter in Sep 2010

- *Injection of JavaScript code to a page using a tweet*
- *You posted following tweet to Twitter*

```
1 | There is a great event happening at  
2 | http://someurl.com/@"onmouseover="alert('test xss')"/
```

- *Twitter parses the link and wraps it with `<a>` element*

```
1 | There is a great event happening at  
2 | <a href="http://someurl.com/@"onmouseover="alert('test xss')"  
3 |     target="_blank">http://someurl.com/@"onmouseover=  
4 |     "alert('test xss')"/</a>
```

- *See details at Twitter mouseover exploit [🔗](#)*

- Other example: Google Contacts

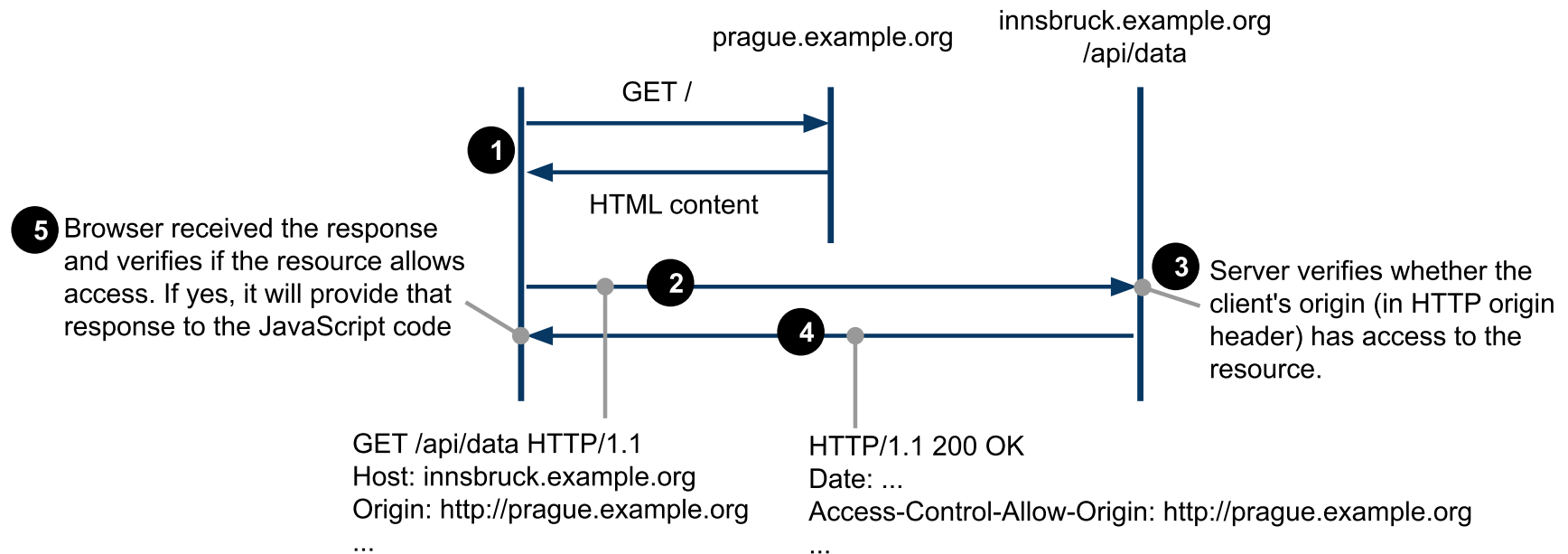
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  - *Scripting Attacks*
  - *Cross-origin Resource Sharing Protocol (CORS)*
- JSON and JSONP

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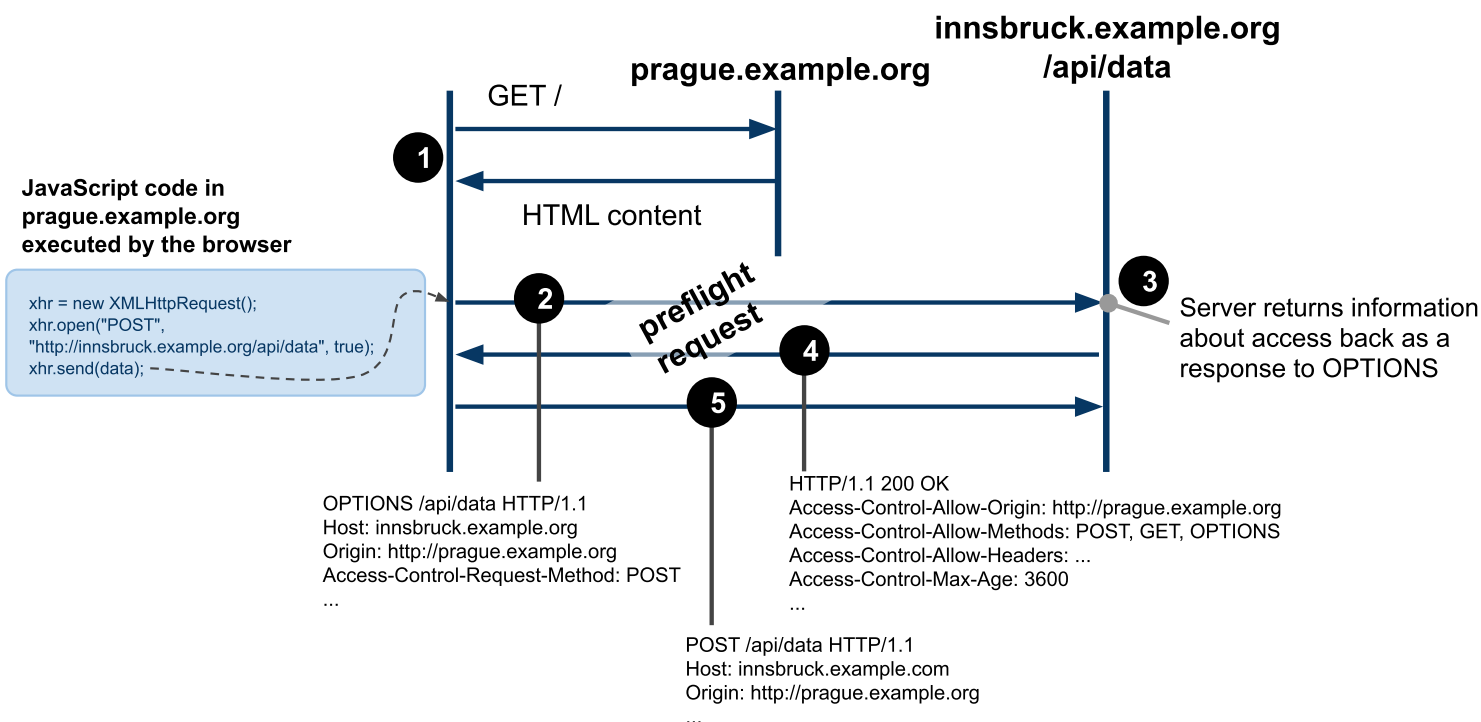
- Increasing number of mashup applications
  - *client-side mashups involving multiple sites*
  - *mechanism to control an access to sites from within JavaScript*
- Allow for **cross-site HTTP requests**
  - *HTTP requests for resources from a different domain than the domain of the resource making the request.*
- W3C Recommendation
  - *see Cross-origin Resource Sharing [↗](#)*
  - *Browsers support it*
    - *see HTTP Access Control [↗](#) at Mozilla*

# CORS Protocol – GET



- Read-only resource access via HTTP GET
- Headers:
  - **Origin** – identifies the origin of the request
  - **Access-Control-Allow-Origin** – defines who can access the resource
  - either the full domain name or the wildcard (\*) is allowed.

# CORS Protocol – other methods and "preflight"



- Preflight request queries the resource using **OPTIONS** method
  - requests other than *GET* (except *POST* w/o payload) or with custom headers
  - A browser should run preflight automatically for any XHR request meeting preflight conditions
  - The browser caches responses according to **Access-Control-Max-Age**

# Overview

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# Recall: JSON

- JSON = JavaScript Object Notation
  - *Serialization format for data representation*
  - *Very easy to use in JavaScript*
    - *no need to use a parser explicitly*
  - *Also great support in many programming environments*
- Key constructs
  - ***object** is a collection of comma-separated key/value pairs:*  
`{"name" : "tomas", "age" : 18, "student" : false, "car" : null}`
  - ***array** is an order list of values:*  
`[ "prague", "innsbruck", 45 ]`
  - *can be nested: objects as values in an **array**:*  
`[ { "name" : "tomas", "age" : 18 },  
 { "name" : "peter", "age" : 19 } ]`
  - *and the other way around: array as values in an **object**:*  
`{ "cities" : ["prague", "innsbruck"],  
 "states" : ["CZ", "AT"] }`
  - *A complete grammar see JavaScript Object Notation [🔗](#)*

# JSON in JavaScript

- Native data format

```
1 // data needs to be assigned
2 var data = { "people" : ["tomas", "peter", "alice", "jana"] };
3
4 // go through the list of people
5 for (var i = 0; i < data.people.length; i++) {
6     var man = data.people[i];
7     // ... do something with this man
8 }
```

- Responses of service calls in JSON

- *Many support JSON, how can we load that data?*

- Example Request-Response

```
1 GET http://pipes.yahoo.com/pipes/pipe.run?_id=638c670c40c97b62&_render=json
2
3 {"count":1,"value":
4   {"title":"Web 2.0 announcements",
5     "description":"Pipes Output",
6     "link":"http://pipes.yahoo.com/pipes/pipe.info...",
7     "pubDate":"Mon, 07 Mar 2011 18:27:20 +0000",
8     "generator":"..."
9   },
10  ...
11 }
```

# JSONP

- Service that supports JSONP
  - *allows to specify a query string parameter for a wrapper function to load the data in JavaScript code*
  - *otherwise the data cannot be used in JavaScript*
    - *they're loaded into the memory but assigned to nothing*
- Example
  - *if a resource at [http://someurl.org/json\\_data](http://someurl.org/json_data) returns*

```
{ "people" : ["tomas", "peter", "alice", "jana"] }
```

*then the resource at*  
[http://someurl.org/json\\_data?\\_callback=loadData](http://someurl.org/json_data?_callback=loadData) *returns*

```
loadData({ "people" : ["tomas", "peter", "alice", "jana"] });
```
- A kind of workaround for the same origin policy
  - *only GET, nothing else works obviously*
  - *no XHR, need to load the data through the dynamic `<script>` element*

# JSONP in JavaScript

- JSONP example
  - *loads JSON data using JSONP by dynamically inserting `<script>` into the current document. This will download JSON data and triggers the script.*

```
1  var TWITTER_URL = "http://api.twitter.com/1/statuses/user_timeline.json?" +
2      "&screen_name=web2e&count=100&callback=loadData";
3
4  // this needs to be loaded in window.onload
5  // after all document has finished loading...
6  function insertData() {
7      var se = document.createElement('script');
8      se.setAttribute("type","text/javascript");
9      se.setAttribute("src", TWITTER_URL);
10     document.getElementsByTagName("head")[0].appendChild(se);
11     // And data will be loaded when loadDta callback fires...
12 }
13
14 // loads the data when they arrive
15 function loadData(data) {
16     // we need to know the the structure of JSON data that is returned
17     // and code it here accordingly
18     for (var i = 0; i < data.length; i++) {
19         data[i].created_at // contains date the tweet was created
20         data[i].text // contains the tweet
21     }
22 }
```