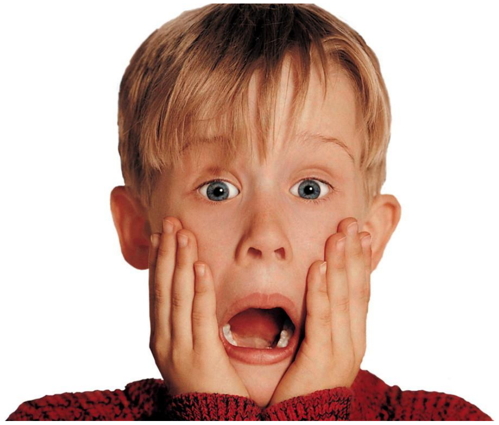
Web Security

CS 161: Computer Security

Ruta Jawale and Rafael Dutra

July 25, 2019



The web architecture is a mess when it comes to security

Slides credit: Raluca Ada Popa, David Wagner, Dan Boneh

Announcements

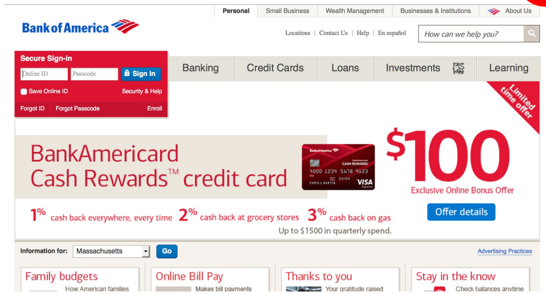
- Project 2 due next week Monday (7/29)
  - Project party tomorrow (3-5 pm @ Soda 606)
- Homework 2 due next week Thursday (8/1)
- Midterm 2 in 1.5 weeks (8/5)
  - Make sure to attend lectures and discussions

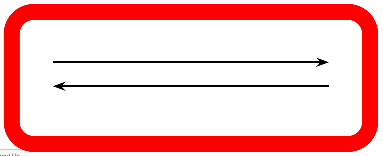
Web 101

What is the Web?

A platform for deploying applications and sharing information, *portably* and *securely*

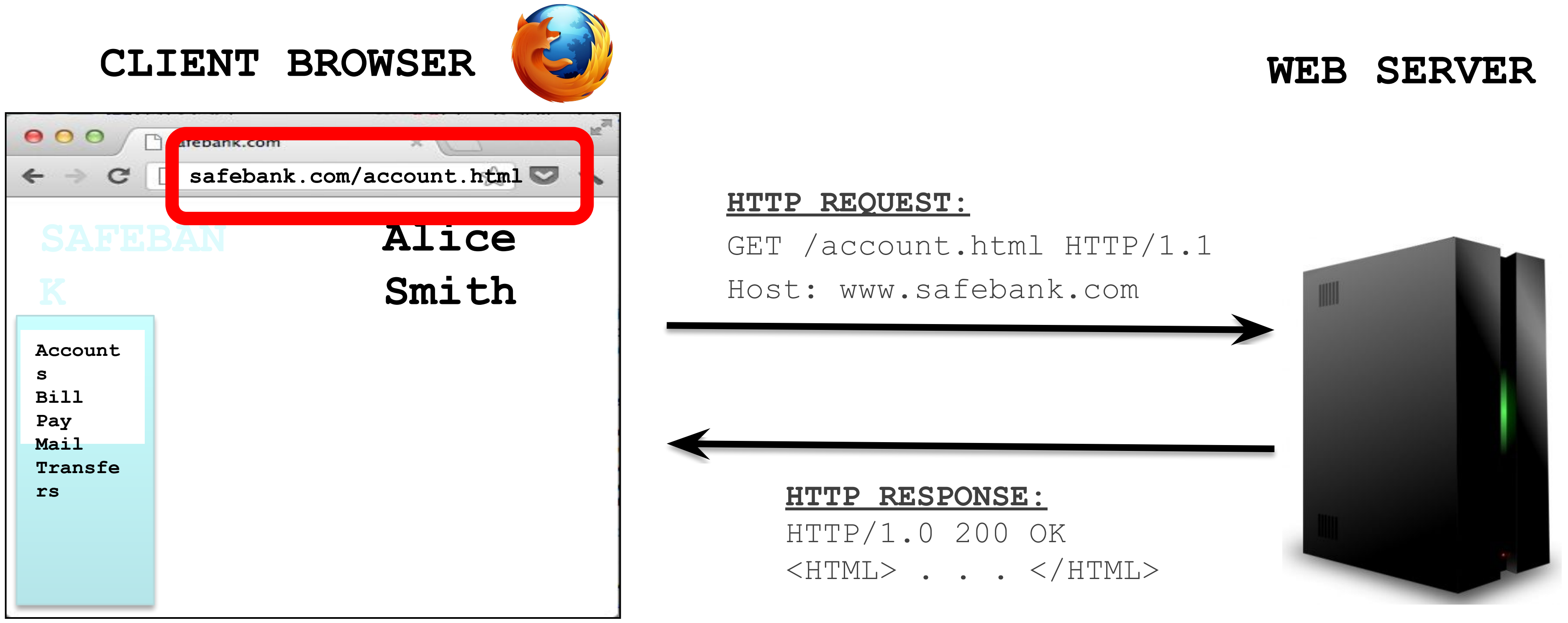
client **client browser** **web server**





HTTP
(Hypertext Transfer Protocol)

A common data communication protocol on the web

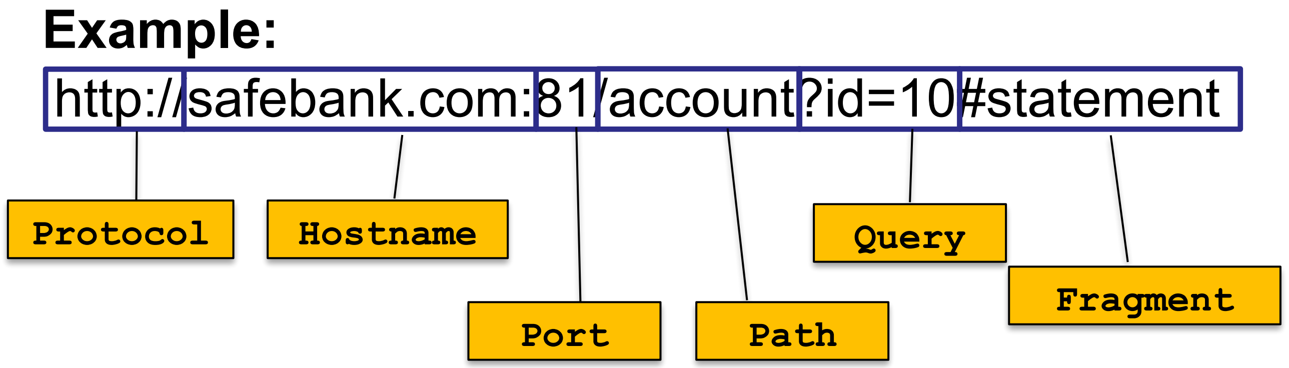


HTTP REQUEST:
```
GET /account.html HTTP/1.1
Host: www.safebank.com
```

HTTP RESPONSE:
```
HTTP/1.0 200 OK
<HTML> . . . </HTML>
```

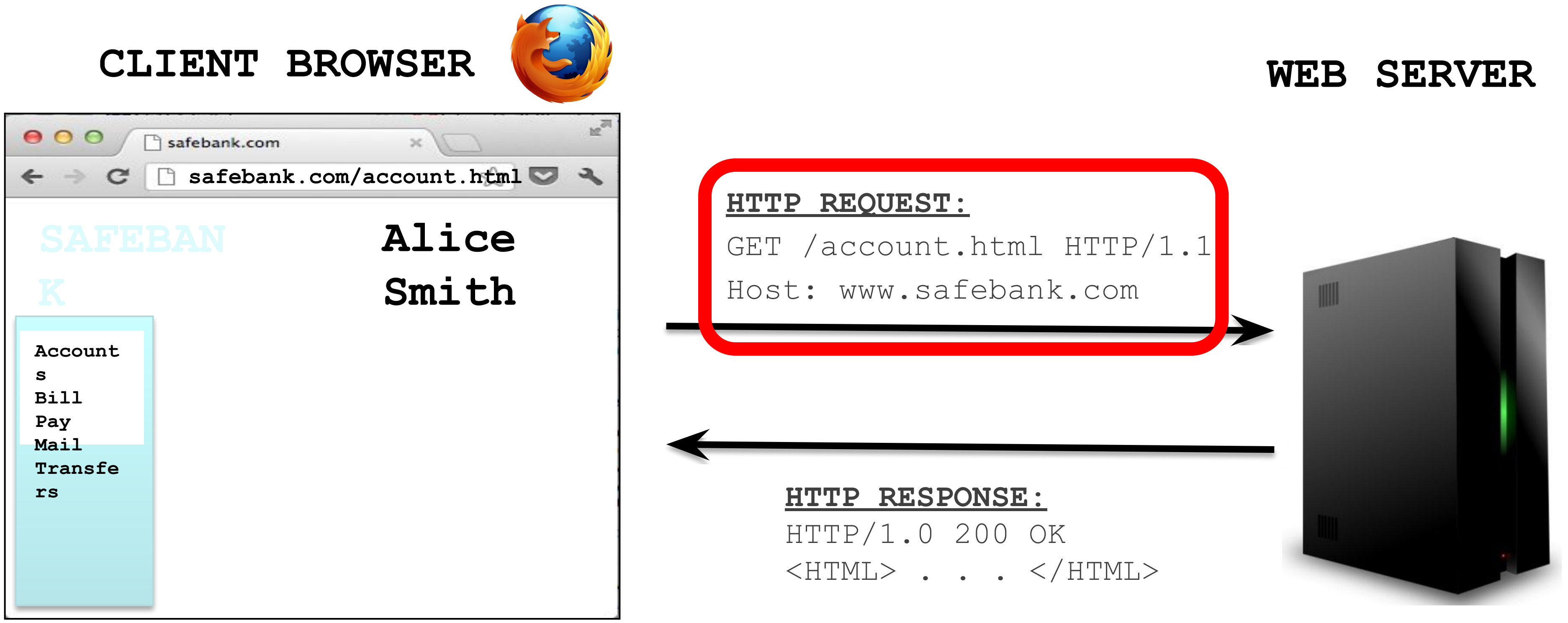
URLs

Global identifiers of network-retrievable resources



- Protocol
  - http, https, ftp, …
- Port
  - http: 80, https: 443, …
- Sent to web server
  - path, query
- Local to client browser
  - fragment

HTTP



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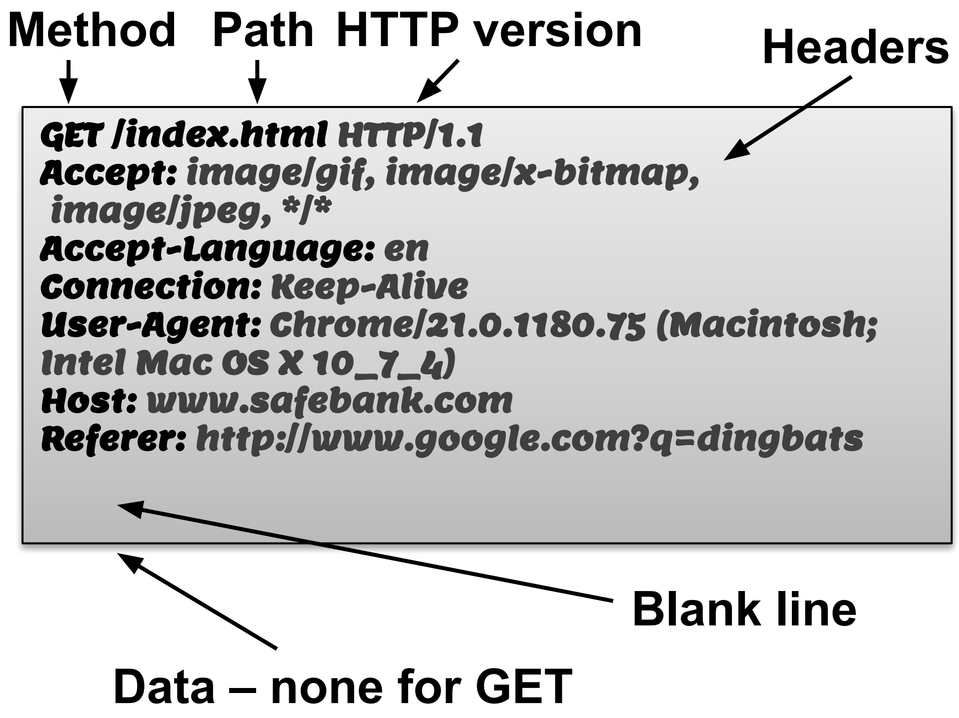
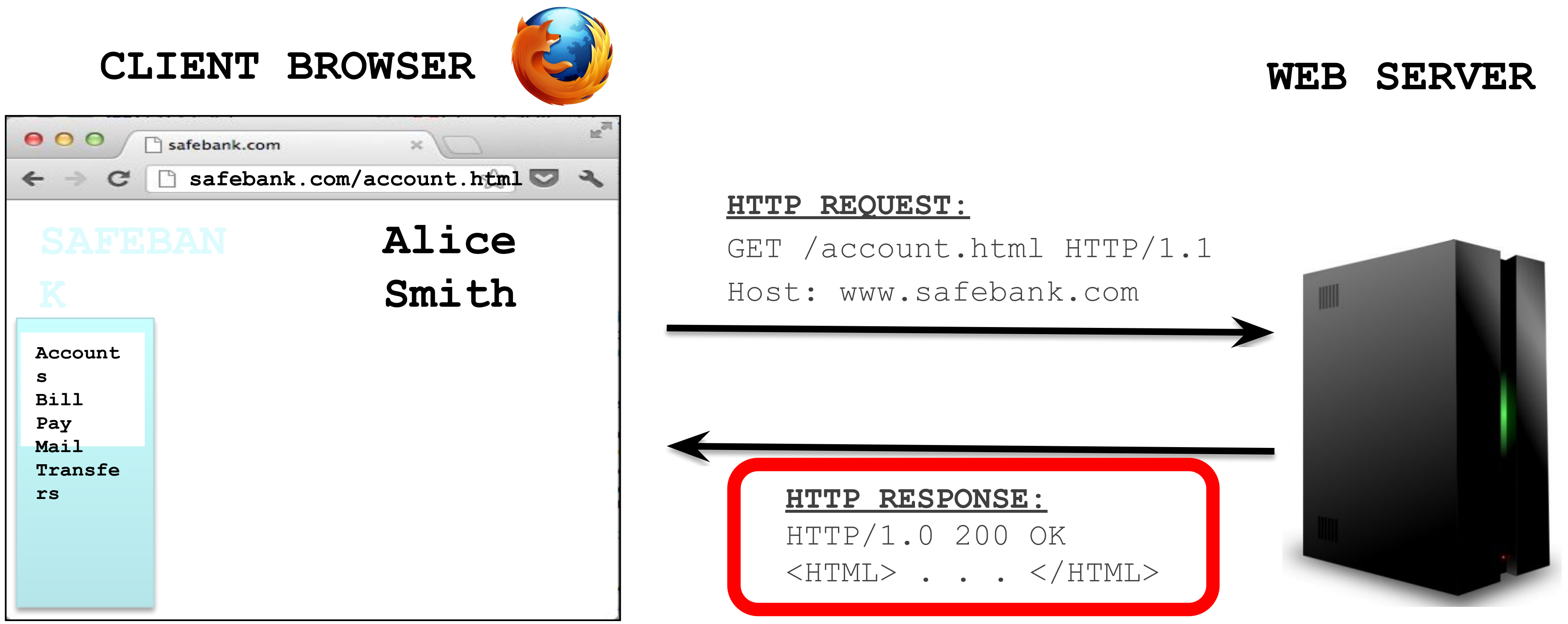
HTTP Request

GET: no side effect
POST: possible side effect



```
GET /index.html HTTP/1.1
Accept: image/gif, image/x-bitmap,
 image/jpeg, */*
Accept-Language: en
Connection: Keep-Alive
User-Agent: Chrome/21.0.1180.75 (Macintosh;
Intel Mac OS X 10_7_4)
Host: www.safebank.com
Referer: http://www.google.com?q=dingbats
```

HTTP



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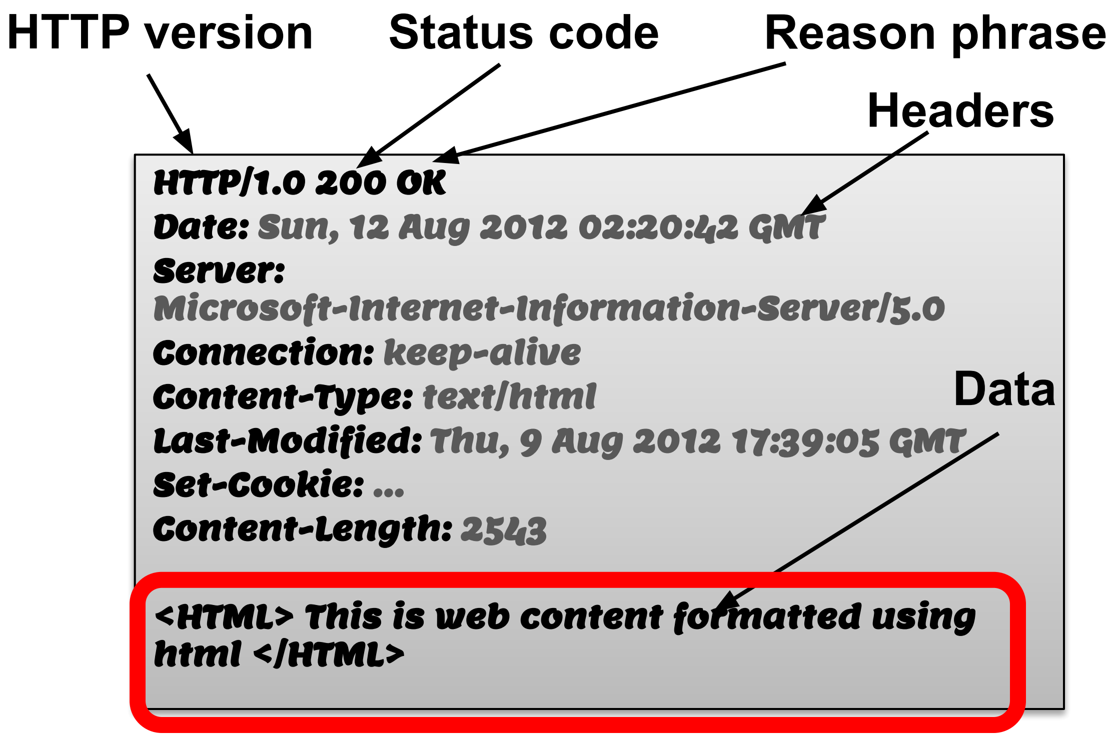
HTTP Response

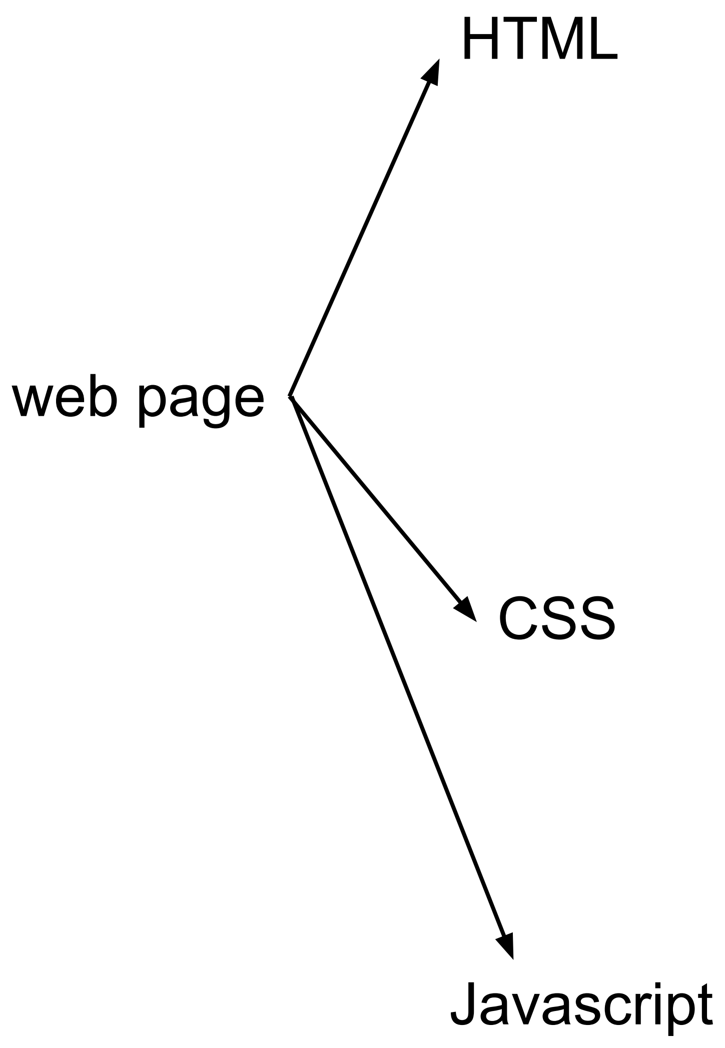


```
HTTP/1.0 200 OK
Date: Sun, 12 Aug 2012 02:20:42 GMT
Server:
Microsoft-Internet-Information-Server/5.0
Connection: keep-alive
Content-Type: text/html
Last-Modified: Thu, 9 Aug 2012 17:39:05 GMT
Set-Cookie: ...
Content-Length: 2543

<HTML> This is web content formatted using
html </HTML>
```

Can be a webpage

Web page



HTML

A language to create structured documents
One can embed images, objects, or create interactive forms

index.html

```
<html>
    <body>
        <div>
            foo
            <a href="http://google.com">Go to Google!</a>
        </div>
        <form>
            <input type="text” />
            <input type=”radio” />
            <input type=”checkbox” />
        </form>
    </body>
</html>
```

CSS (Cascading Style Sheets)

Style sheet language used for describing the presentation of a document

index.css

```
p.serif {
font-family: "Times New Roman", Times, serif;
}
p.sansserif {
font-family: Arial, Helvetica, sans-serif;
}
```

Javascript

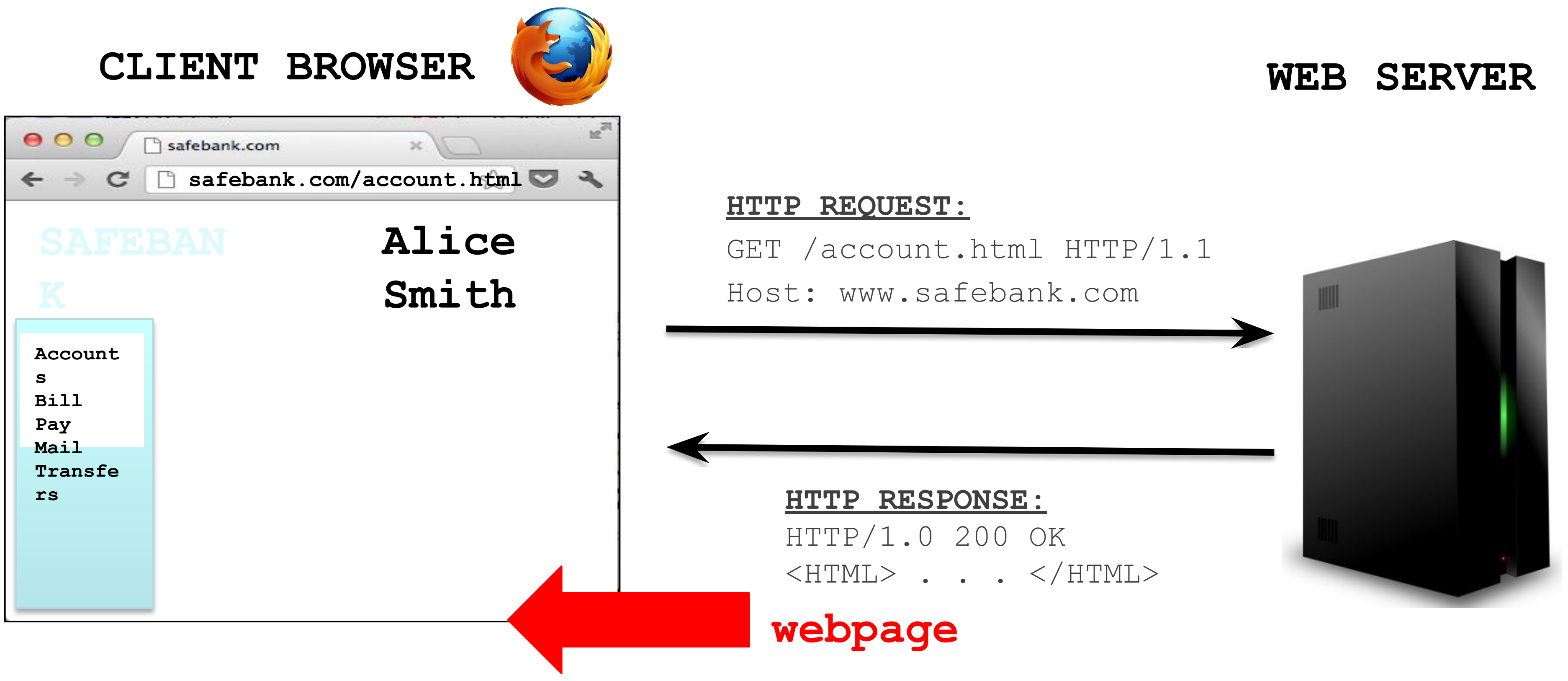
Programming language used to manipulate web pages. It is a high-level, untyped and interpreted language with support for objects.

Supported by all web browsers

```
<script>
function myFunction() {
document.getElementById("demo").innerHTML = ”Text changed.";
}
</script>
```

Very powerful!

HTTP



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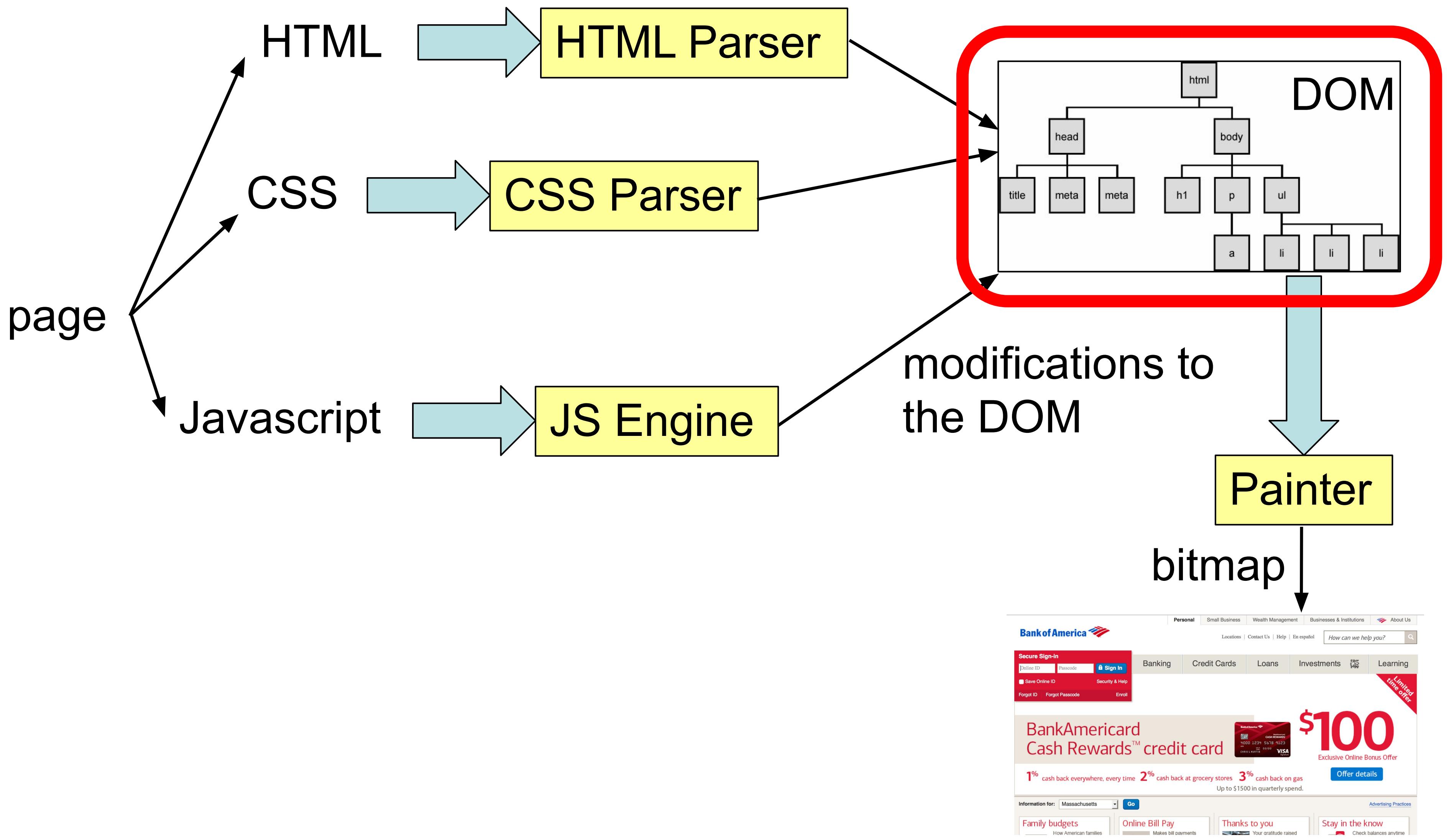
Page rendering



DOM (Document Object Model)

a cross-platform model for representing and interacting with objects in HTML

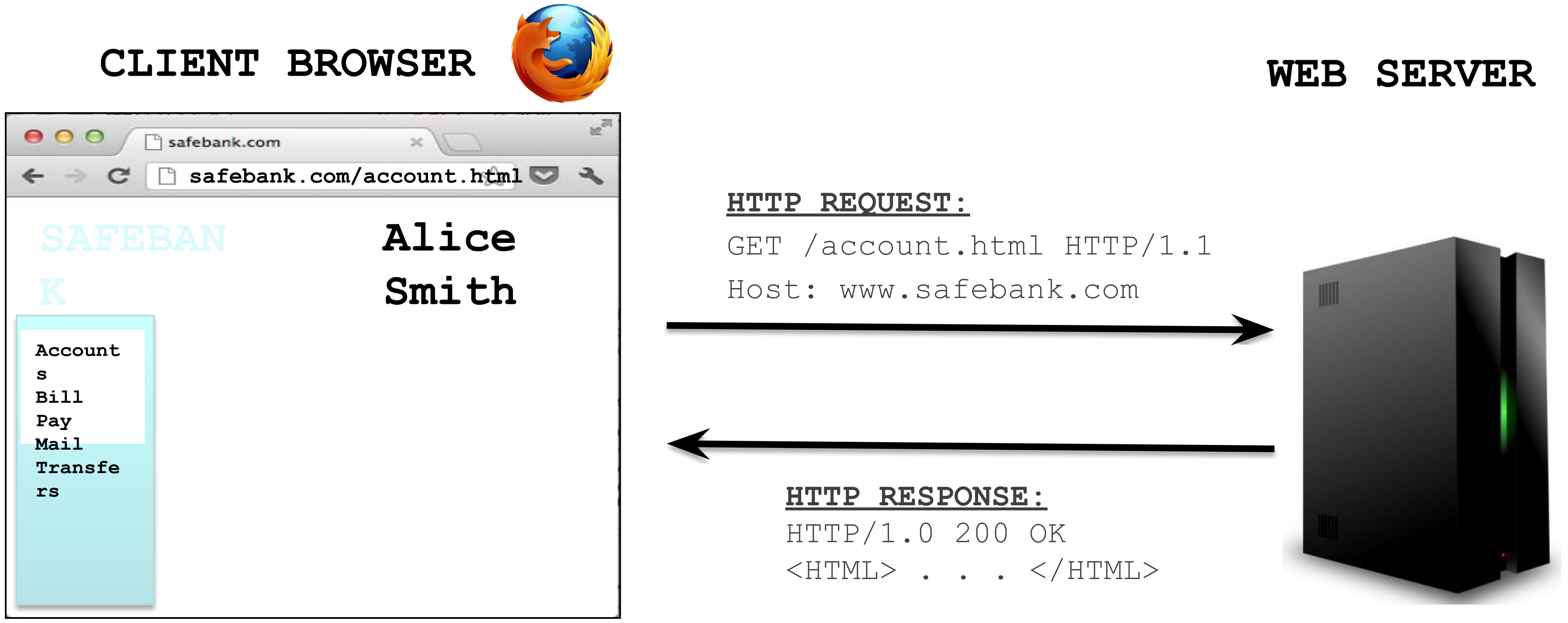
HTML

```
<html>
    <body>
        <div>
            foo
        </div>
        <form>
            <input type="text" />
            <input type="radio" />
            <input type="checkbox" />
        </form>
    </body>
</html>
```

DOM Tree

```
|-> Document
   |-> Element (<html>)
     |-> Element (<body>)
       |-> Element (<div>)
         |-> text node
       |-> Form
            |-> Text-box
            |-> Radio Button
            |-> Check Box
```

Web & HTTP 101



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The power of Javascript

Get familiarized with it so that you can think of all the attacks one can do with it

What can you do with Javascript?

Almost anything you want to the DOM!

A JS script embedded on a page can modify in almost arbitrary ways the DOM of the page. The same happens if an attacker manages to get you load a script into your page.

w3schools.com has nice interactive tutorials: https://www.w3schools.com/js

Example of what Javascript can do…

Can change HTML content:

```
<p id="demo">JavaScript can change HTML content.</p>

<button type="button"
onclick="document.getElementById('demo').innerHTML =
'Hello JavaScript!'">
   Click Me!</button>
```

DEMO from w3schools.com

Other examples

- Can change images
- Can change style of elements
- Can hide elements
- Can unhide elements
- Can change cursor

Other example: can access cookies

Will learn later that cookies are useful for authentication.

JS can read cookie:

```
var x = document.cookie;
```

Change cookie with JS:

```
document.cookie = "username=John Smith; expires=Thu,
18 Dec 2013 12:00:00 UTC; path=/";
```

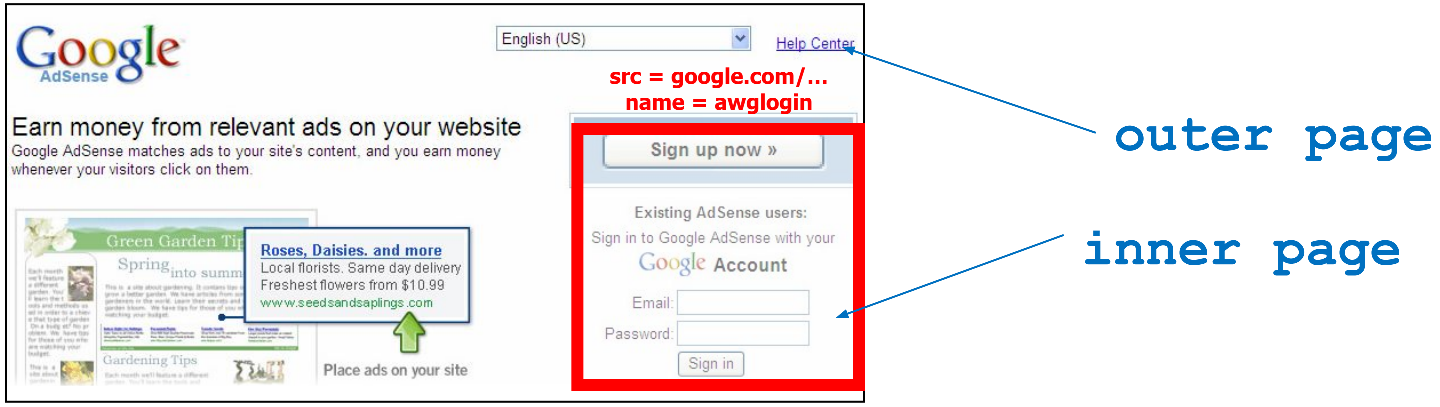
Demo

Frames

Frames

- Enable embedding a page within a page

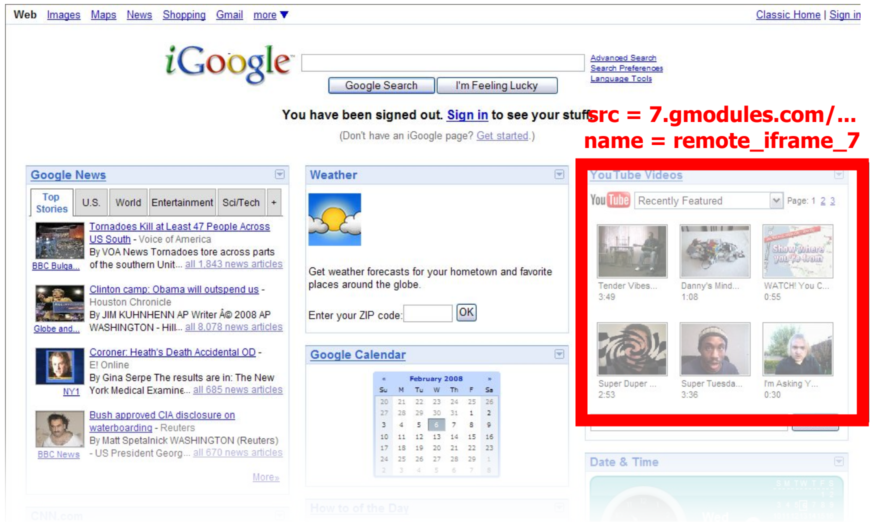
```
<iframe src="URL"></iframe>
```



Earn money from relevant ads on your website

Google AdSense matches ads to your site's content, and you earn money whenever your visitors click on them.

Frames



You have been signed out. Sign in to see your stuff.
(Don't have an iGoogle page? Get started.)

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By VOA News Tornadoes tore across parts of the southern Unit... all 1,843 news articles

Clinton camp: Obama will outspend us - Houston Chronicle
By JIM KUHNHENN AP Writer Â© 2008 AP WASHINGTON - Hill... all 8,078 news articles

Coroner: Heath's Death Accidental OD - E! Online
By Gina Serpe The results are in: The New York Medical Examine... all 685 news articles

Bush approved CIA disclosure on waterboarding - Reuters
By Matt Spetalnick WASHINGTON (Reuters) - US President Georg... all 670 news articles

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Enter your ZIP code: OK

- Modularity
  - Brings together content from multiple sources
  - Client-side aggregation
- Delegation
  - Frame can draw only on its own rectangle

Slide from Dan Boneh

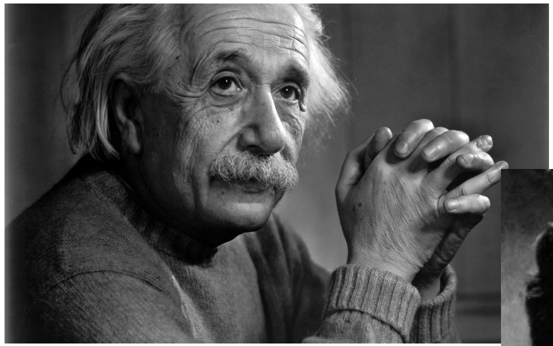
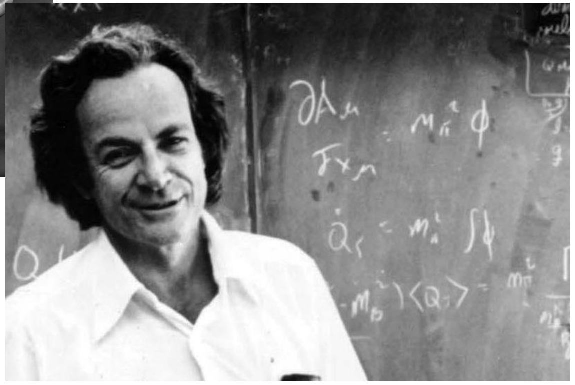
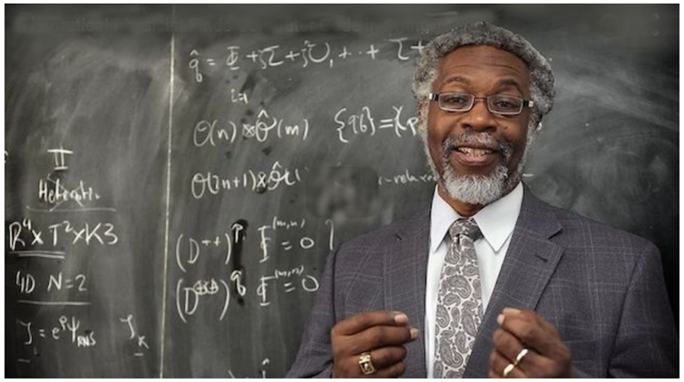
Frames

- Outer page can specify only sizing and placement of the frame in the outer page
  - demo
- Frame isolation: Our page cannot change contents of inner page, inner page cannot change contents of outer page

Web Security

A historical perspective

- The web is an example of “bolt-on security”
- Originally, the web was invented to allow physicists to share their research papers
  - Only textual web pages + links to other pages; no security model to speak of

The web became complex and adversarial quickly

- Then we added embedded images
  - Crucial decision: a page can embed images loaded from another web server
- Then, Javascript, dynamic HTML, AJAX, CSS, frames, audio, video, …
- Today, a web site is a distributed application
- Attackers have various motivations

Web security is a challenge!

Desirable security goals

- **Integrity:** malicious web sites should not be able to tamper with integrity of my computer or my information on other web sites
- **Confidentiality:** malicious web sites should not be able to learn confidential information from my computer or other web sites
- **Privacy:** malicious web sites should not be able to spy on me or my activities online
- **Availability**: attacker cannot make site unavailable

Security on the web

- Risk #1: we don't want a malicious site to be able to trash my files/programs on my computer
  - Browsing to `awesomevids.com` (or `evil.com`) should not infect my computer with malware, read or write files on my computer, etc.
- Defense: Javascript is sandboxed;
  try to avoid security bugs in browser code;
  privilege separation; automatic updates; etc.

Security on the web

- Risk #2: we want data stored on a web server to be protected from unauthorized access
- Defense: server-side security
  - Think Project 2

Security on the web

- Risk #3: we don't want a malicious site to be able to spy on or tamper with my information or interactions with other websites
  - Browsing to `evil.com` should not let `evil.com` spy on my emails in Gmail or buy stuff with my Amazon account
- Defense: the same-origin policy
  - A security policy grafted on after-the-fact, and enforced by web browsers

Security on the web

- Risk #4: we don't want malicious websites to subvert or act in opposition to user's intent
  - Clickjacking attack
- Defense: frame busting can help prevent some clickjacking attacks

Break Time: Spencer McCall

- Missouri -> San Diego, CA
- Enjoys game theory, also crypto
- English, French, Italian

- Accidentally DoS government server while web scrapping

Image: Getty Images/iStockphoto

Same-origin Policy

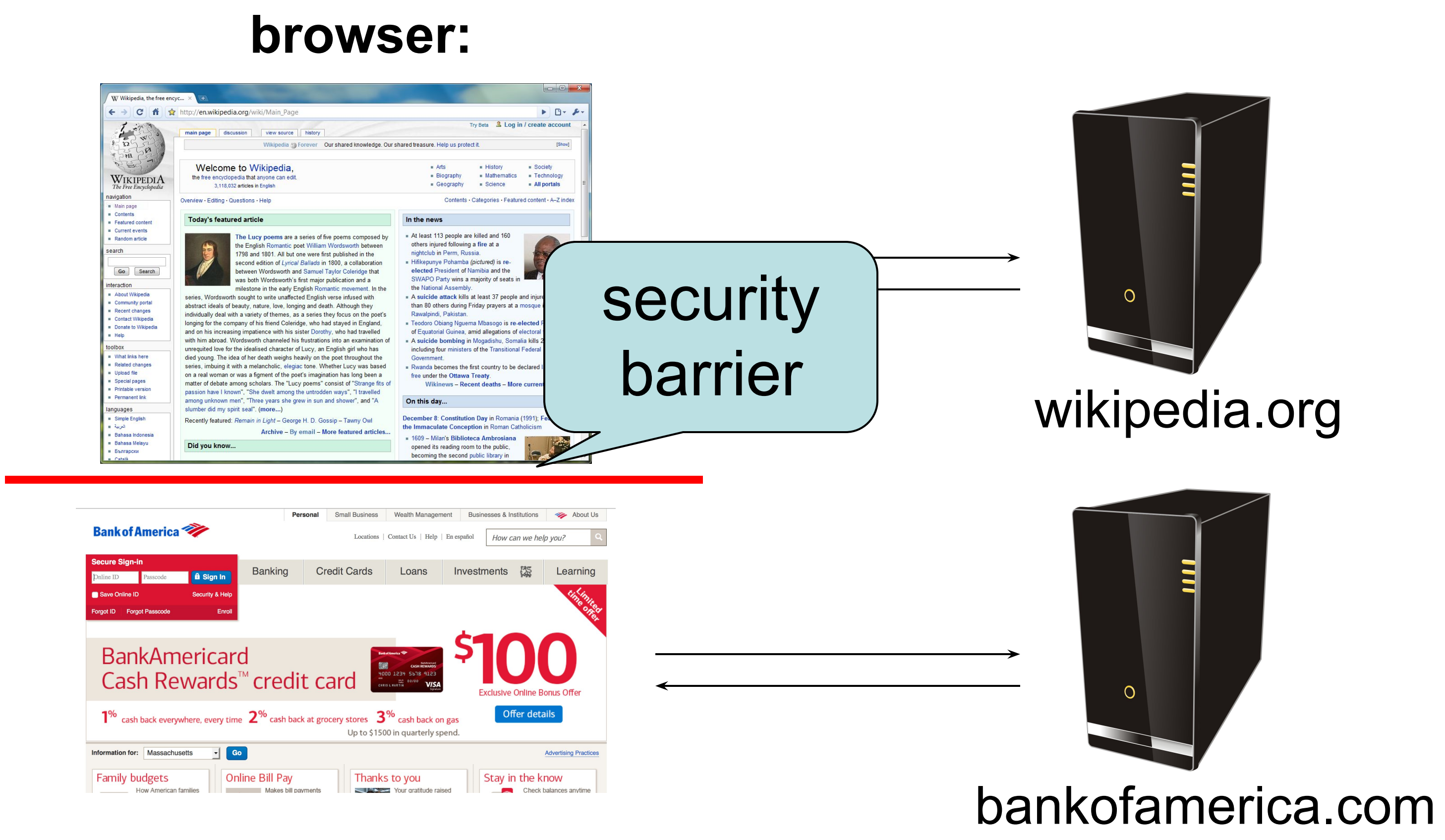
Same-origin policy

One origin should not be able to access the resources of another origin

Javascript on one page cannot read or modify pages from different origins

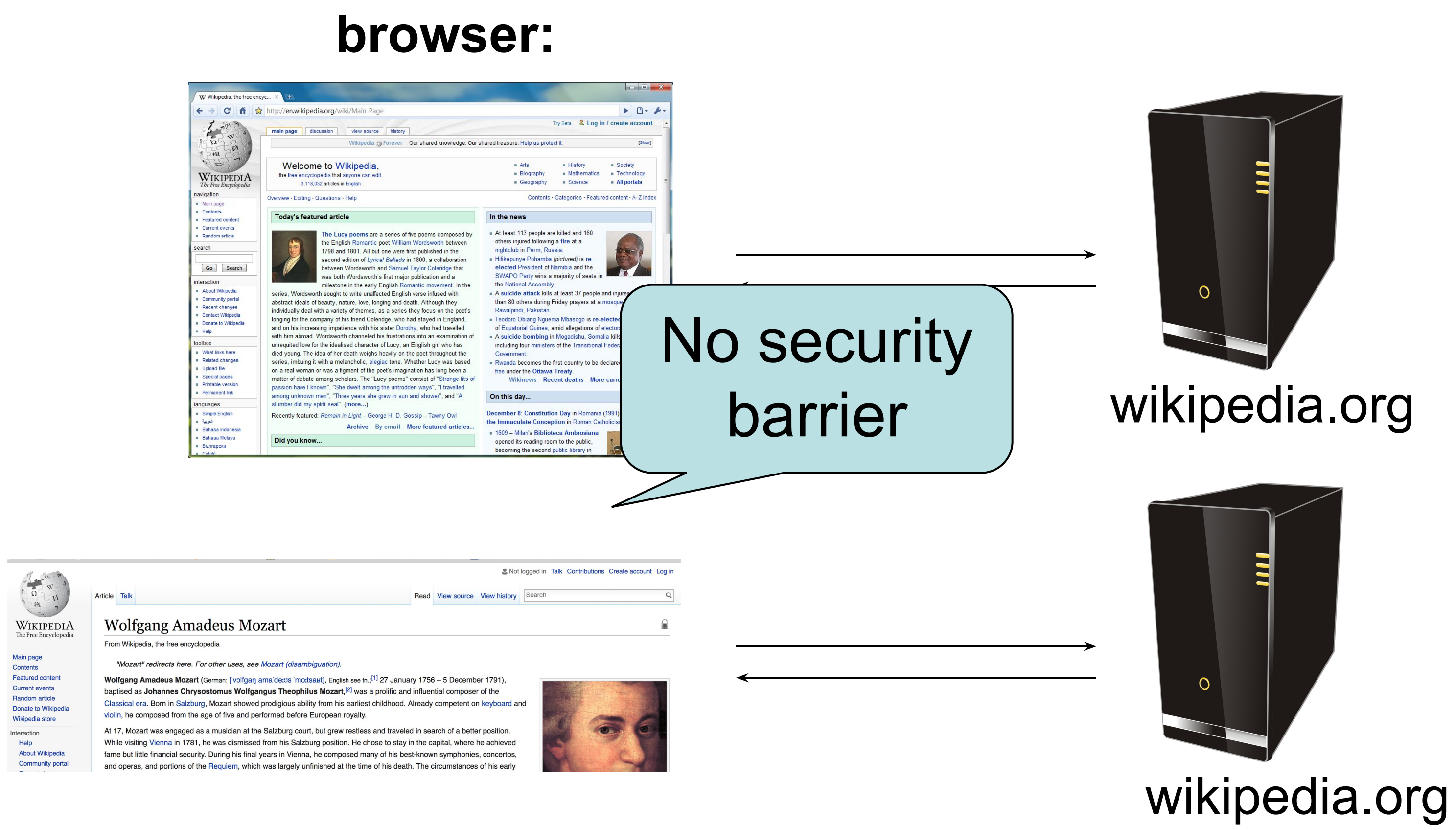
Same-origin policy

- Each site in the browser is isolated from all others



Same-origin policy

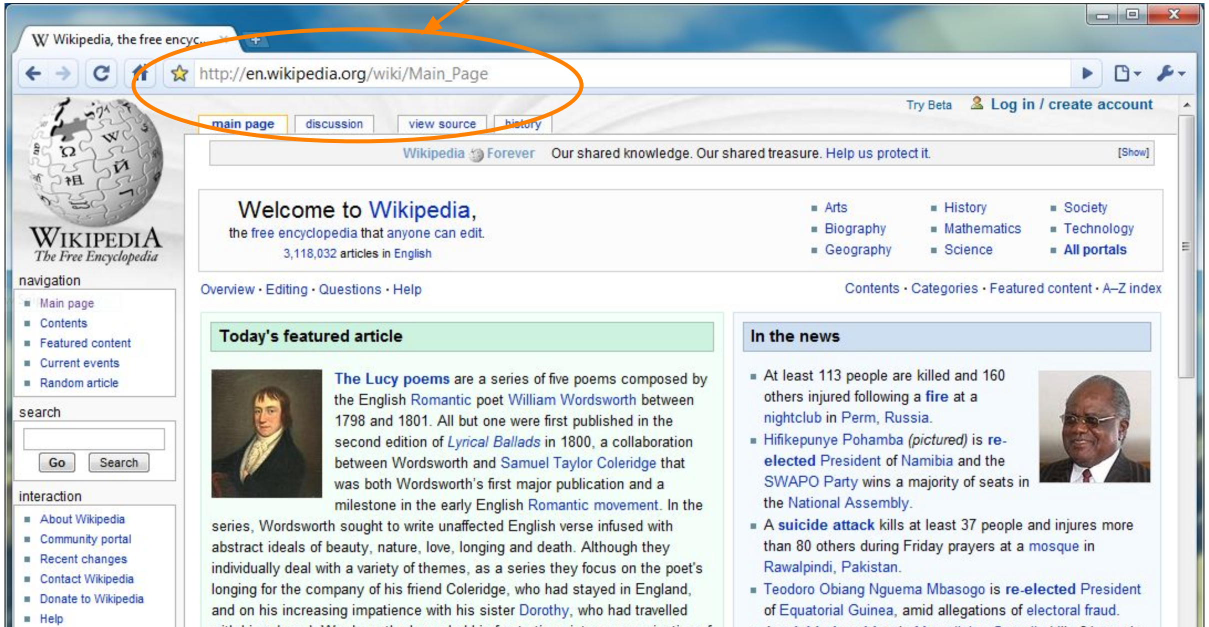
- Multiple pages from the same site are not isolated



Same-origin policy

- The origin of a site is derived from its URL

http://en.wikipedia.org



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Today's featured article

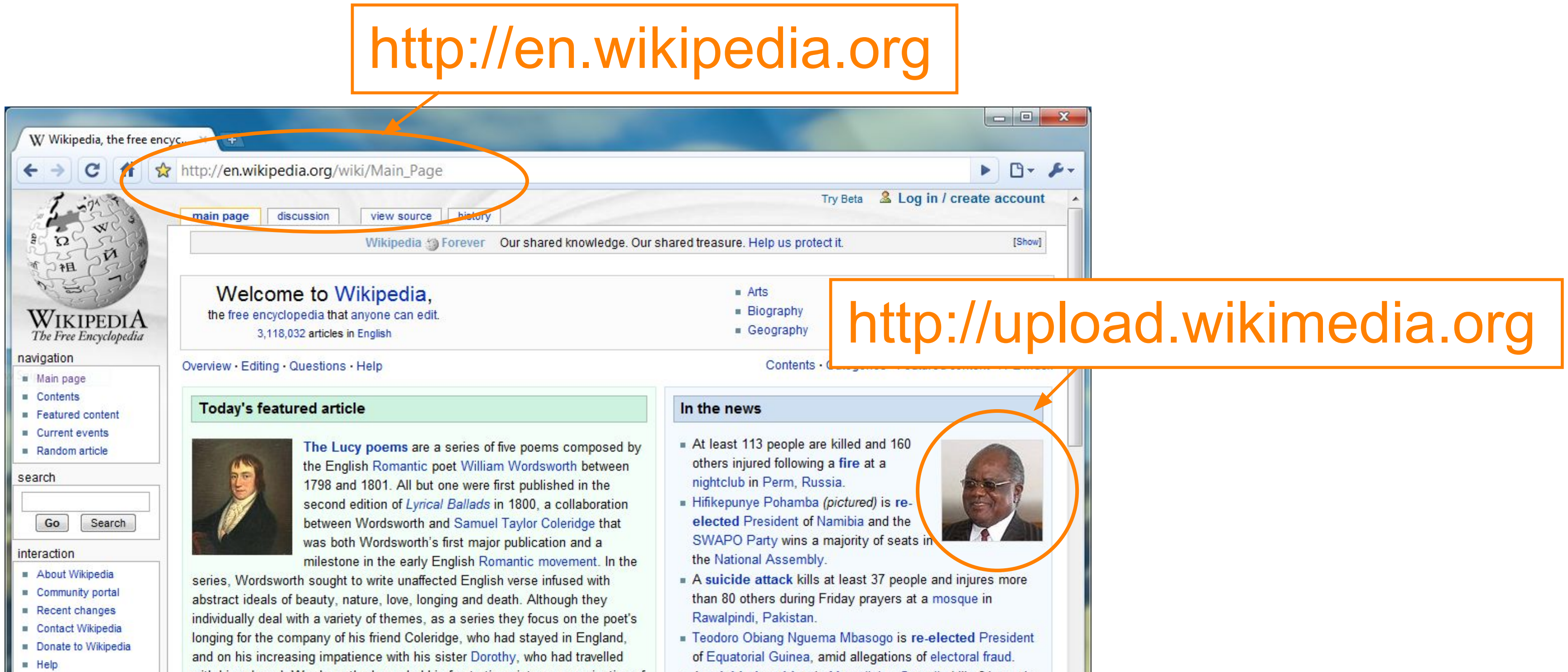
The Lucy poems are a series of five poems composed by the English Romantic poet William Wordsworth between 1798 and 1801. All but one were first published in the second edition of *Lyrical Ballads* in 1800, a collaboration between Wordsworth and Samuel Taylor Coleridge that was both Wordsworth's first major publication and a milestone in the early English Romantic movement. In the series, Wordsworth sought to write unaffected English verse infused with abstract ideals of beauty, nature, love, longing and death. Although they individually deal with a variety of themes, as a series they focus on the poet's longing for the company of his friend Coleridge, who had stayed in England, and on his increasing impatience with his sister Dorothy, who had travelled

In the news

- At least 113 people are killed and 160 others injured following a **fire** at a nightclub in Perm, Russia.
- Hifikepunye Pohamba *(pictured)* is **re-elected** President of Namibia and the SWAPO Party wins a majority of seats in the National Assembly.
- A **suicide attack** kills at least 37 people and injures more than 80 others during Friday prayers at a mosque in Rawalpindi, Pakistan.
- Teodoro Obiang Nguema Mbasogo is **re-elected** President of Equatorial Guinea, amid allegations of electoral fraud.

Same-origin policy

- The origin of a site is derived from its URL
  - Images adopt origin of site that loads them



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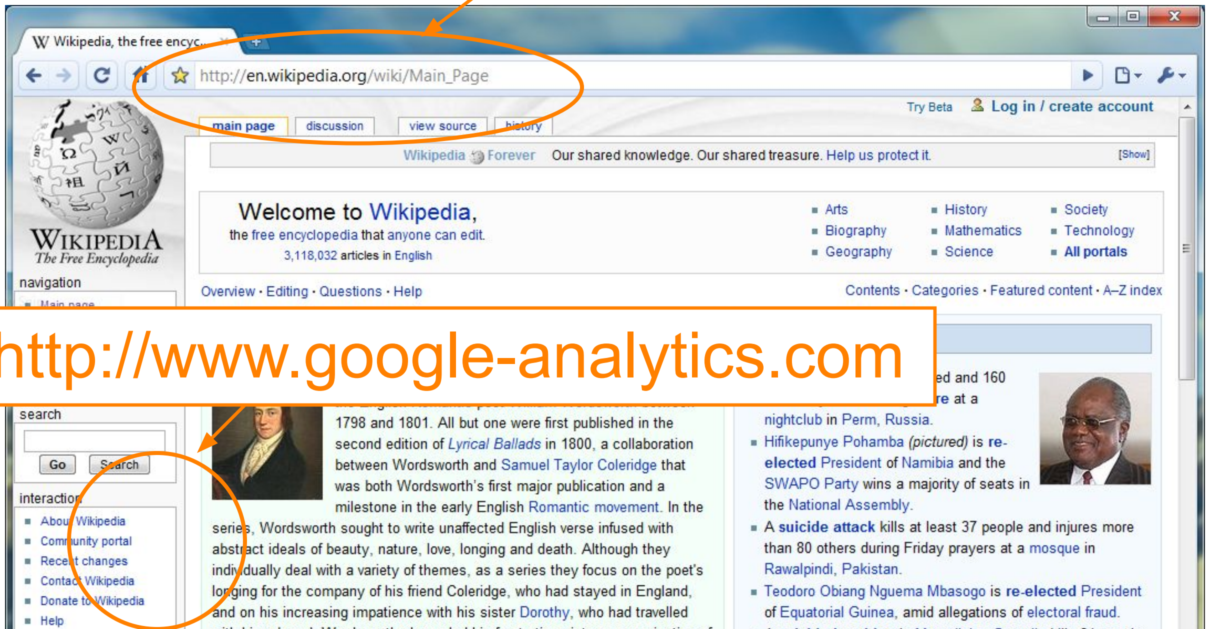
Same-origin policy

- The origin of a site is derived from its URL
  - Images adopt origin of site that loads them
  - Javascript runs with the origin of the site that loaded it

http://en.wikipedia.org



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Contents · Categories · Featured content · A–Z index

navigation
- Main page

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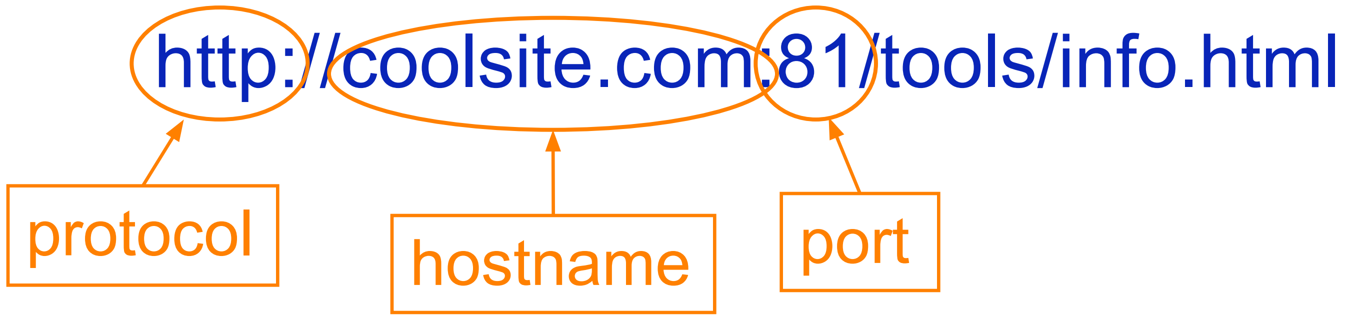
http://www.google-analytics.com

Origins of Frames

- iframes do not adopt origin of site that loads them
  - iframe origin is the inner site (being displayed), and not the outer site (loading website)

Origin

- Granularity of protection for same origin policy
- Origin = protocol + hostname + port

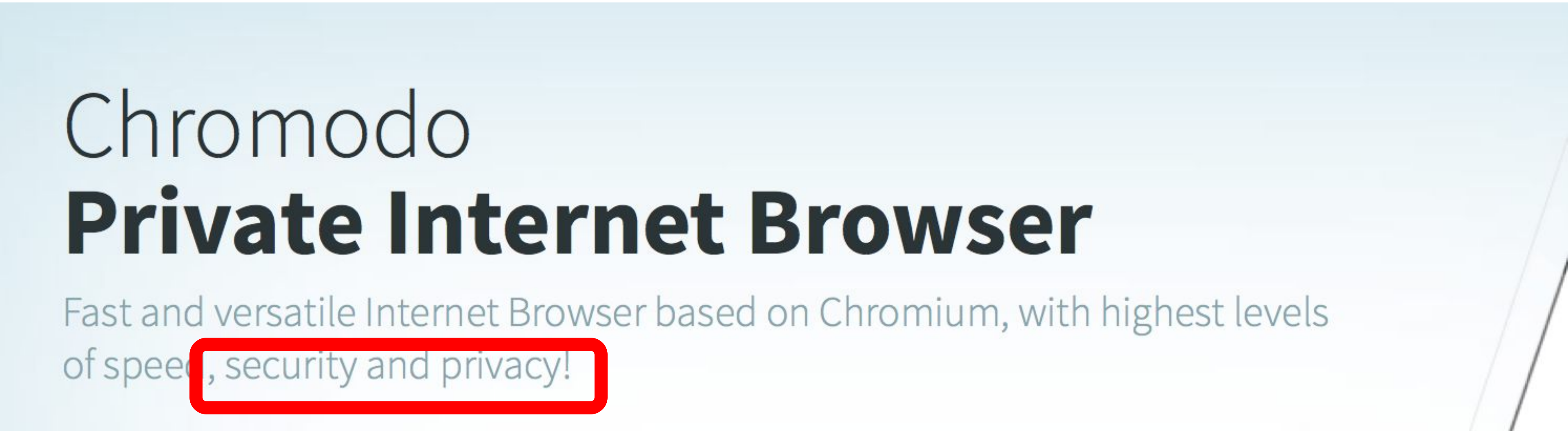


- Origin is determined by **string matching**! If these match, it is same origin, else it is not.
  – However, port matching depends on browser implementation

Exercises

Originating document	**Accessed document**	
http://wikipedia.org/**a**/	http://wikipedia.org/**b**/	✓
http://wikipedia.org/	http://**www.**wikipedia.org/	✗
http://wikipedia.org/	**https**://wikipedia.org/	✗
http://wikipedia.org**:80**/	http://wikipedia.org**:81**/	✗
http://wikipedia.org**:80**/	http://wikipedia.org/	✗

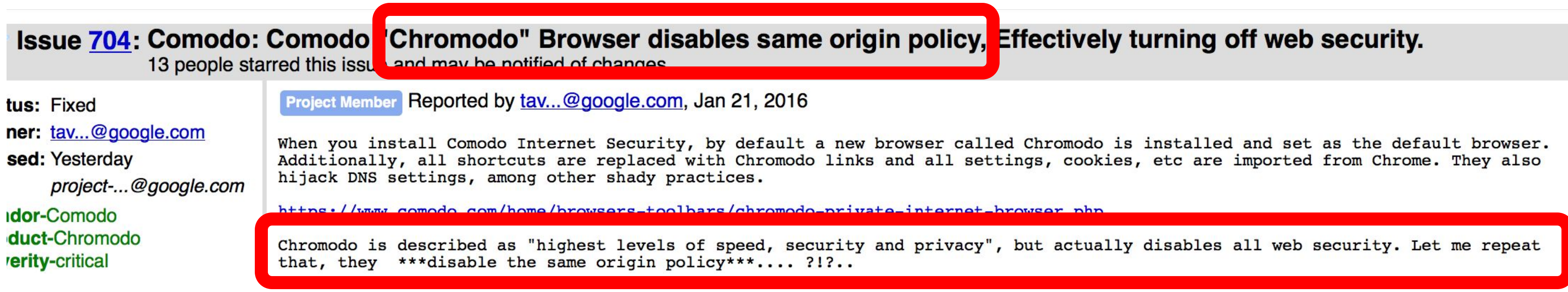
except !!!



Chromodo

Private Internet Browser

Fast and versatile Internet Browser based on Chromium, with highest levels of spee, security and privacy!



Issue 704: Comodo: Comodo "Chromodo" Browser disables same origin policy, Effectively turning off web security.

13 people starred this issu and may be notified of changes.

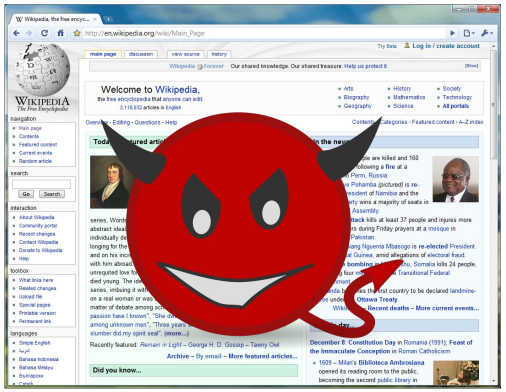
tus: Fixed
ner: tav...@google.com
sed: Yesterday
project-...@google.com
dor-Comodo
duct-Chromodo
erity-critical

Project Member Reported by tav...@google.com, Jan 21, 2016

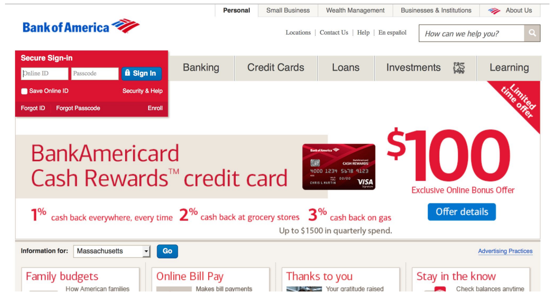
```
When you install Comodo Internet Security, by default a new browser called Chromodo is installed and set as the default browser.
Additionally, all shortcuts are replaced with Chromodo links and all settings, cookies, etc are imported from Chrome. They also
hijack DNS settings, among other shady practices.

https://www.comodo.com/home/browsers-toolbars/chromodo-private-internet-browser.php

Chromodo is described as "highest levels of speed, security and privacy", but actually disables all web security. Let me repeat
that, they  ***disable the same origin policy***.... ?!?..
```

Cross-origin communication

- Allowed through a narrow API: **postMessage**
- Receiving origin decides if to accept the message based on origin (whose correctness is enforced by browser)



```
postMessage
("run this
script",
script)
```



Check origin, and request!

Clickjacking

Clickjacking attacks

- Exploitation where a user’s mouse click is used in a way that was not intended by the user

Talk to your partner

- How can a user’s click be used in a way different than intended?

Simple example

```
<a
   onMouseDown=window.open(http://www.evil.com)
      href=http://www.google.com/>
   Go to Google
</a>
```

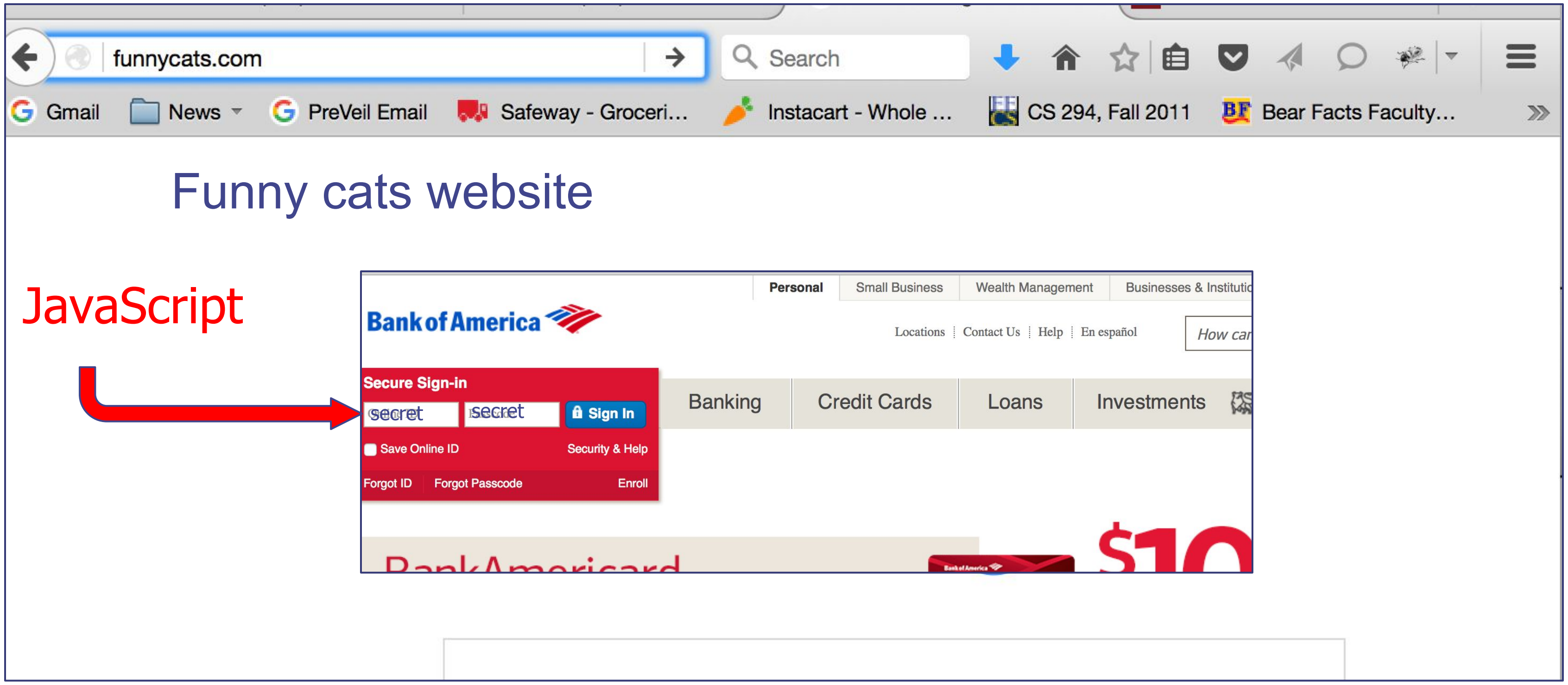
What does it do?

- Opens a window to the attacker site

Why include ***href*** to Google?

- Browser status bar shows URL when hovering over as a means of protection

What happens in this case?


funnycats.com

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Funny cats website

JavaScript

Frames: same-origin policy

- Frame inherits origin of its URL
- Same-origin policy: if frame and outer page have different origins, they cannot access each other
  - In particular, malicious JS on outer page cannot access resources of inner page

How to bypass same-origin policy for frames?

Clickjacking

Clickjacking using frames

- Evil site frames good site
- Evil site covers good site by putting dialogue boxes or other elements on top of parts of framed site to create a different effect
- Inner site now looks different to user

How can we defend against clickjacking?

Defenses

- User confirmation

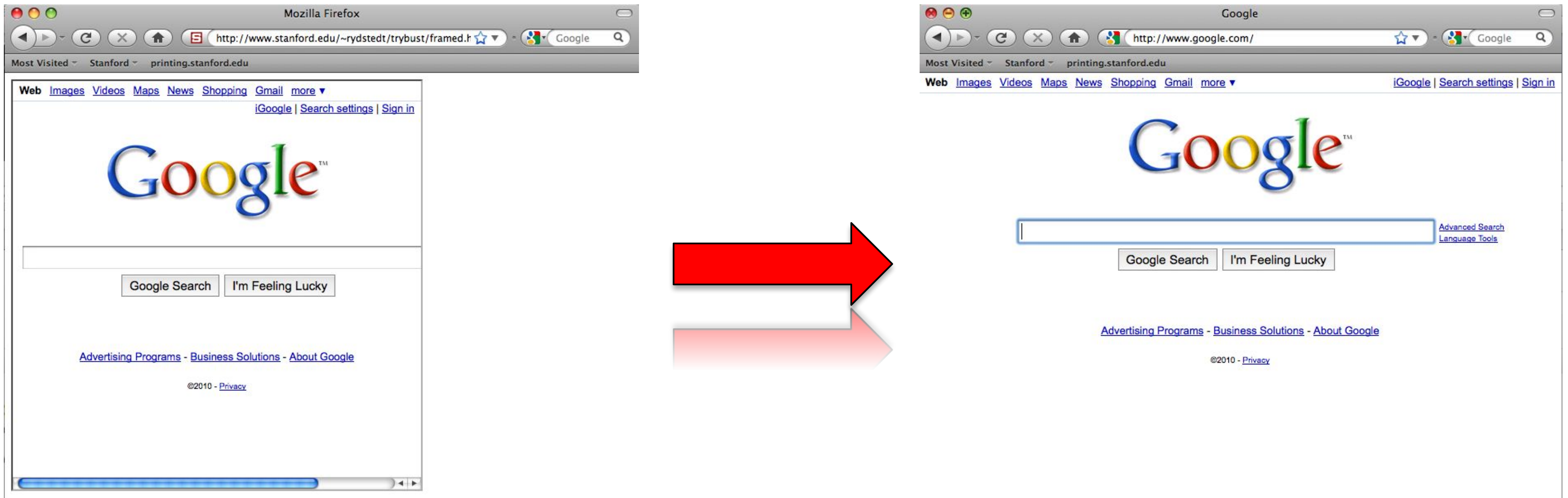
- Good site pops dialogue box with information on the action it is about to make and asks for user confirmation
- Degrades user experience

- UI randomization

- good site embeds dialogues at random locations so it is hard to overlay
- Difficult & unreliable (e.g. multi-click attacks)

Defense 3: Framebusting

Web site includes code on a page that prevents other pages from framing it


Mozilla Firefox
http://www.stanford.edu/~rydstedt/trybust/framed.h
Most Visited Stanford printing.stanford.edu
Web Images Videos Maps News Shopping Gmail more
iGoogle | Search settings | Sign in
Google
Google Search I'm Feeling Lucky
Advertising Programs - Business Solutions - About Google
©2010 - Privacy
Google
http://www.google.com/
Advanced Search
Language Tools

Demo

What is framebusting?

Framebusting code is often made up of

- a conditional statement and
- a counter action

Common method:

```
if (top != self) {
    top.location = self.location;
}
```

A Survey

Framebusting is very common at the Alexa Top 500 sites

[global traffic rank of a website]

Top 10	60%
Top 100	37%
Top 500	14%

credit: Gustav Rydstedt

Many framebusting methods

```
if (top != self)
if (top.location != self.location)
if (top.location != location)
if (parent.frames.length > 0)
if (window != top)
if (window.top !== window.self)
if (window.self != window.top)
if (parent && parent != window)
if (parent &&  parent.frames &&
parent.frames.length>0)
if((self.parent && !(self.parent===self)) &&
(self.parent.frames.length!=0))
```

Many framebusting methods

```
top.location = self.location
top.location.href = document.location.href
top.location.href = self.location.href
top.location.replace(self.location)
top.location.href = window.location.href
top.location.replace(document.location)
top.location.href = window.location.href
top.location.href = "URL"
document.write(”)
top.location = location
top.location.replace(document.location)
top.location.replace(’URL’)
top.location.href = document.location
```

Most current framebusting can be defeated

Easy bugs

Goal: bank.com wants only bank.com’s sites to frame it

Bank runs this code to protect itself:

```
if (top.location != location) {
      if (document.referrer &&
         document.referrer.indexOf(”bank.com") == -1)
         {
             top.location.replace(document.location.href);
         }
    }
```

Problem: http://badguy.com?q=bank.com

Abusing the XSS filter

IE8 reflective XSS filters:

- Browser requested URL contains javascript:
  - http://www.victim.com?var=<script> alert('xss'); </script>
- Server responds
- Brower checks
  - If <script> alert('xss'); </script> appears in rendered page word for word, the IE8 filter will replace it with

    <sc#pt> alert('xss'); </sc#pt>

How can attacker abuse this?

Abusing the XSS filter

- Attacker figures out the framebusting code of victim site (easy: visit victim site in attacker’s browser and view the source code)
  - <script> if(top.location != self.location) //framebust </script>
- Framing page (attacker’s outer page) does:
  - <iframe src=“http://www.victim.com?var=**<script> if(top.location != self.location) //framebust </script>**“>
- IE8 XSS filter modifies victim site’s script to:
  - **<sc#pt>** if(top.location != self.location)

XSS filter disables legitimate framebusting code!!

Coming up:

attacks on web servers!