Middleware Architectures 2

Lecture 2: Browser Networking

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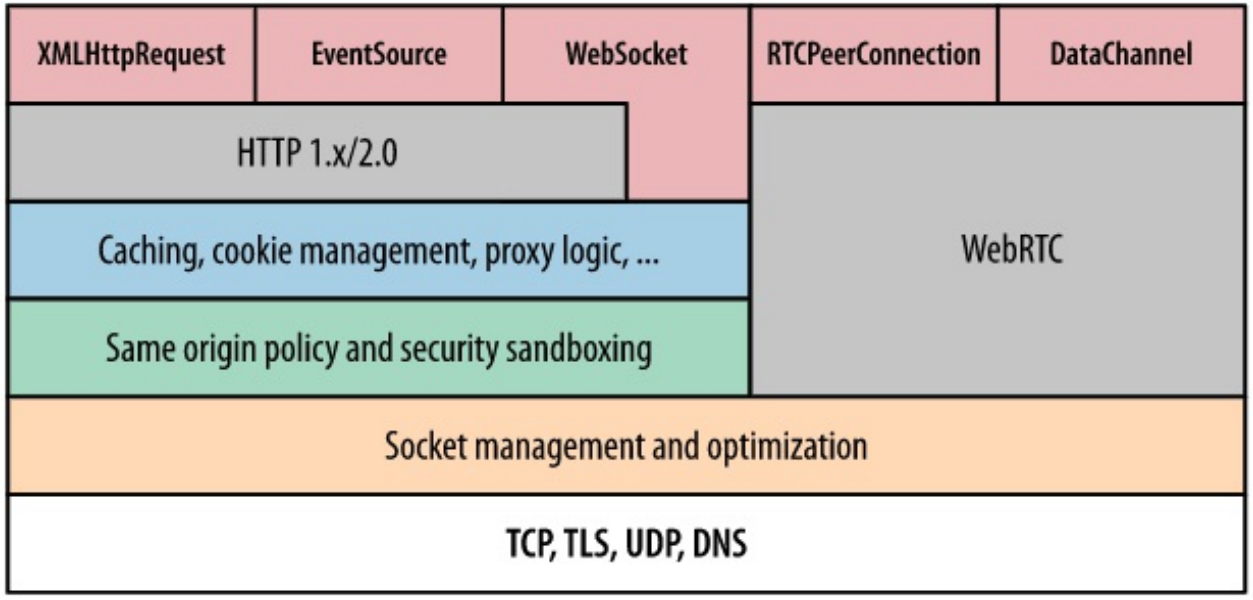
Overview

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

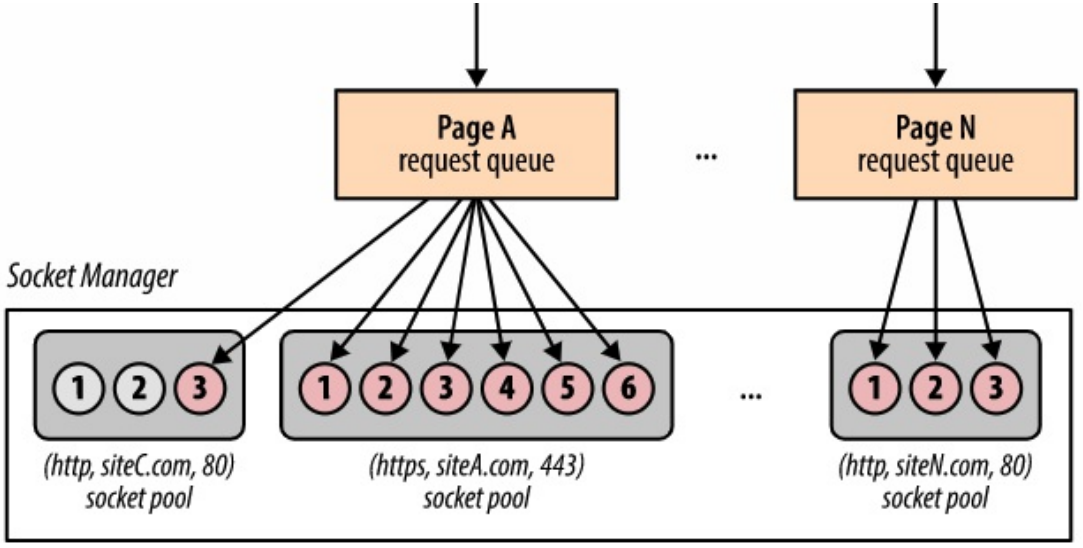
Browser Networking

- 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*
  - *Enfocring 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 fials, 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

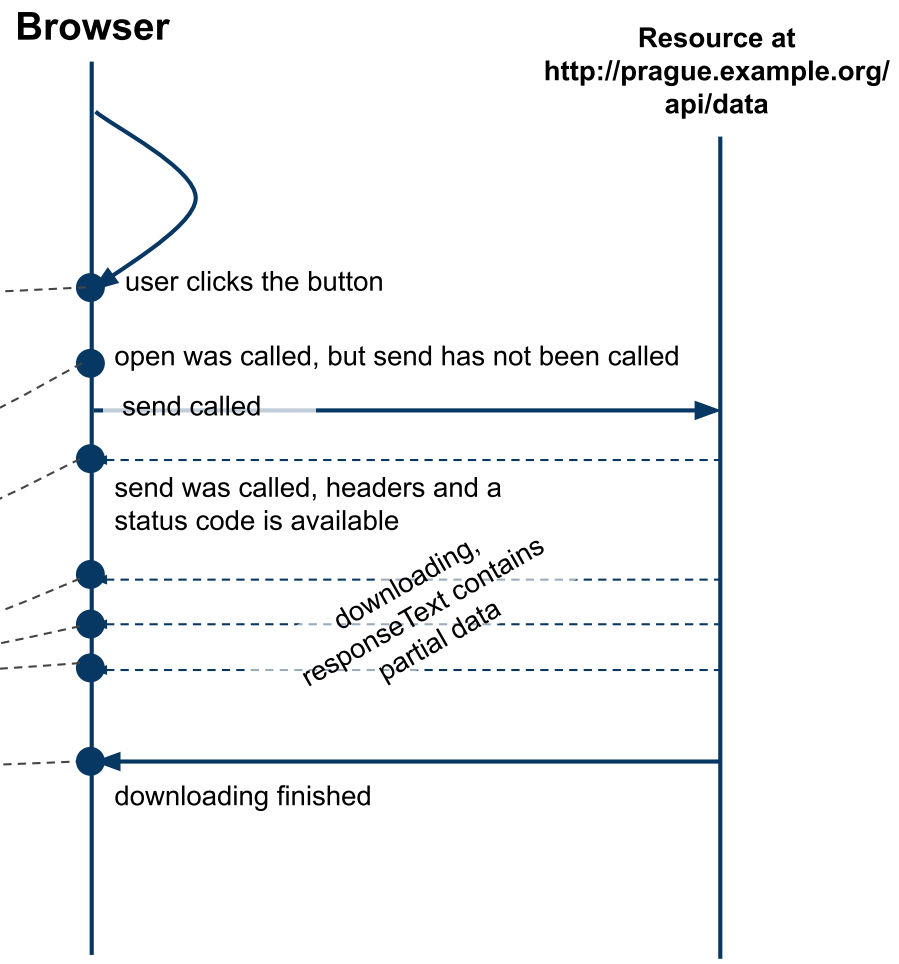
- Method and properties of XHR object
  - `open`, *opens the request, parameters:*
    `method` – *method to be used (e.g. GET, PUT, POST),*
    `url` – *url of the resource,*
    `asynch` – *true to make asynchronous call,*
    `user`, `pass` – *credentials for authentication.*
  - `onReadyStateChange` – *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 XMLHttRequest (W3C), or XMLHttRequest (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>
```

pointer to JavaScript object function



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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 easilly 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:

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

Making request

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

```
fetch('https://api.github.com/users/tomvit')
    .then(response => response.json())
    .then(data => console.log(data))
    .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`*

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

- 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.*

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  - *Scripting Attacks*
  - *Cross-origin Resource Sharing Protocol (CORS)*
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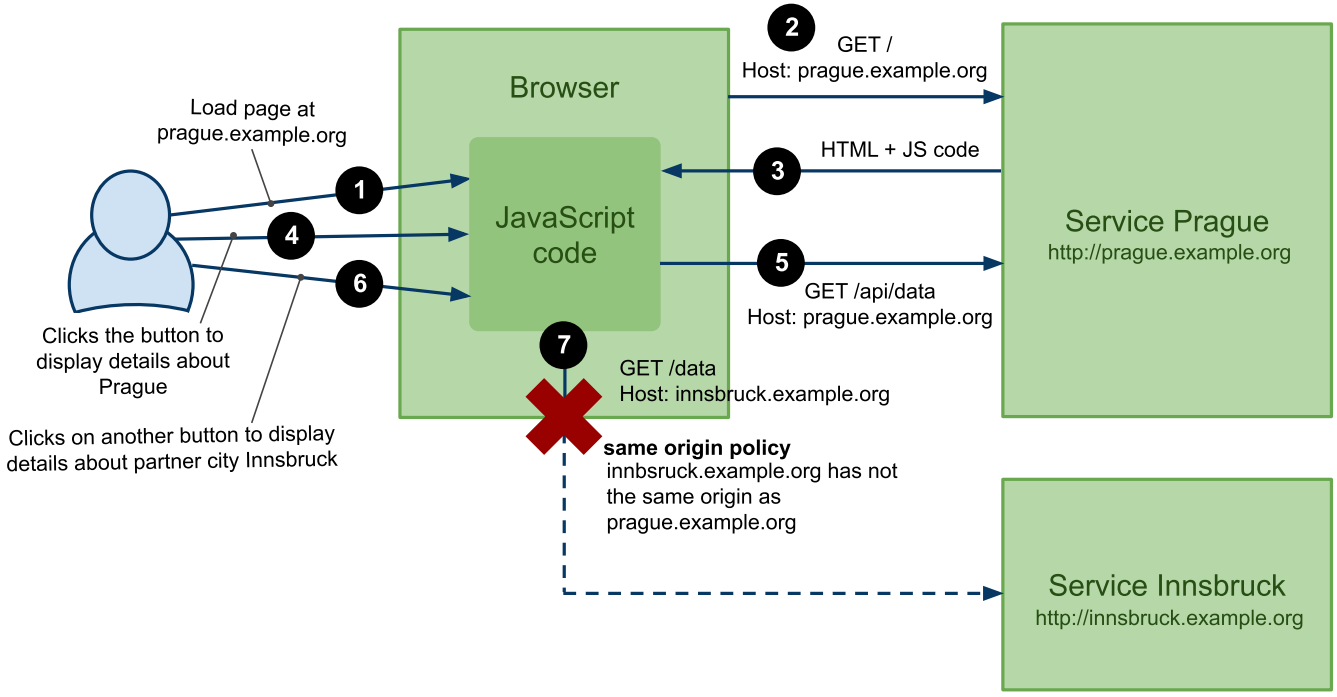
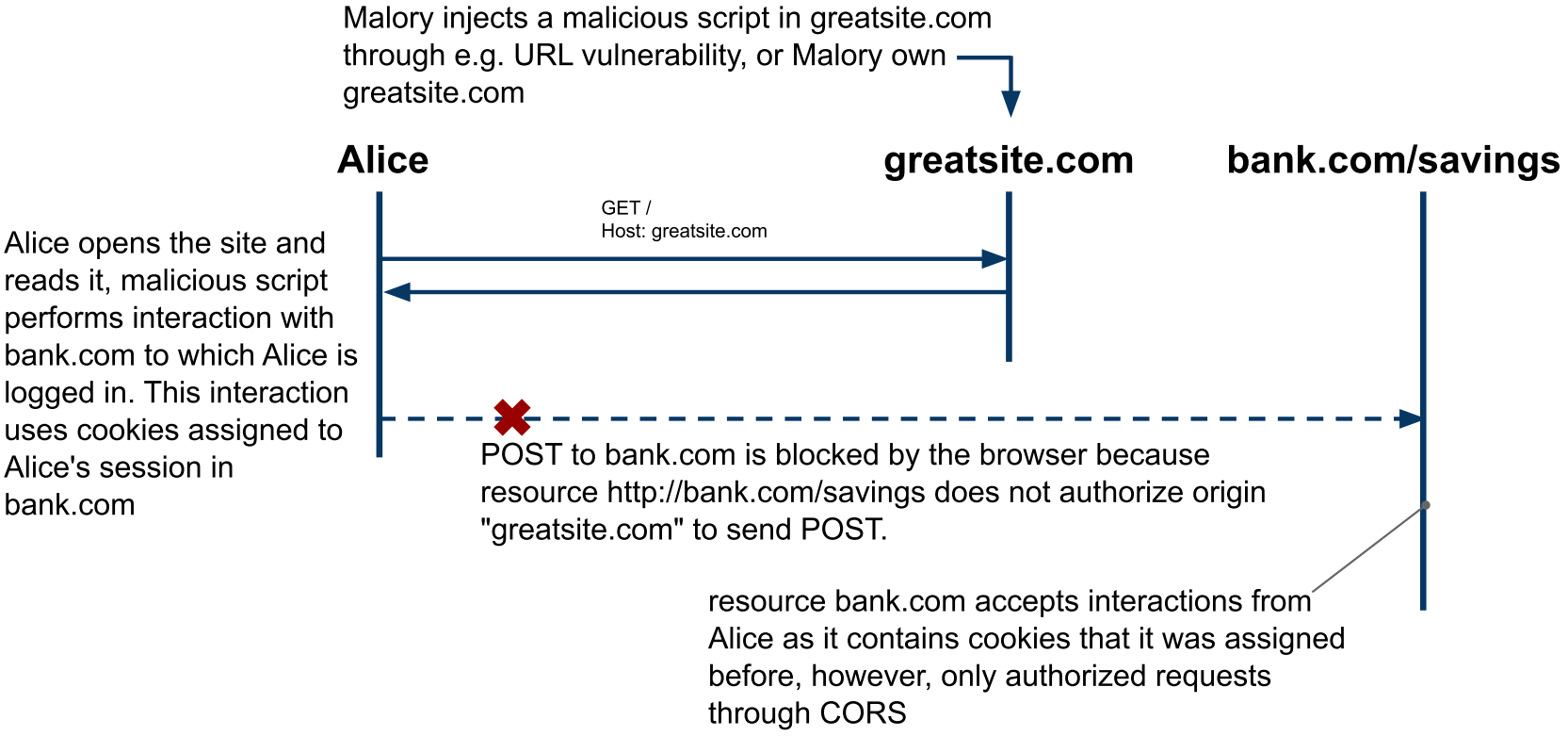
Same Origin Policy



- 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



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  - *Scripting Attacks*
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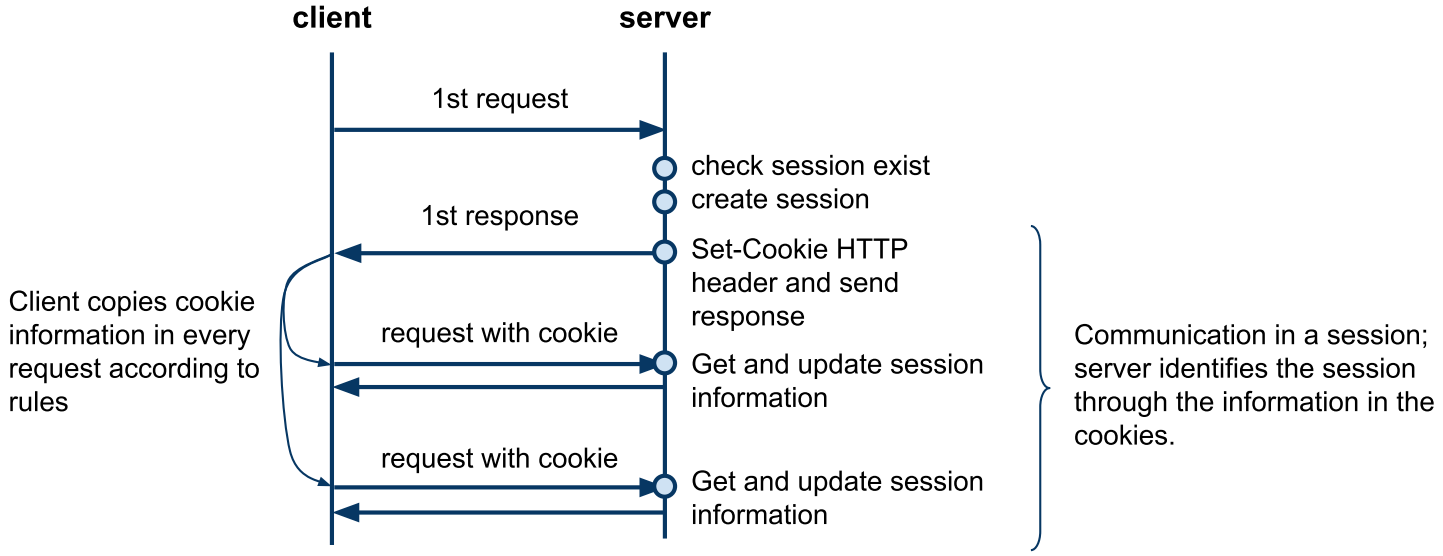
Overview

- 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)

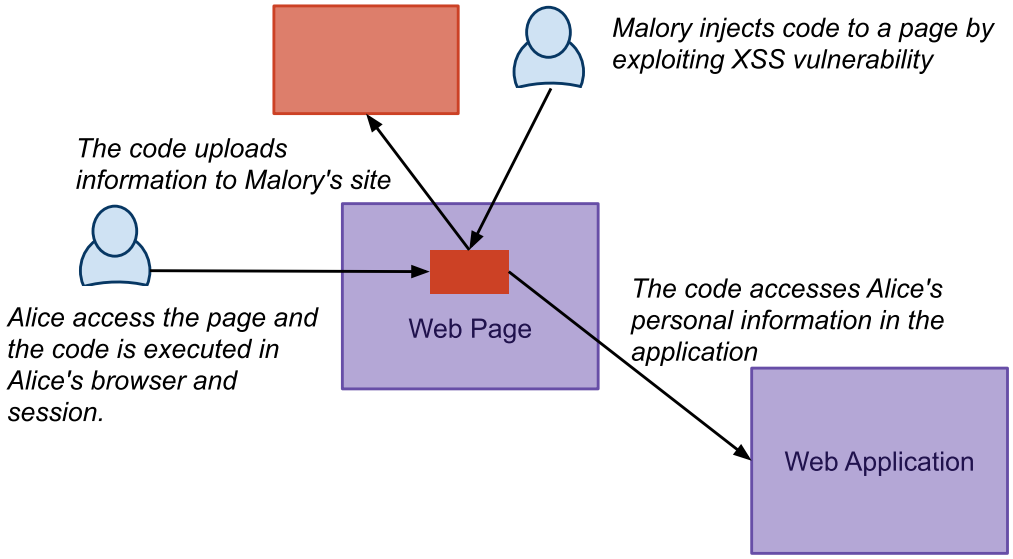
- Exploits a trust of a website in a user's browser
- Scenario
  1. *Mallory sends a link to Alice (in an email, in a chat, etc.)*
     - *The link points to a page that has HTML code with hrefs to Alice's private resources*
     - *For example, to perform an action on Alice's account, it is possible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

```
1 | <img src="https://bank.com/account?do=transfer_money&amount=50000"/>
```

  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 vilotes 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*

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

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

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

  - *See details at Twitter mouseover exploit*
- Other example: Google Contacts

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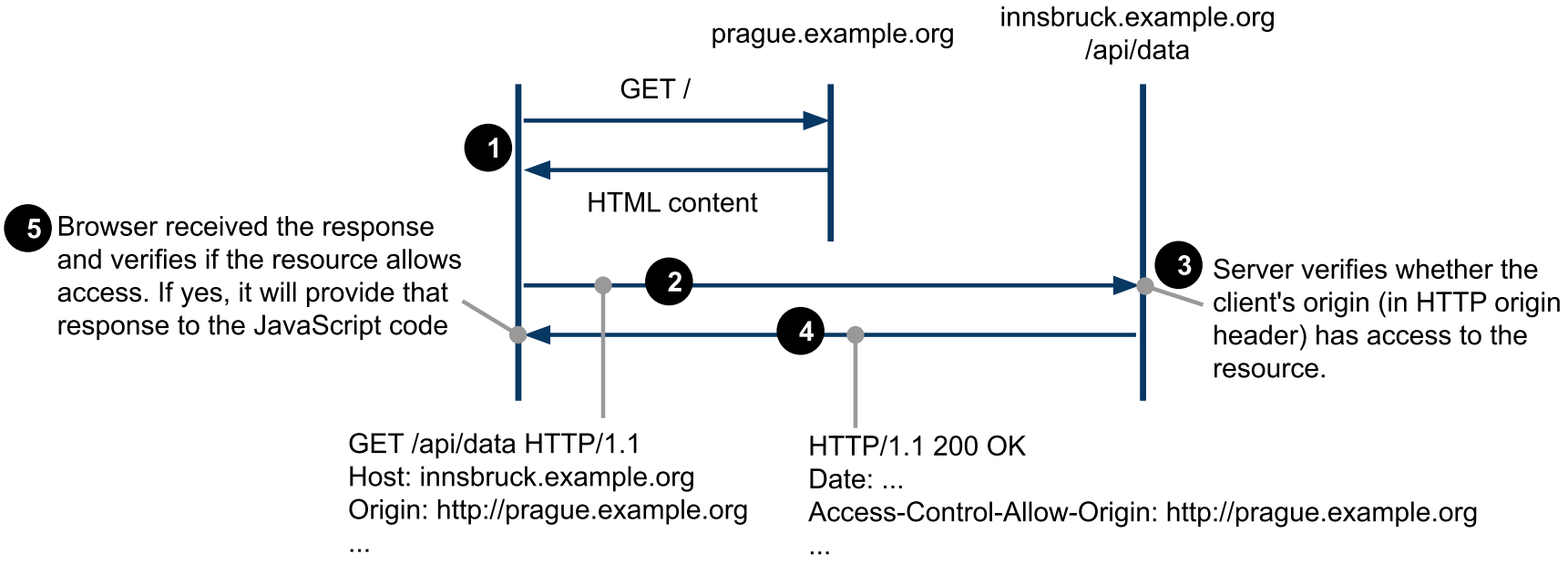
Overview

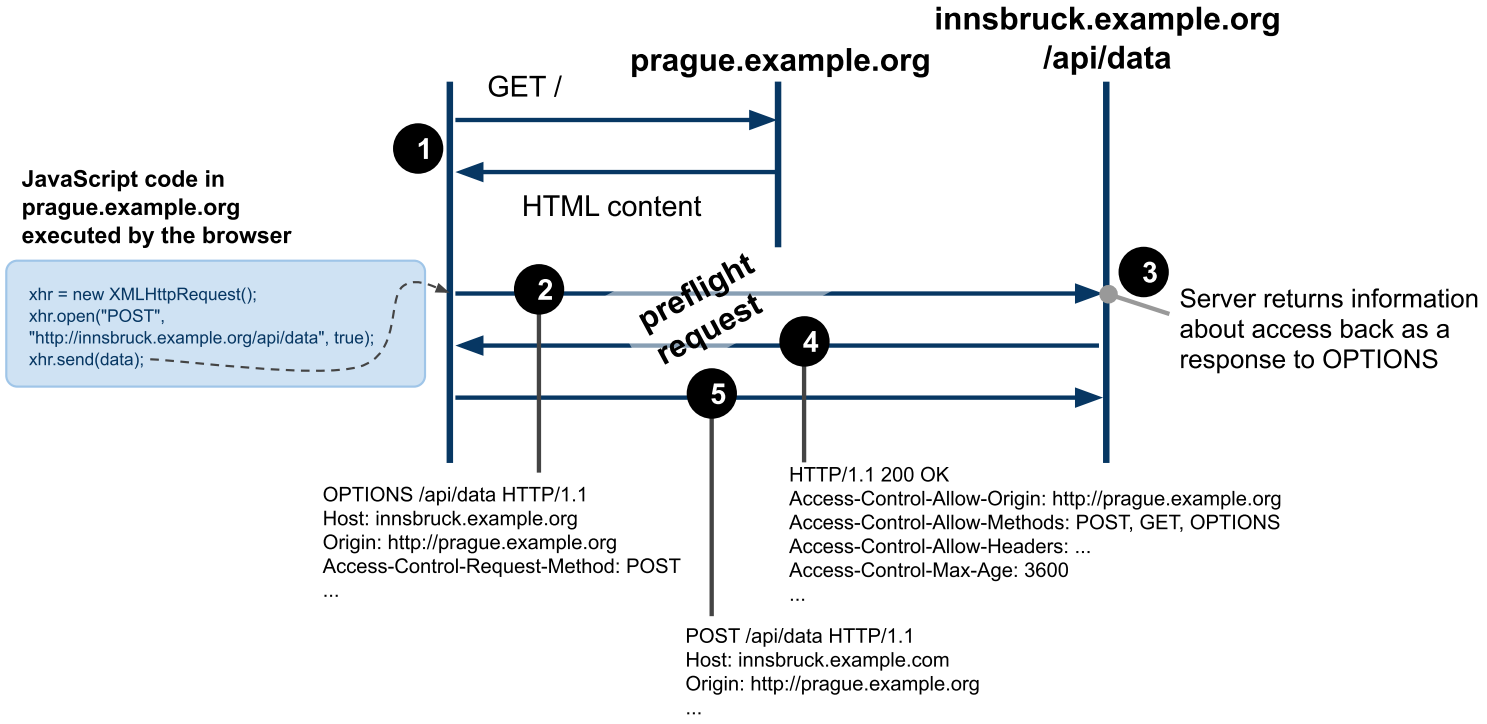
- Increasing number of mashup applications
  - *client-side mashups involving multiple sites*
  - *mechanism to control an access to sites from within JavaScript*
- Allow for **cross-site HTTP requests**
  - *HTTP requests for resources from a different domain than the domain of the resource making the 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`

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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

```
// data needs to be assigned
var data = { "people" : ["tomas", "peter", "alice", "jana"] };

// go through the list of people
for (var i = 0; i < data.people.length; i++) {
    var man = data.people[i];
    // ... do something with this man
}
```

- Responses of service calls in JSON
  - *Many support JSON, how can we load that data?*
- Example Request-Response

```
GET http://pipes.yahoo.com/pipes/pipe.run?_id=638c670c40c97b62&_render=json

{"count":1,"value":
   {"title":"Web 2.0 announcements",
    "description":"Pipes Output",
    "link":"http:\/\/pipes.yahoo.com\/pipes\/pipe.info...",
    "pubDate":"Mon, 07 Mar 2011 18:27:20 +0000",
    "generator":"..."
    ...
   }
}
```

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` *returns*

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

    then the resource at
    `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 }
```