Ajax (in)security

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Overview

- Architecture of web applications
- What is Ajax?
- How does Ajax help?
- Four security issues with Ajax and Ajax applications
- Guidelines for secure Ajax development

Architecture of Web Applications

Traditional Web Application

Browser receives input from user

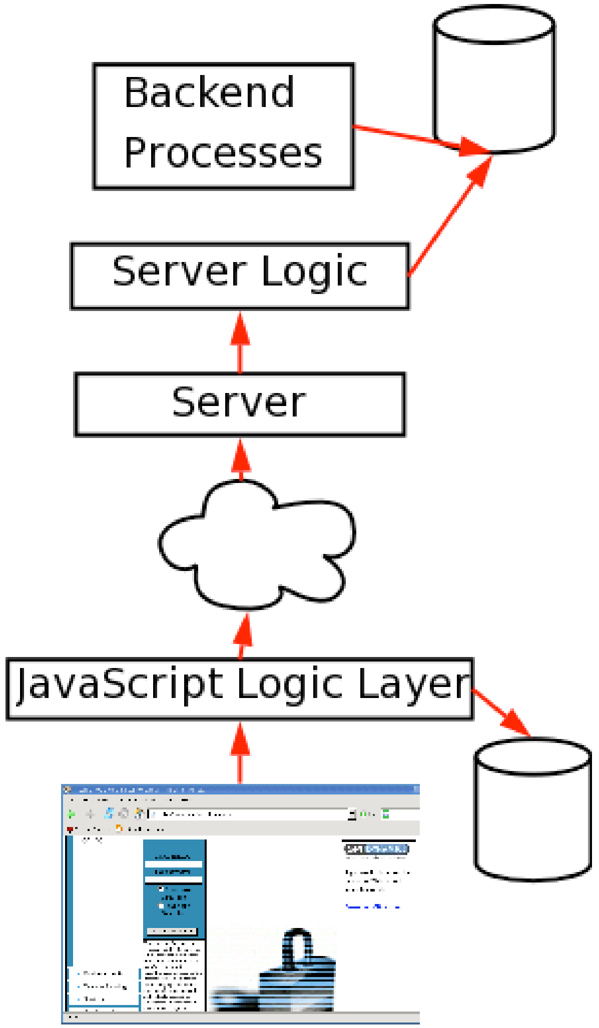
Uses JavaScript for simple logic and optimizations

Sends HTTP request across the Internet

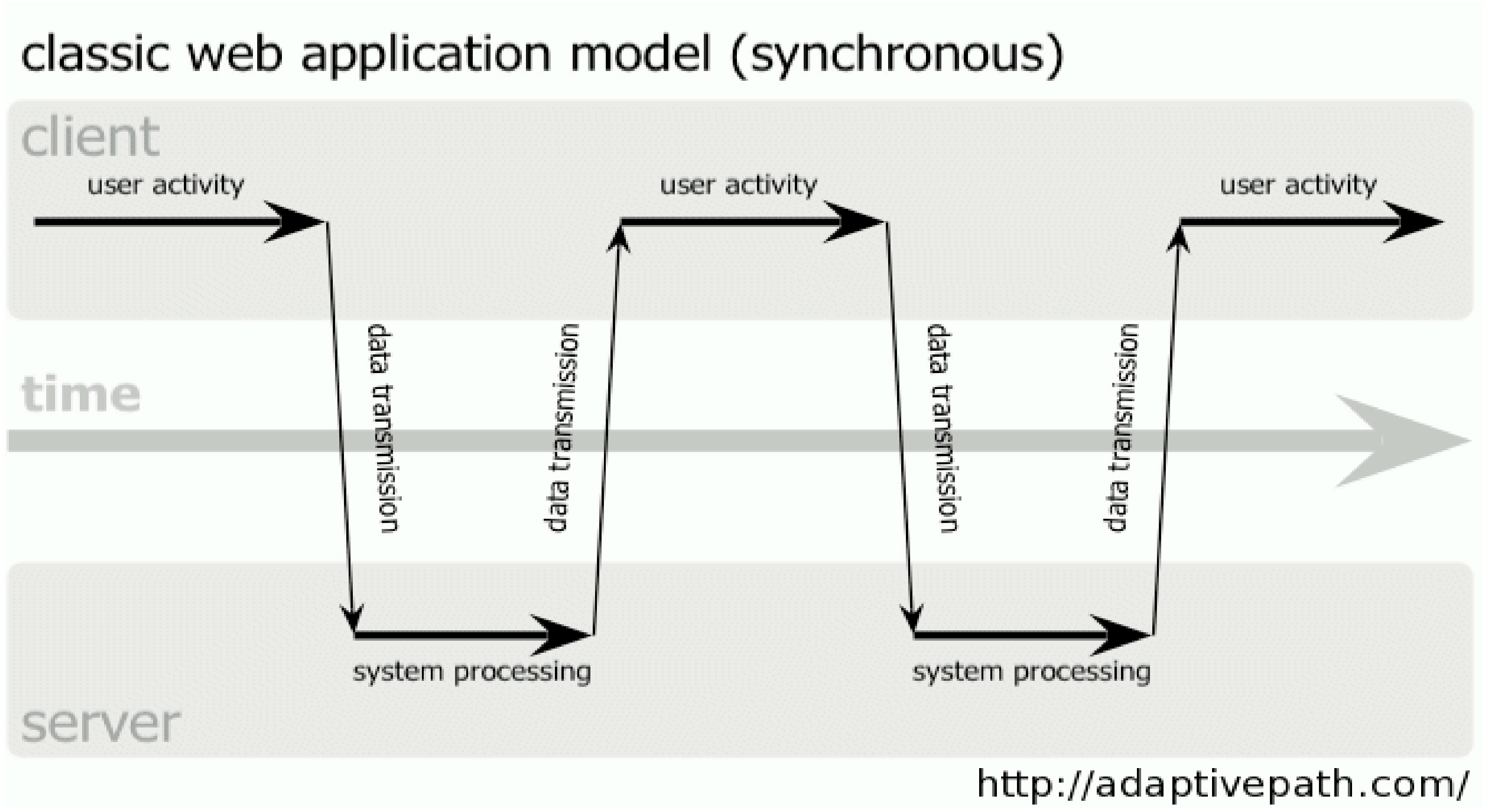
Server processes response

- Backend logic evaluates input (PHP, ASP, JSP, etc)
- Possibly access other tiers (database, etc)

Resource is returned to user



Problems with Traditional Web Apps



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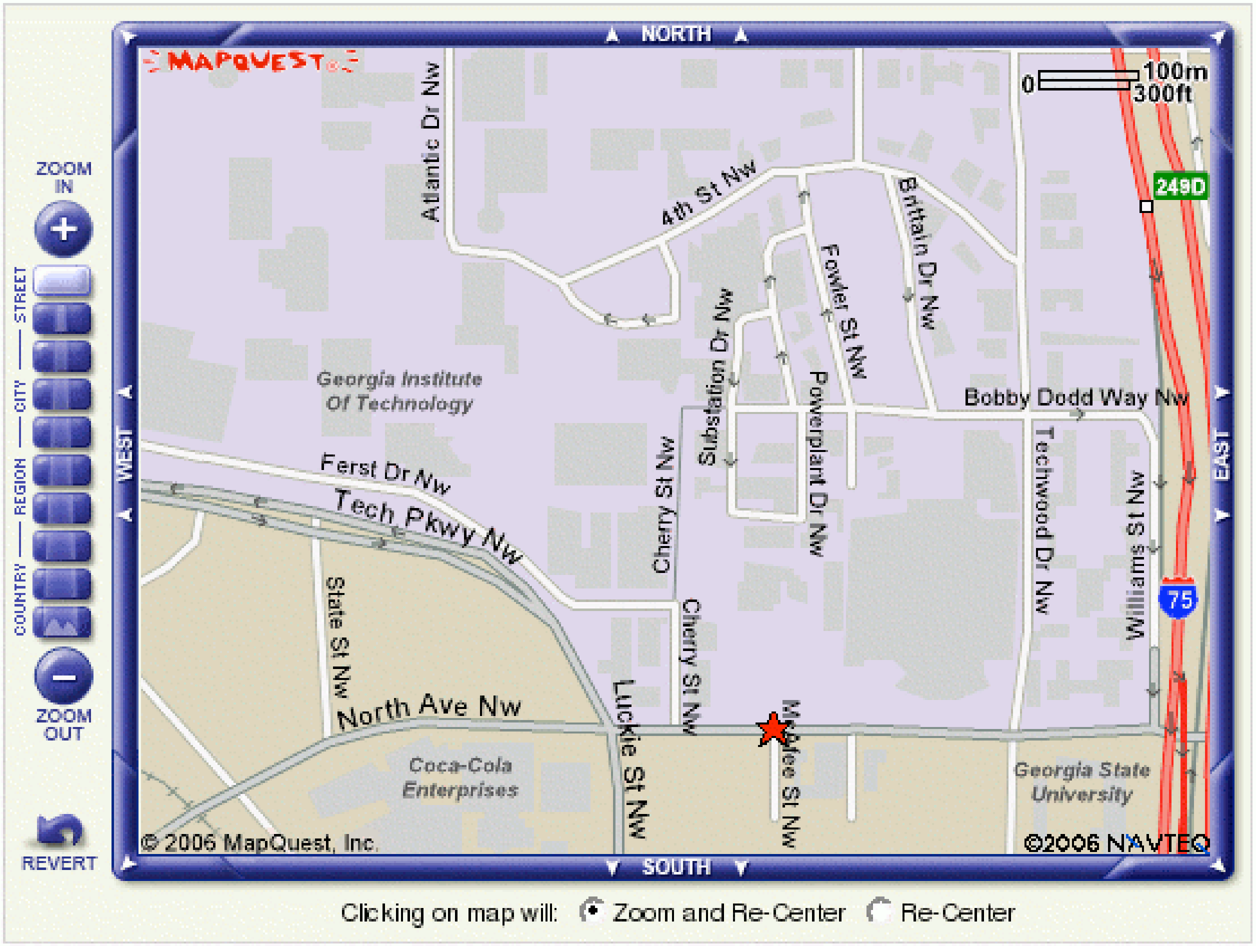
Case Study: MapQuest



Clicking on map will: [✓ Zoom and Re-Center] Re-Center

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Reducing the Long Wait

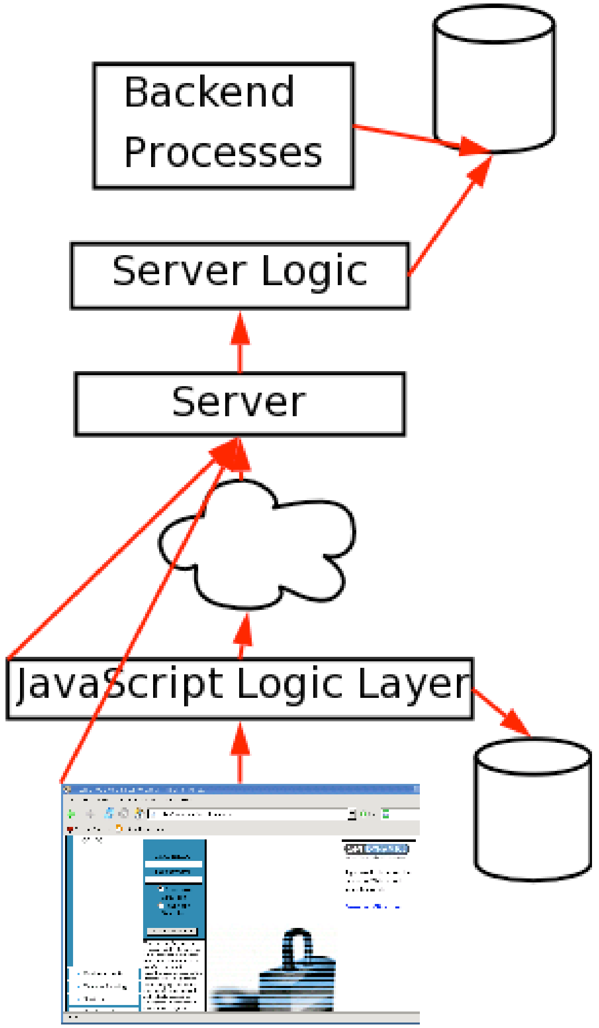
- These long pauses are very noticeable
- Regular applications don't with the user this way
- Reducing the delay between input and response is key
  - Request is a fixed size
  - Response is a fixed size
  - Network speed,latency is fixed
  - Server processes relatively fixed
- Trick the user with better application feedback
- This is what Ajax does

What is Ajax?

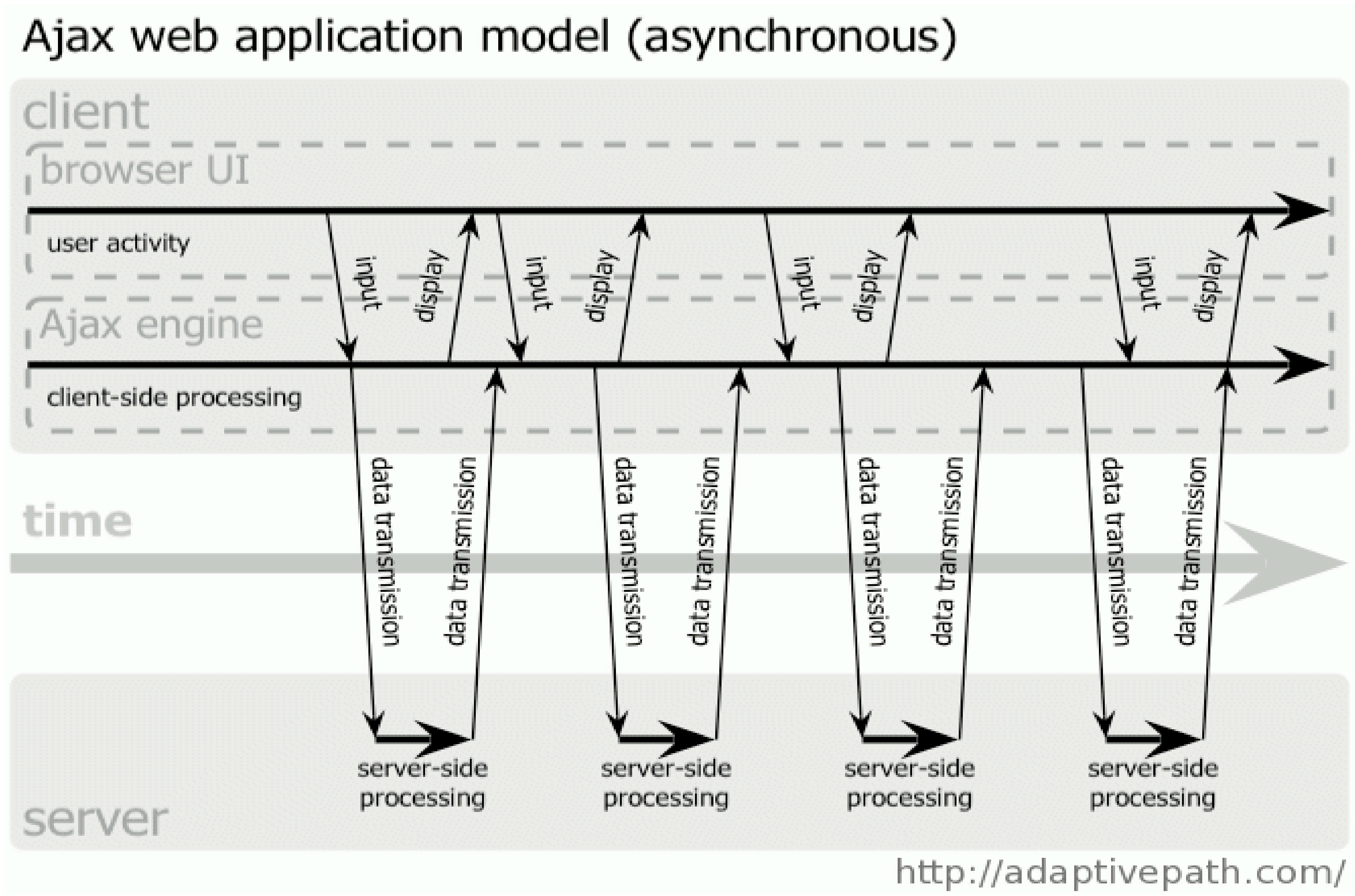
Asynchronous JavaScript And XML

JavaScript takes on a larger role

- Send HTTP request
- Provides immediate feedback to user
- Application continues to respond to user events, interaction
- Eventually processes response from server and manipulates the DOM to present results



Providing a Rich User Experience



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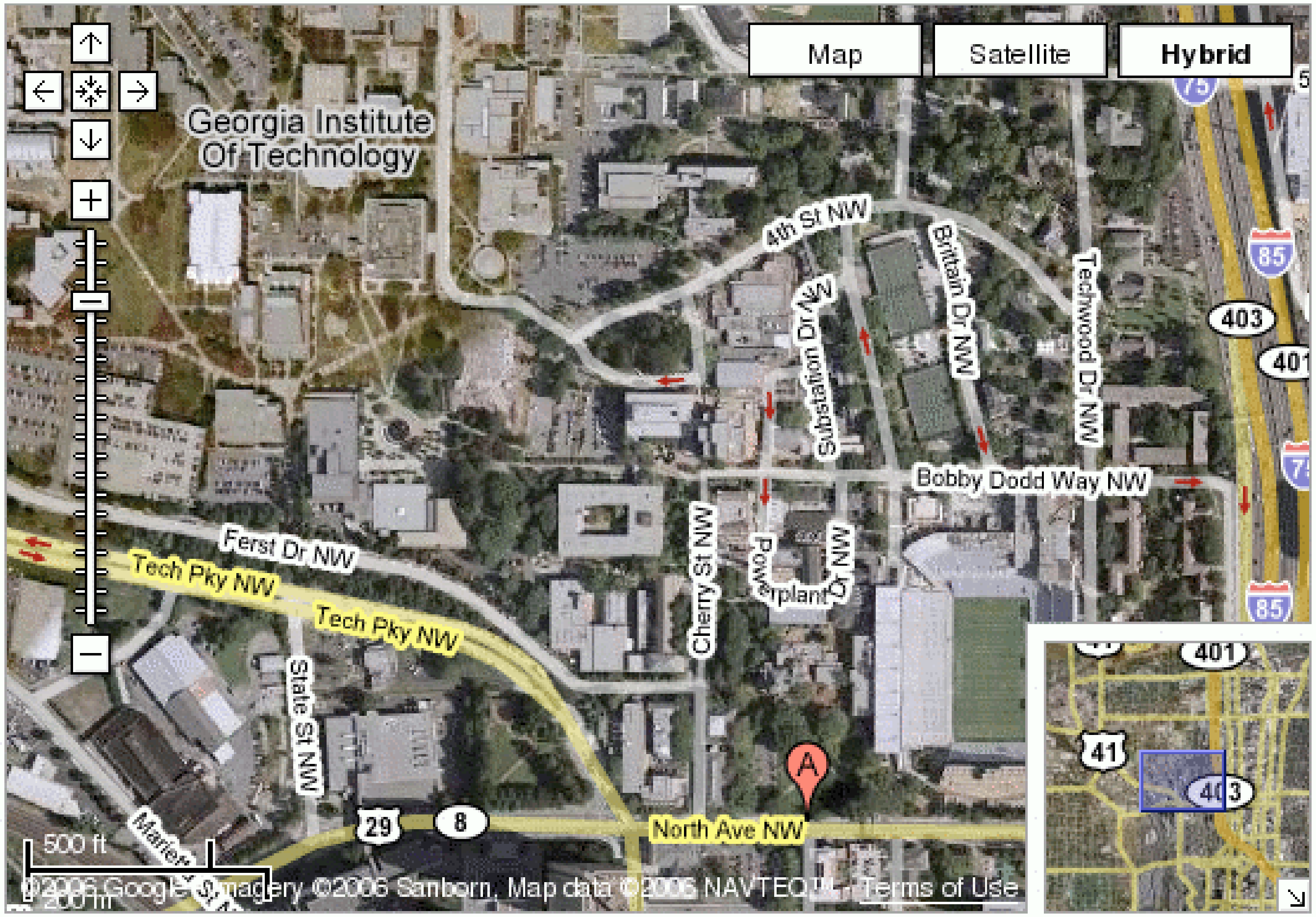
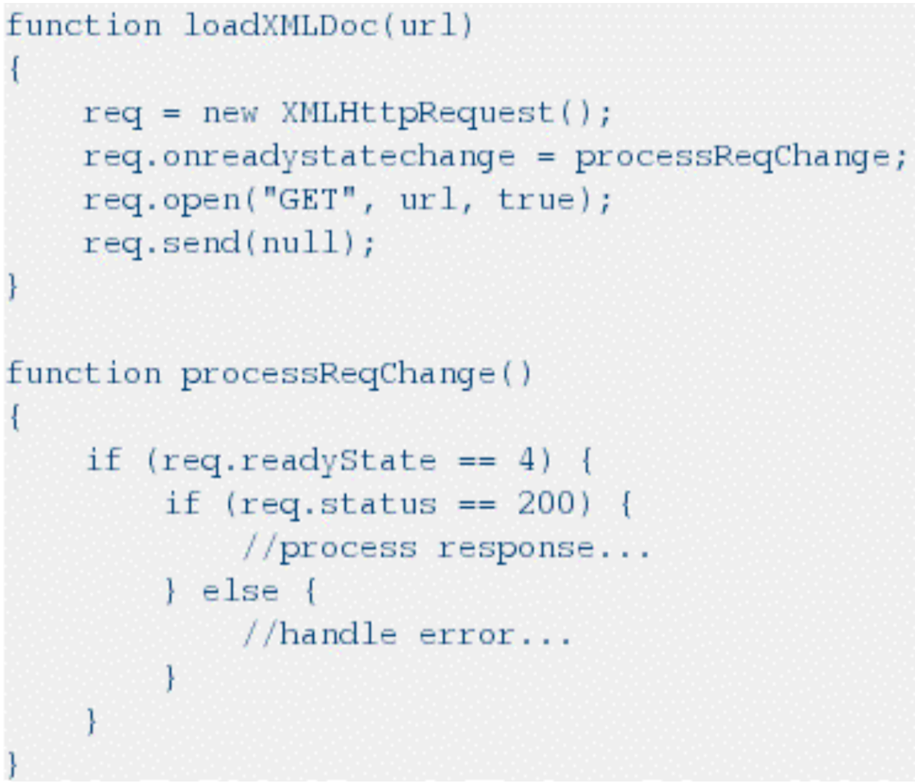
Case Study: Google Maps



More information on Ajax

- Use XmlHttpRequest Object
- Sends any HTTP method
  - Simple: GET, POST, HEAD
  - WebDav: COPY, DELETE
- Limited to where JavaScript came from (hostname, port)
- Fetch any kind of resource
  - XML, HTML, plain text
  - Images, Flash, media content
  - Script (Atlas Framework)



```
function loadXMLDoc(url)
{
    req = new XMLHttpRequest();
    req.onreadystatechange = processReqChange;
    req.open("GET", url, true);
    req.send(null);
}

function processReqChange()
{
    if (req.readyState == 4) {
        if (req.status == 200) {
            //process response...
        } else {
            //handle error...
        }
    }
}
```

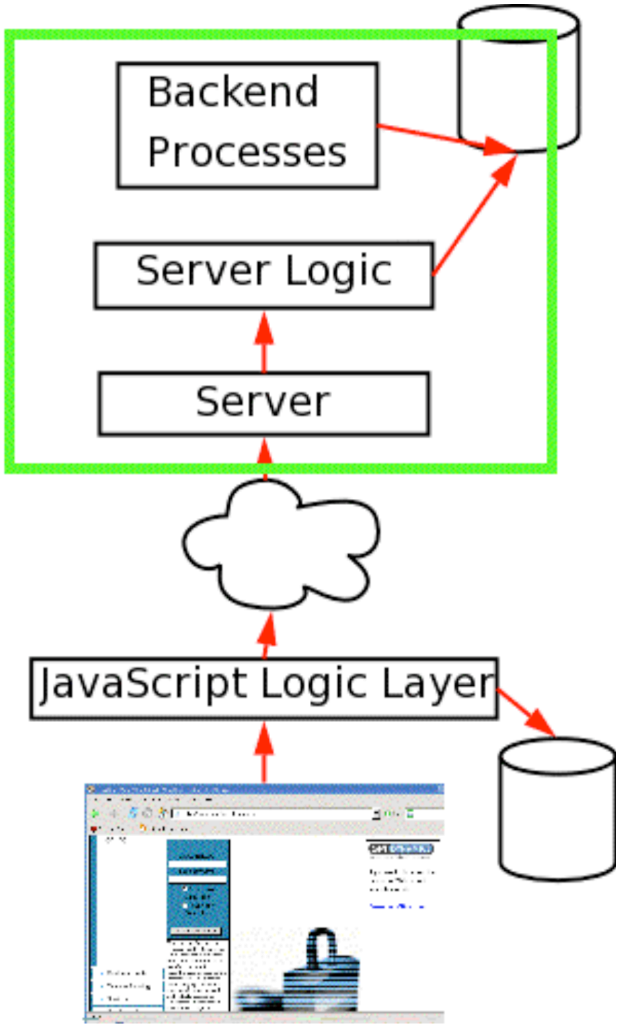
Security Issues Surrounding Ajax

- Ajax applications have larger attack surface then traditional applications
- Implementation issues of Ajax make it insecure
  - Repudiation of requests
  - Implementation of “bridging”
- “Buzz” around Ajax is leading to inappropriate use

Attack Surface of Ajax Applications

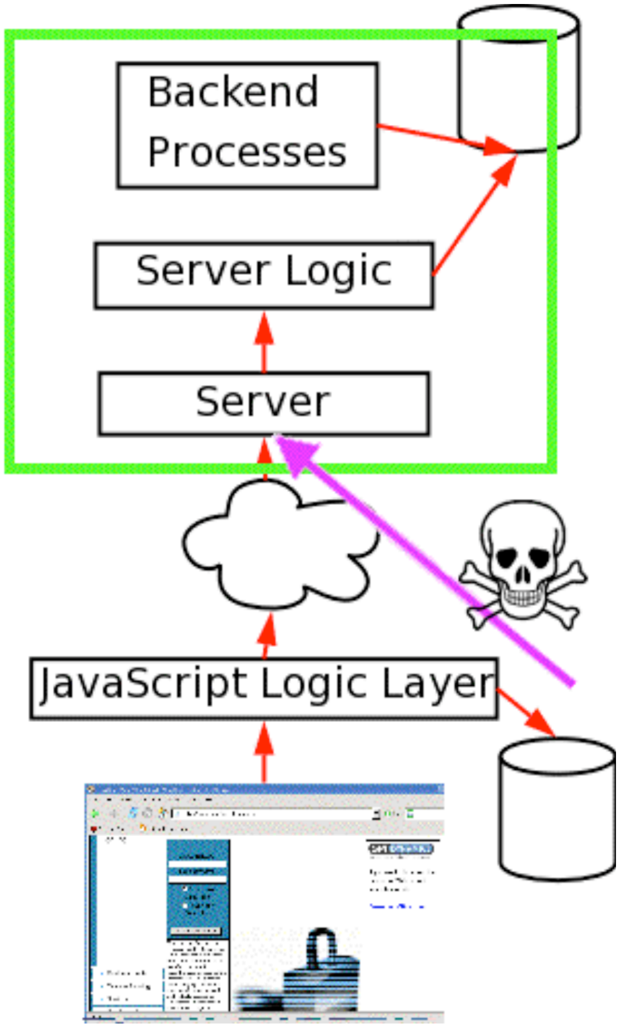
Architecture of Traditional Web Application

- Application exists almost exclusively on server (except validation)
- Very similar to dumb terminal applications
- Commands from user sent to server
  - User clicked "checkout" button
  - User submits post to forum
  - User navigates to page for product #24
- Application returns whole "new" page
- "What to do" not "How to do it"



Attacks Against Traditional Web Applications

- Attacks involve sending malformed commands
  - User submits post with HTML tags
  - User uploads bad image to corrupt database, exploit
  - User navigates to page for product -1
  - User requests resource without logging in
- These malicious commands hit edge cases in application design



Input Validation for Web Applications

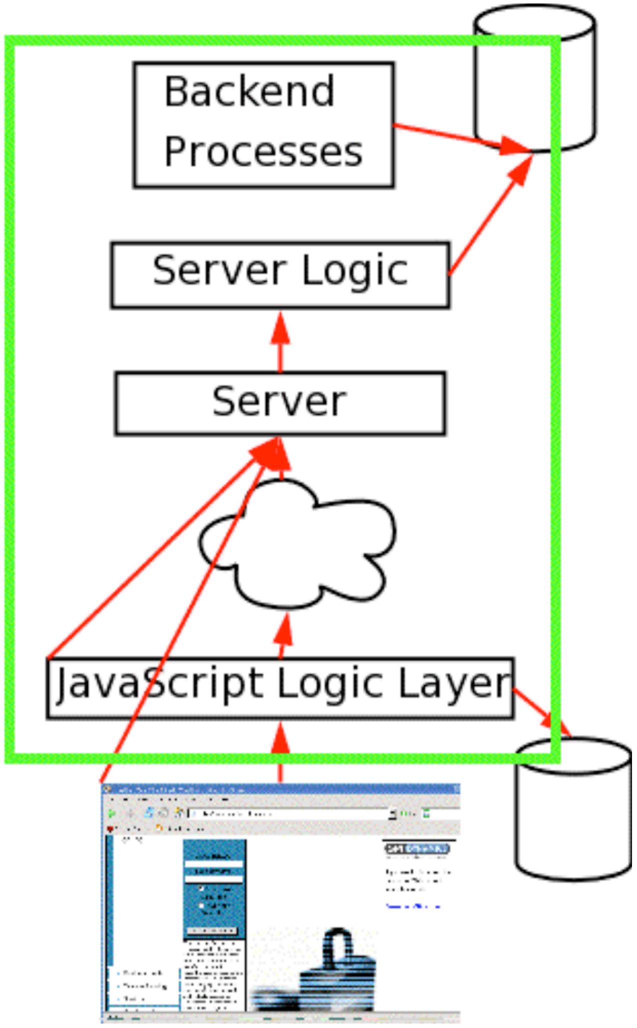
- Ensure commands are correct
- Takes place on both client and server
  - Client validation = performance
  - Server validation = security
- Should be very easy
  - Datatypes of inputs are known
  - Valid ranges and values are known
  - Very limited number of inputs
  - Everything is defined by you
- So how secure are traditional web applications?

Security State of the Union

- Web application vulnerabilities are everywhere!
  - Gartner: “70% of attacks are through the application layer”
  - Majority of posts on mailing lists are web vulnerabilities
- Theory: Input validation is easy on traditional applications
- **Reality: Web developers are doing a poor job validating user input**

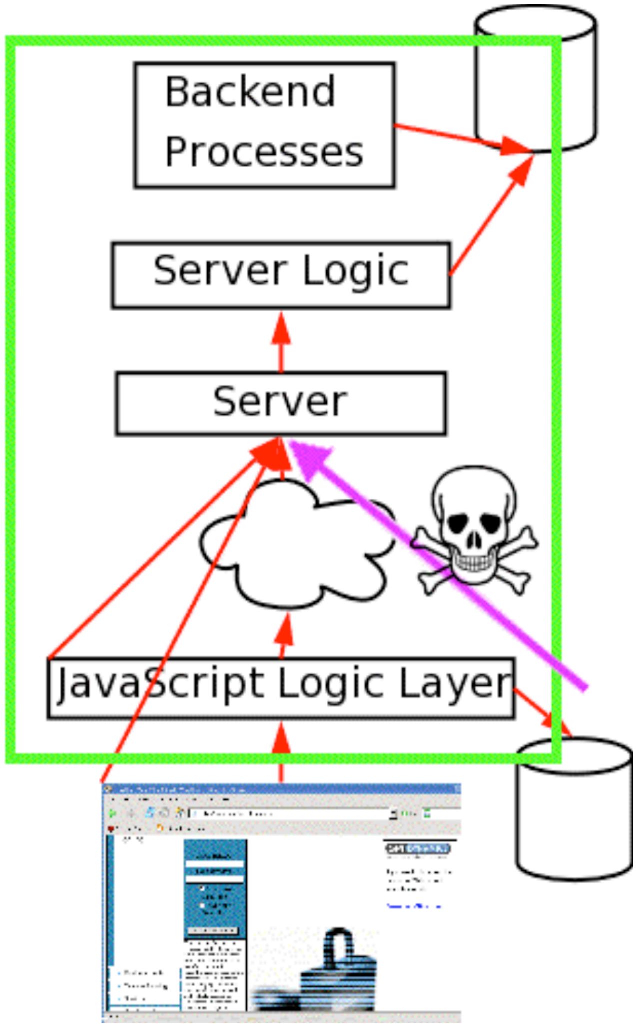
Architecture of an Ajax Application

- Ajax applications extend across client and server
- JavaScript traps user commands, makes *function calls* to server
  - Return price for product #24
  - Return valid cities for given state
  - Return last valid address for user #78
  - Update users age in database
- "How to do it" is being sent over the Internet!



Attacks Against Ajax Applications

- Attacker is now inside your application!
- Knowledge increases
  - Function/variable names
  - Function parameters and return types
  - Datatypes and valid ranges
- Attack surface increases
  - No longer attacking limited inputs, hoping attacks get through
  - Can audit application's entire API!
- Exploit trust relationship of client and server



Attacks Against Ajax Applications

- 3 types of inputs to filter
  - Forms input
    - Example: form variables, either GET or POST
    - Validation is not implemented enough
  - File Formats
    - Example: Images, ZIP files
    - WMF exploit, numerous PNG/JPG bugs
  - Exposed functions and web services
    - Example: control logic, functions
    - Rarely have validation, if any for QA, unit testing

Function Input Validation in the Wild

- Real world application using Microsoft's “Atlas” framework
- Function input not validated

```
[WebMethod]
public string updatePassword(string custID, string newPassword) {

    //connect to SQL Server (connection string defined earlier
    SqlConnection conn = new SqlConnection(strCn);

    //create query
    string q = "UPDATE tblUser SET Password = '" + newPassword +
    "' WHERE CustomerID='" + custID + "'";

    SqlCommand cmd = new SqlCommand(q, conn);
    cmd.ExecuteNonQuery();

    return "Password Updated to " + newPassword;
}
```

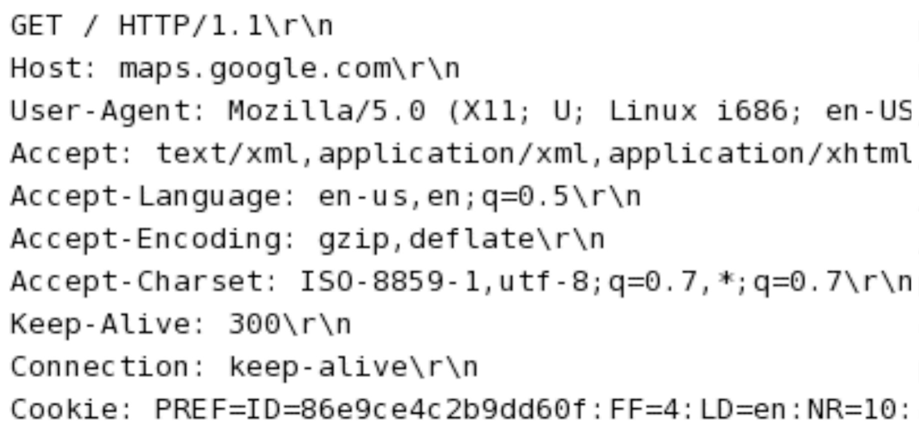
Repudiation of Requests (or, “No, I really didn't make that stock trade!”)

Overview of Repudiation

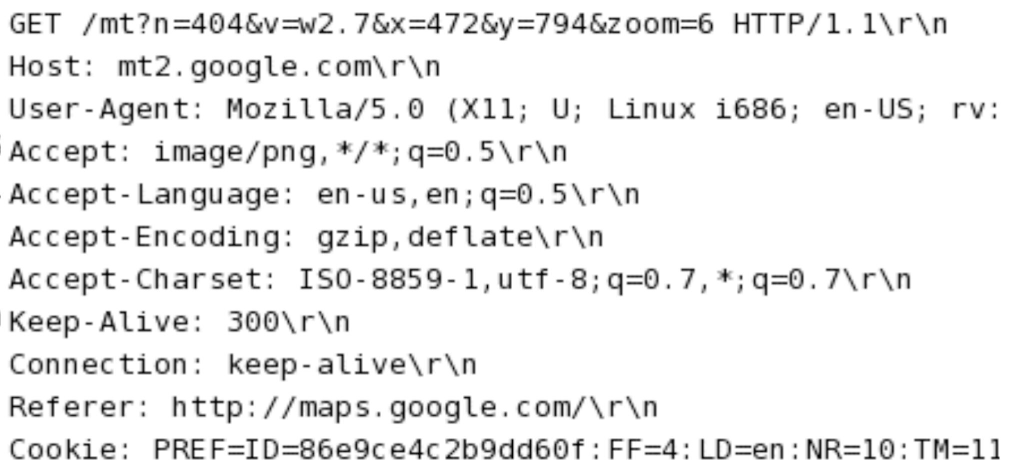
- What is repudiation?
  - Being able to deny you did something
  - Very specific in cryptography
- Pretty important in the computer world today
- How does this apply to Ajax?

More Information on Ajax

- HTTP requests look identical
  - Headers
  - Statekeeping/Authentication tokens (cookies)
- Server cannot discern Ajax requests from browser requests!



```
GET / HTTP/1.1\r\n
Host: maps.google.com\r\n
User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US
Accept: text/xml,application/xml,application/xhtml
Accept-Language: en-us,en;q=0.5\r\n
Accept-Encoding: gzip,deflate\r\n
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\n
Keep-Alive: 300\r\n
Connection: keep-alive\r\n
Cookie: PREF=ID=86e9ce4c2b9dd60f:FF=4:LD=en:NR=10:
```



```
GET /mt?n=404&v=w2.7&x=472&y=794&zoom=6 HTTP/1.1\r\n
Host: mt2.google.com\r\n
User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:
Accept: image/png,*/*;q=0.5\r\n
Accept-Language: en-us,en;q=0.5\r\n
Accept-Encoding: gzip,deflate\r\n
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\n
Keep-Alive: 300\r\n
Connection: keep-alive\r\n
Referer: http://maps.google.com/\r\n
Cookie: PREF=ID=86e9ce4c2b9dd60f:FF=4:LD=en:NR=10:TM=11
```

Ajax Design on Repudiation

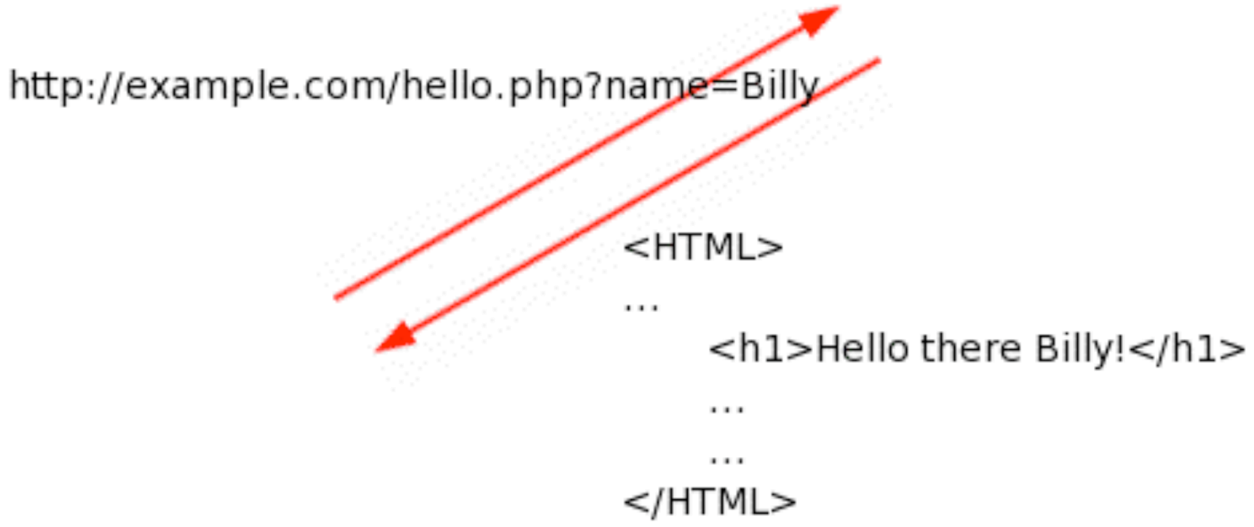
- You can't prove you didn't cause an XmlHttpRequest to happen
- In other words
  - JavaScript can make requests for resources
  - Request is hidden
  - Happens while you are use the computer
  - Contain authentication information
  - JavaScript can read response, send derived requests

Cross Site Scripting (XSS)

- Cross Site Scripting is injecting script (Javascript or VBScript) into the page that is returned to the user's browser
- This scripts gets executed by the users browser exposing them to a variety of threats
  - Cookie theft
    - Session hijacking
    - Information leakage
  - Keylogging
  - Screen scrapping
  - Malicious requests

How Cross Site Scripting Works

- Personalized greeting page functioning normally

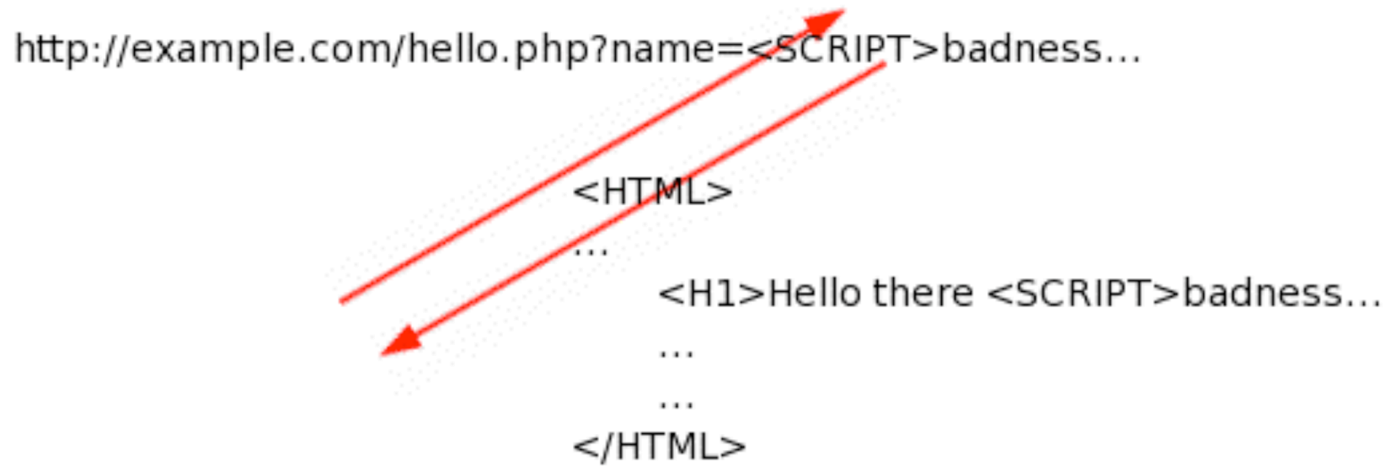


```
http://example.com/hello.php?name=Billy

<HTML>
...
      <h1>Hello there Billy!</h1>
      ...
      ...
</HTML>
```

How Cross Site Scripting Works

- Personalized greeting page with XSS



```
http://example.com/hello.php?name=<SCRIPT>badness...

                    <HTML>
                    ...
                        <H1>Hello there <SCRIPT>badness...
                        ...
                        ...
                    </HTML>
```

Ajax Empowers XSS

- XSS can now make malicious requests with a user's credentials
- No hard refresh
- Drastically increases damage, information theft XSS can do
- Screen Scrapping
  - Before Ajax
    - Passively scrap what user visits (venus fly trap)
  - After Ajax
    - Actively hunt for specific content (tiger)
    - XSS/Ajax crawler: Scrap for data and links, repeat
    - Can access resources/data not available to passive

Injecting and Propagating XSS

- Before Ajax
  - By hand by a person
  - Typically can only inject one part of a website
    - Reflection based XSS
    - Stored based XSS
  - Self-propagation
    - Use *Image object, DOM tricks to send requests*
    - *Limited to GET, sometimes POST*
    - *Blind requests, cannot see response*

Injecting and Propagating XSS

- After Ajax
  - XSS payload can now autonomously inject itself into pages
  - Easily re-inject same host with more XSS
  - Can do this all seamlessly (no hard refresh)
  - Can send multiple requests using complex HTTP methods to accomplish propagation
  - Sound like a virus doesn't it
  - It is

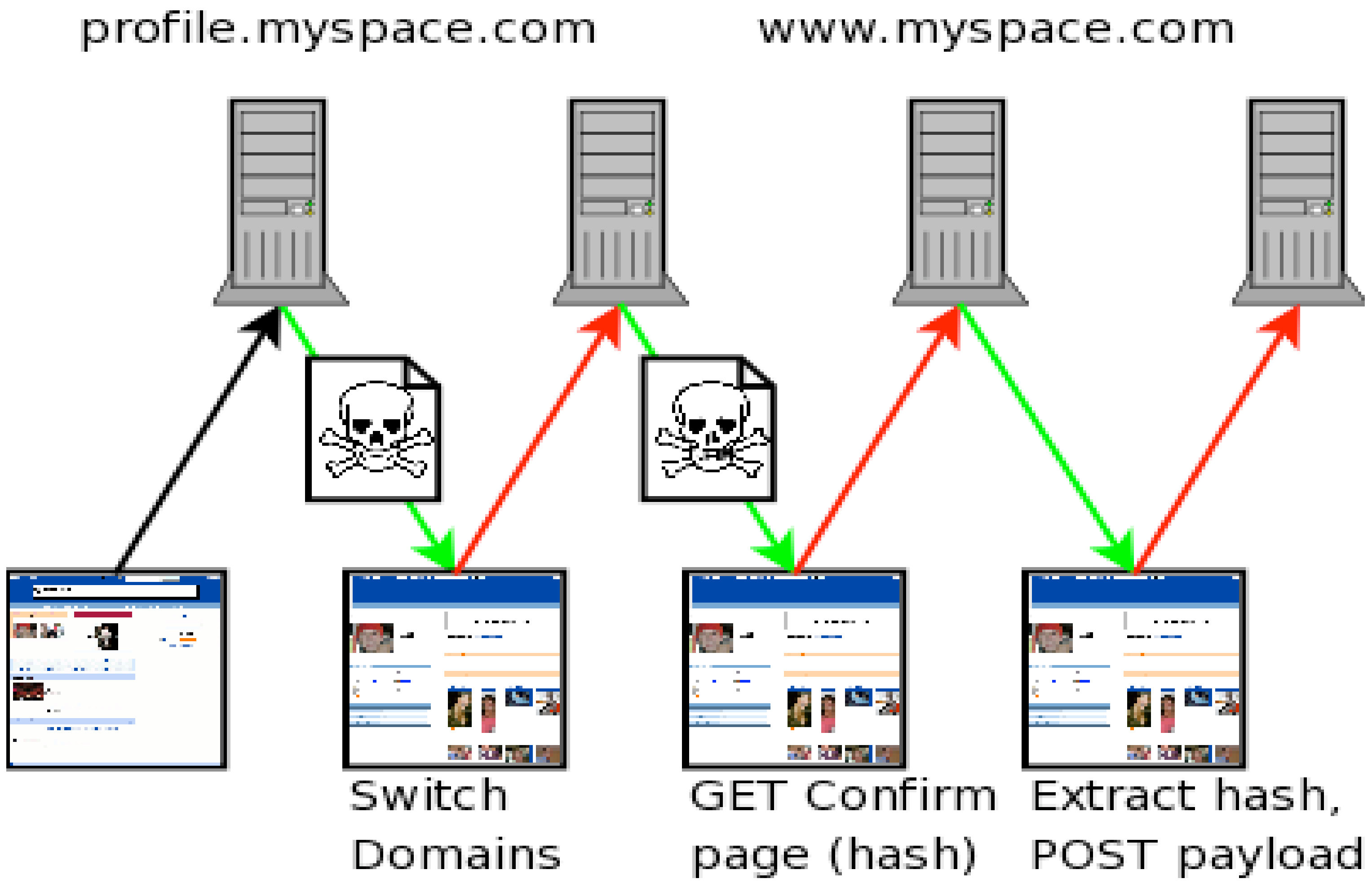
Analysis of MySpace.com Virus

- Web virus
- October 2005: Infected 5th largest domain on the Internet
- JavaScript with Ajax
- Attack vector: XSS exploit allowed <SCRIPT> into user's profile
- Propagation:
  - Used Ajax to inject virus into the user profile of anyone who viewed an infected page
- Payload:
  - Used Ajax to force viewing user to add user "Samy" to their friends list
  - Used Ajax to append "Samy is my hero" to victim's profile

•Blacklisting Input is Hard!

- MySpace.com did a pretty good job filtering, but used blacklisting.
- Blocked things like <SCRIPT>, innerHtml, and special characters
- Samy used *eval statement*
  - *Allows you to execute JavaScript statements stored inside a string*
  - *Stored his payload in the DOM, used eval*
- *<DIV id=”code expr=”alert('xss') style=”background('javascript:eval(document.code.expr))>*
- *See http://namb.la/popular/tech.html for all the details*

MySpace Infection Method Explained



Analysis of MySpace.com Virus

- Awesome hack!
- No, I didn’t write it.
  - I did present about XSS + Ajax attacks at Toorcon 7 a month before the virus hit
- Excellent proof of concept about how using Ajax is a security risk even though it obeys the DOM security model
  - Web server cannot tell the difference between Ajax requests and web browser requests
- Shows how Ajax + JavaScript RegExs can handle complex login sequences spanning multiple pages
- MySpace lucked out as it could have been much worse

Design problems with Ajax

- Request made using XmlHttpRequest are identical to normal requests
- The server cannot tell the difference
- You cannot repudiate the traffic created by Ajax
- Ajax makes XSS scarier
  - XSS can self propagate
  - XSS can make complex requests
  - Consider the MySpace attack inside a stock trading web application...

Ajax Bridging

What is an Ajax Bridge?

- Hack to overcome Ajax limitation
- Provides a “bridge” for client-side script to access 3rd party
- “Web service to another web service”
- How it works
  - Ajax can only connect back to host it came from
  - To allow script to access 3rd part, host provides bridge
  - Bridge acts as a proxy, forwarding traffic between parties
- Support
  - Many frameworks include bridges (“Atlas,” PHP add ons)
  - Even more are custom (CGI gateways, etc)

Data over the Bridge

- What 3rd parties can the bridge connect to?
  - Web service on a host
    - SOAP/REST/custom
  - Arbitrary web resource on a host
    - RSS feeds
    - Raw content (HTML, Flash, etc)
- What can the bridge return?
  - JSON
  - XML
  - Raw resource/custom

Exploiting Mash-up Trust

- This type of aggregate of 3rd party services is encouraged
  - Mash-up
- Any web service is fair game
- Any commercial use requires a more formal agreement
  - These formal agreements care some kind of trust
  - Aggregator will and will not do certain things
  - Bridge provide a hole around most attempts to enforce these rules
  - Bridge allows malicious users to exploit this trust relationship

Security Issues with Bridges

- Open proxy that only goes one place
- No built in security mechanisms
  - No throttling
  - No authentication
  - No authorization
  - No obfuscation
- Relies on other components for security
  - We have seen how well that works
- Multiple attack vectors through an Ajax bridge

Dumping Database Through a Bridge

- Sure users can get free key to access Amazon's API
- Key for book lover's aggregate site will have more privileges than standard keys
  - More simultaneous connections
  - Higher bandwidth limits
  - More unique queries
- Performance enhancements only help me!
  - Aggregate site using shared cache for queries?
  - Dump results even faster

Hacking 3rd Parties Through Bridges

- Start sending XSS, SQL injection, etc web attacks
  - Maybe 3rd party notices
    - Google: “Why is housingmaps.com” SQL injecting me?
    - Another layer to hide behind
  - Maybe auto-shunning IDS/IPS along the way notices
    - IPS: “This site is SQL injecting me!” [Blocks IP]
    - Wanted SQL injection, got DoS of aggregate site
  - Maybe 3rd party doesn't notice at all
    - Large site lots of requests from affiliates
    - Preforms less analysis. Attacks only work through bridge

Layers of Indirection

- Really 2 connections here
- Bridges can perform transforms on the data at any time
  - User to 3rd party
  - 3rd party to user
- Transforms are useful for regular users
  - Convert datatypes
  - Naming conventions
  - Nationality conversions
- Don't transforms prevent our attacks?

“I Once Was Blind, But Now I See...”

- Results of web attack against 3rd party proxied by bridge may get filter/munged/converted
  - Useful error messages will be lost
- Unfortunately, this is a mature area of study
- Blind SQL injection methodology
  - Send good request, bad request, take the difference
  - Can know identify if attack work
- Attackers can use blind SQL injection methodology for other attacks
  - LDAP, XSS, content injection, etc

Hype Surrounding Ajax

All About the Money

- Web 2.0 almost like another bubble
- Lots of money in the air
  - MySpace.com bought for $400 million
  - Writely.com purchased by Google
  - Del.icio.us bought by Yahoo $50 million
  - Facebook turned down $700 million, wants $2 billion
  - O'Reilly's $1500 Where, Web 2.0, other conferences
- Not judging right or wrong
- Blood in the water

Buzzwords in the Air

- Ajax
- Web 2.0
- Social Networking
- Folksonomy
- Blogging
- Collaborative Filtering
- Gadgets
- Reputation Systems
- Tagging
- Swarming
- Mash-ups
- RSS feeds
- Podcasts
- Perpetual beta
- The Long Tail
- Citizen Media
- Traceback
- Rich User Experience
- Permalink
- Cluster mapping

Affects of the Hype

- Move to client-side web application for wrong reasons
  - To appear trendy
    - Office/Windows Live? Come on now.
  - To fight off (perceived) competitors
  - New frontend fun use of time
    - Sexy to customers
    - Companies like it more than bug fixes, or security
  - Because they can

Affects of the Hype

- Driving Inexperienced people into the web applications
  - “You can make money in web apps”
  - Similar to tech boom in the 90s
  - Demand spikes
  - Encourages cut+paste application development
- Technical resources suffering
  - More tutorials aimed at beginners
    - Examples do not include best practices
    - Examples are often wrong on security topics
      - Blacklisting vs. whitelisting

Affects of the Hype

- Technical resources are suffering (continued)
  - Book quality suffers
    - Tech rot forces fast production
    - Contains mistakes
    - Oversimplify important topics
      - "Teach yourself ASP.NET in 24 hours"
      - "Teach yourself enough ASP.NET in 24 hours to create an insecure web application"
    - Topics beyond the books are unknown to most users

Security Ramifications of Hype

- Rush to “Web 2.0”-ize applications with no thought
- Some applications shouldn't be web applications, let allow Ajax
- API's being exposed that never should be
- More and more people are novices
  - Signal to noise ratio approaches zero
    - In forums looking for answers
    - In companies at project meetings
  - Security conscience people become rare
    - Holding up development?

End result of Ajax Hype

- Already way too many web application vulnerabilities
  - BugTraq is swamped with reports
  - php[whatever] exploit of the week
  - Can't browse the Internet without finding new vulnerabilities
- And this was with reasonably educated web developers
  - We are already seeing bad design choices

Designing For Ajax Applications

Design Checklist

- Should you Ajax enable a web application?
  - What is gained?
  - Is it necessary?
- Retrofitting an old application
  - Document current inputs
  - Ensure input validation all existing inputs
- Design Ajax application
  - Minimize the program logic you need to expose
  - Implement validation on all function input
  - Use clear standards, not hacks

Conclusions

- Ajax is a powerful suite of technologies
- Ajax can improve user experience on *appropriate* applications
- Ajax applications live on the client and server
  - Increases the attack surface
  - Exposes internal functions, control layer
  - Creates many more inputs to secure
- Ajax bridges can be extremely dangerous
  - Its input, so secure it
  - Additional security measures
- Hype around Ajax may be deserved, but hurting the industry

Questions?

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