HTTP Overview

UCSD
Jacobs School

It's all about the network…

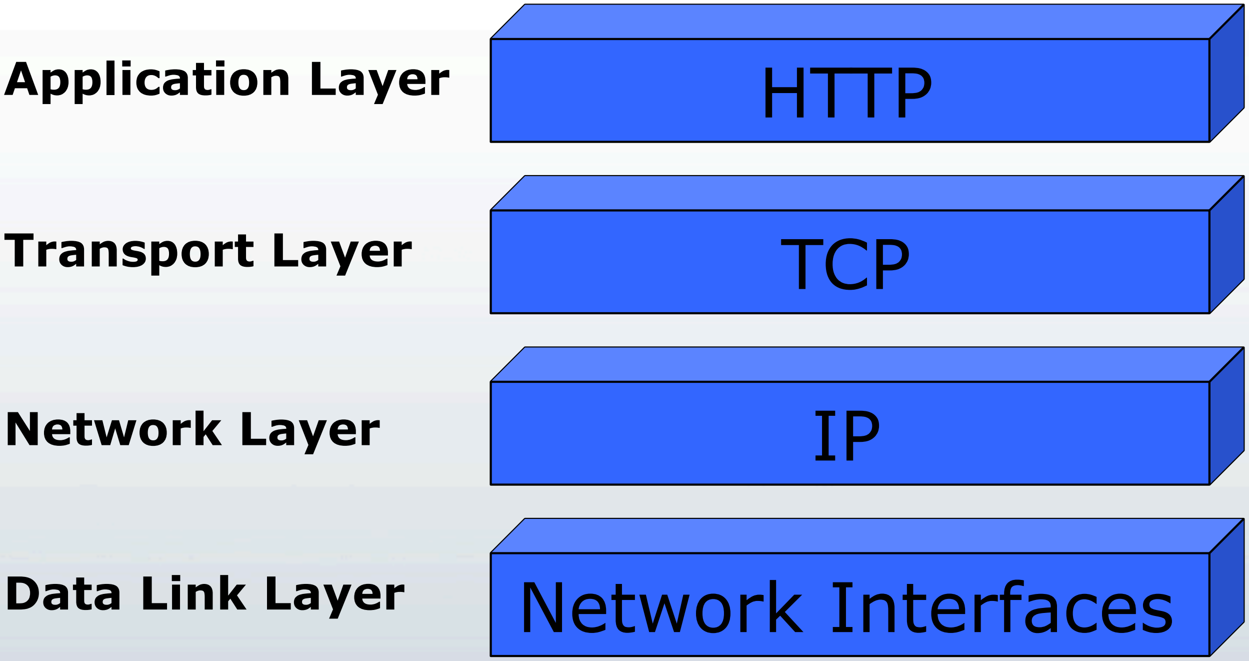
- If you want to really do Web programming right you will need to know the ins and outs of HTTP
  - If the network has problems you/users have problems much more than you are probably aware
- Sadly most don't know as much as they think they do
  - easily demoed by perf and security problems
  - A few examples
    - URLs – case sensitive? Length? Format
    - GET vs POST?
    - Cookies
    - "Layer 8" Error Correction – the meat layer

HTTP Intro

- HTTP (Hyper Text Transfer Protocol)
  - It's an *application layer protocols* similar to SMTP, POP, IMAP, NNTP, FTP, etc.
  - Simple protocol that defines the standard way that clients request data from Web servers and how these server respond
  - Typically it is running on top of TCP/IP
- Three versions have been used (0.9,1.0,1.1) and two are still commonly used
  - RFC 1945 HTTP 1.0 (1996)
  - RFC 2616 HTTP 1.1 (1999)

HTTP and TCP/IP

HTTP sits atop the TCP/IP Protocol Stack



Application Layer — HTTP

Transport Layer — TCP

Network Layer — IP

Data Link Layer — Network Interfaces

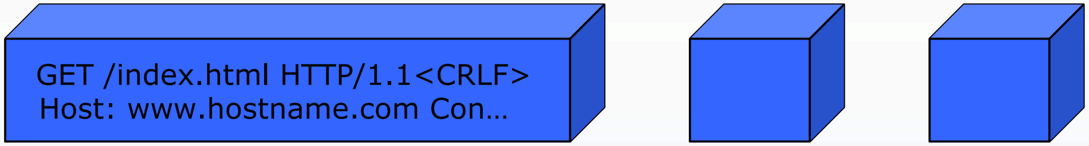
HTTP and TCP/IP, contd.

- IP provides *packets* that are *routed* based on source and destination IP addresses
- TCP provides *segments* that ride inside the IP packets and add connection information based on source and destination *ports*
  - The ports let TCP carry multiple protocols that connect services running on default ports
    - HTTP on port 80
    - HTTP with SSL (HTTPS) on port 443
    - FTP on port 21
    - SMTP on port 25
    - SSH on port 22

HTTP and TCP/IP, contd.

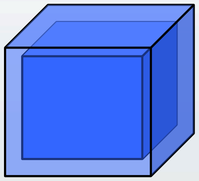
- TCP also provides mechanisms to make the connection a *reliable* bit pipe
  - 3-way handshake, sequence numbers, checksums, control flags
  - A data stream is chopped up into chunks that are reassembled, complete and in correct order on the other endpoint of the connection
- TCP segments, riding inside IP packets, carry the chunks of data
  - When HTTP is the Application Layer protocol on top of the stack, these chunks of data are the contents of the HTTP Message

HTTP over TCP/IP Examples



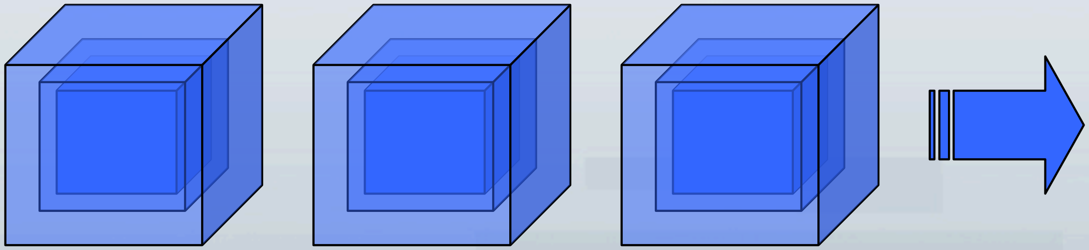
GET /index.html HTTP/1.1<CRLF>
Host: www.hostname.com Con...

HTTP Message's data stream is chopped up into chunks small enough to fit in a TCP segment



The chunks ride inside TCP segments used to reassemble them correctly on the other end of the connection

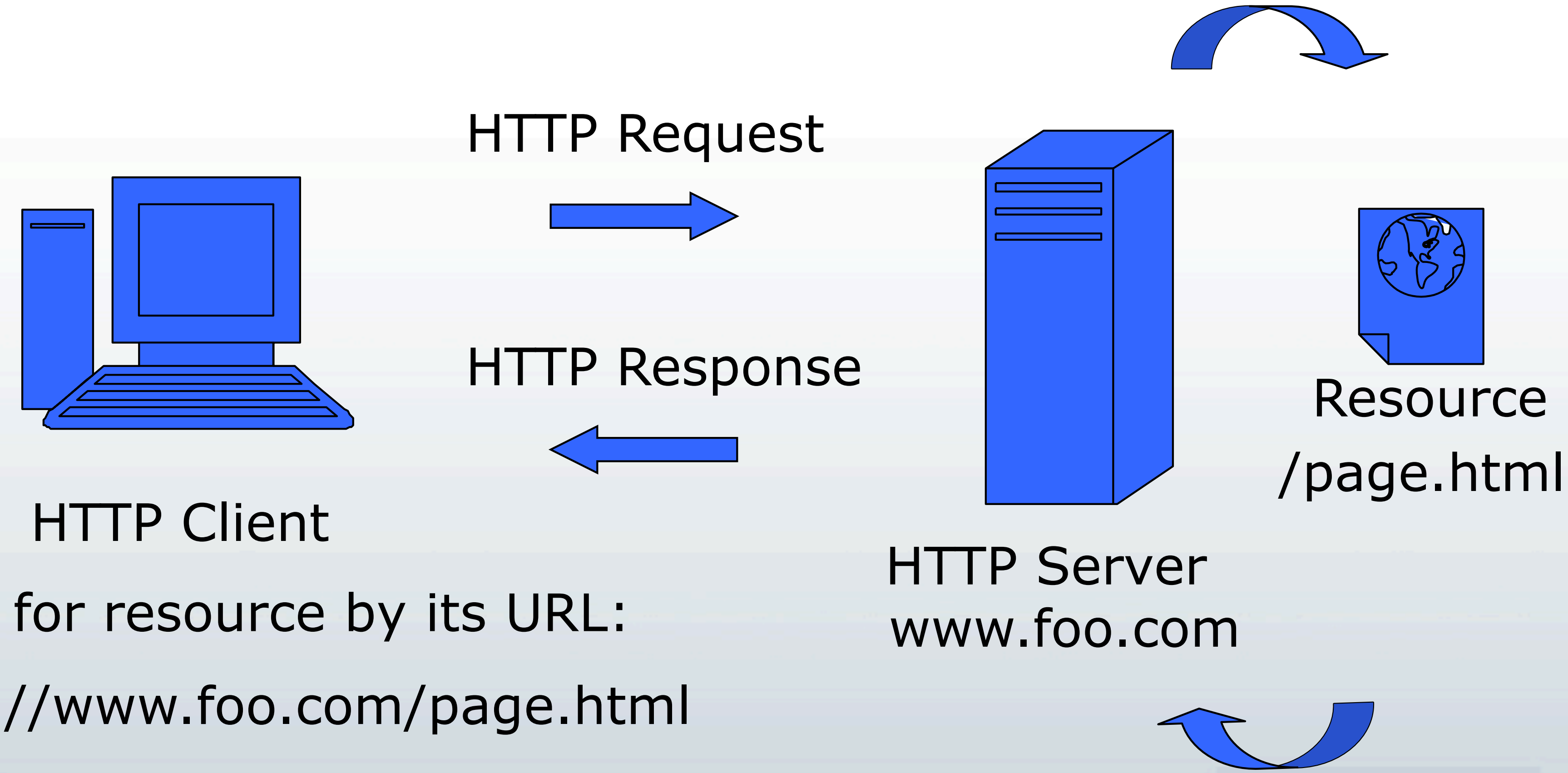
The segments are shipped to the right destination inside IP datagrams



HTTP over TCP/IP Issues?

- HTTP/1.0 opens and closes a new TCP connection for each operation. Since most Web objects are small, this practice means a high fraction of packets are simply TCP
- Add the previous point to TCP's slow start congestion control mechanism and you find HTTP/1.0 operations use TCP at its least efficient.
- HTTP 1.1 addresses these concerns with persistent connections using Keep-Alive
- See http://www.w3.org/Protocols/HTTP/Performance for papers and information on HTTP performance issues

Basic HTTP Request/Response Cycle



HTTP Request

HTTP Response

HTTP Client

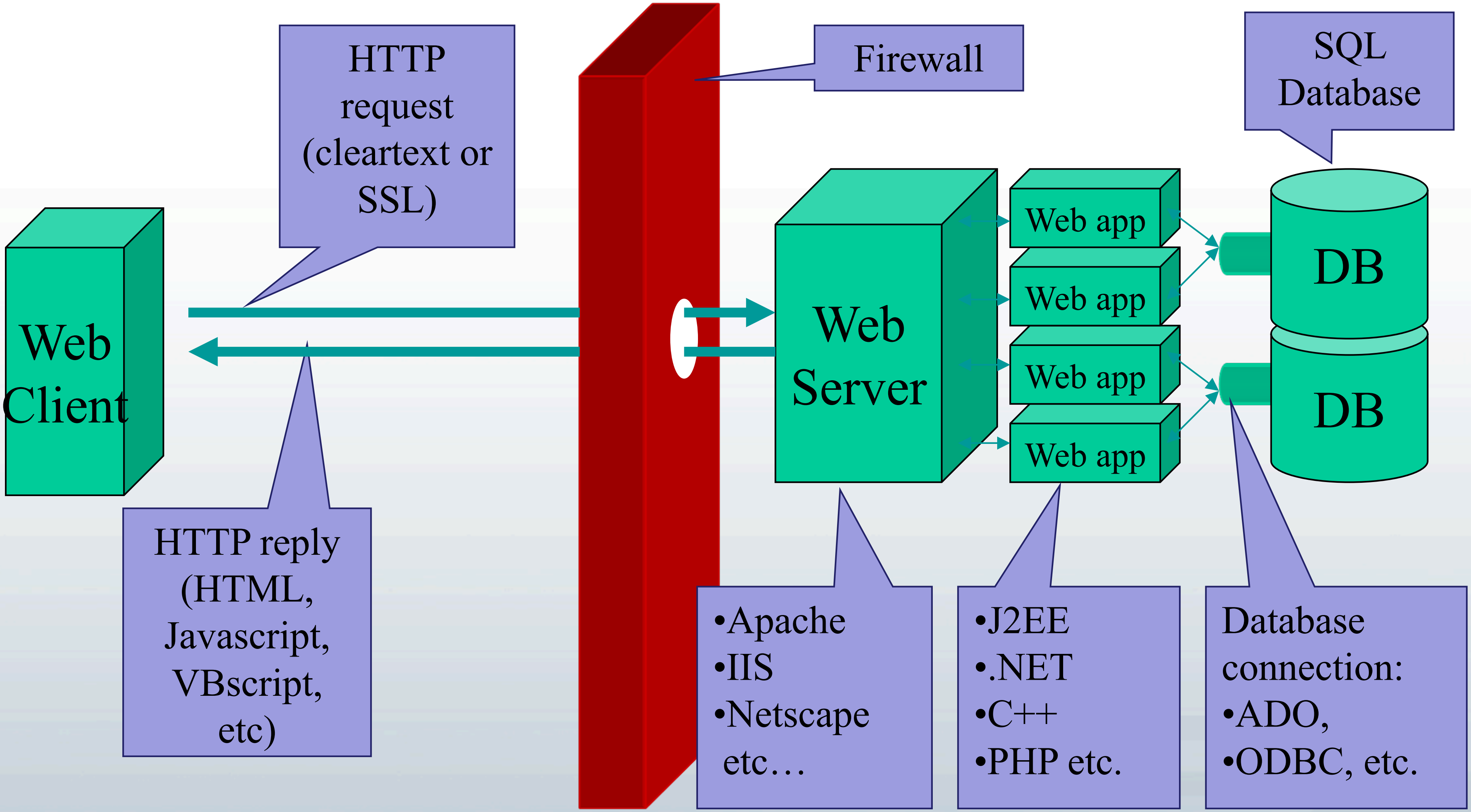
HTTP Server
www.foo.com

Resource
/page.html

Asks for resource by its URL:

http://www.foo.com/page.html

Take 2 - Nothing going on here … it's simple



HTTP request (cleartext or SSL)

Firewall

SQL Database

Web Client

Web Server

Web app

Web app

Web app

Web app

DB

DB

HTTP reply (HTML, Javascript, VBscript, etc)

- Apache
- IIS
- Netscape

etc…

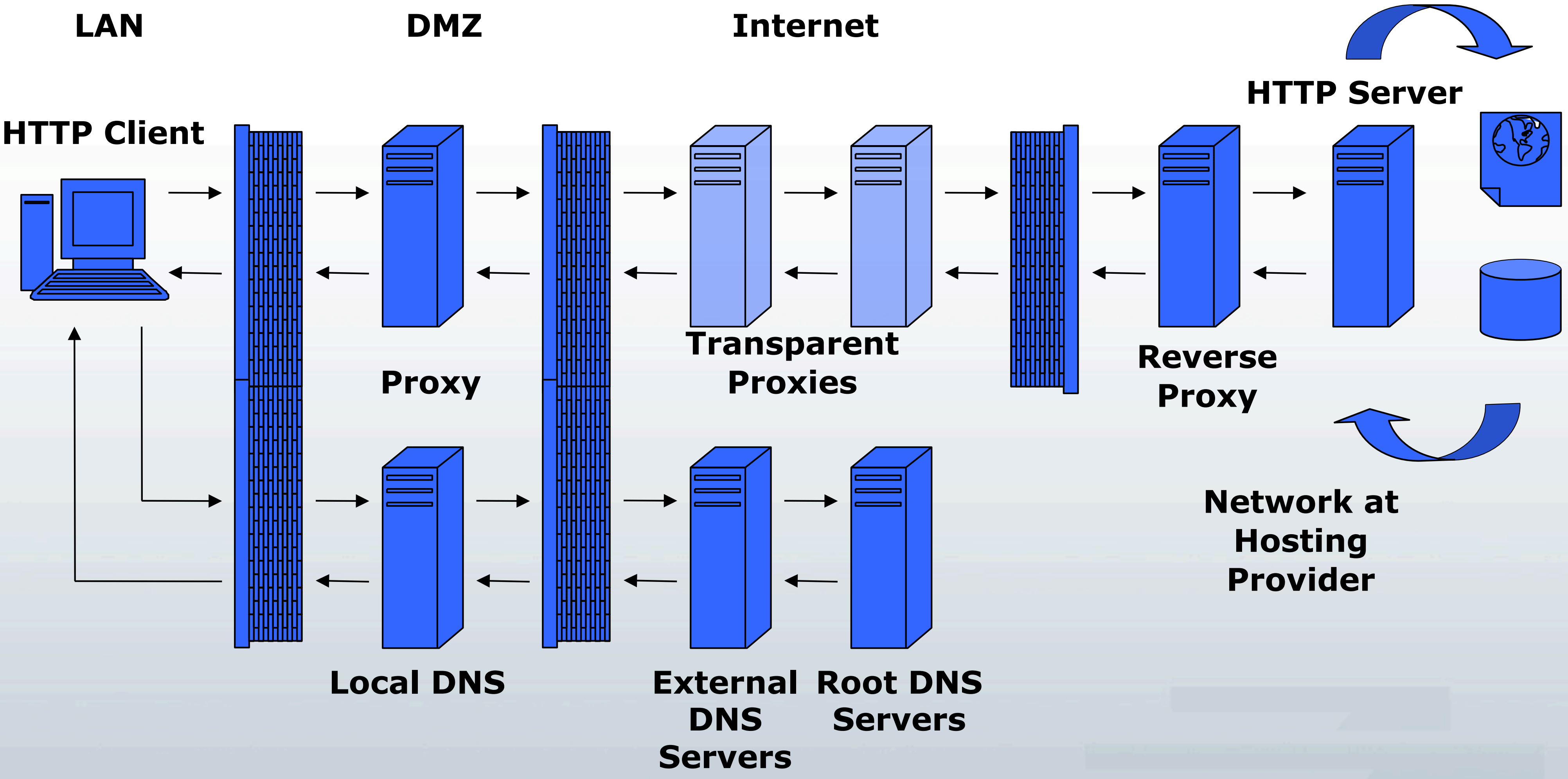
- J2EE
- .NET
- C++
- PHP etc.

Database connection:

- ADO,
- ODBC, etc.

Take 3 – Add to that transit issues

Add crazy last slide here



Types and Uses of Proxy Servers

- Proxies are HTTP Intermediaries
  - All act as both clients and servers
  - Friend and foe to Web devs
- Major types of proxies can be distinguished by where they live and how they get traffic
  - Explicit
  - Transparent/Intercepting
  - Reverse/Surrogate
- Three primary uses for proxies
  1. Security
  2. Performance
  3. Content Filtering

HTTP Requests

- HTTP requests and responses are both types of Internet Messages (RFC 822) , and share a general format:
  - A Start Line, followed by a CRLF
    - Request Line for requests
    - Status Line for responses
  - Zero or more Message Headers
    - field-name ":" [field-value] CRLF
  - An empty line
    - Two CRLFs mark the end of the Headers
  - An optional Message Body if there is a payload
    - All or part of the "Entity Body" or "Entity"

The Law of Three

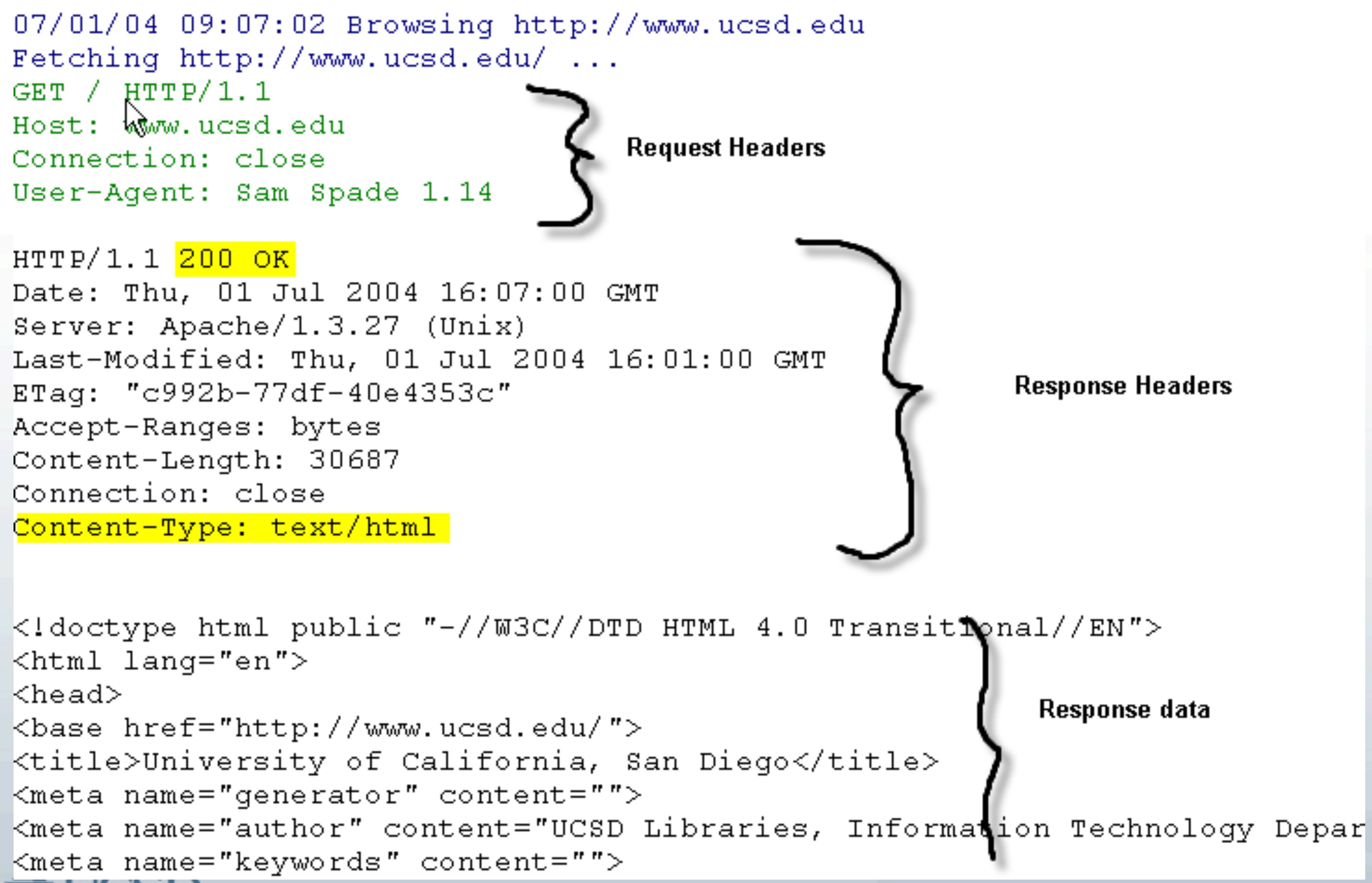
- Consider the form of HTTP requests and responses there are three pieces to each
- As a server-side program you understand you can only get data from the three pieces of the request (so consider those your input and watch them carefully!)
- Furthermore you can only output via the three pieces of the response (mostly the message body)
- This is it, there is nothing more to the bedrock of the Web server side wise (save addressing statefulness)

Making a simple HTTP request

- You can do the last example with a tool or just use telnet to access the default HTTP port (80)
  - C:\>telnet www.google.com 80
- Ask for a resource using a minimal request syntax:
  - GET / HTTP/1.1 <CRLF>
  - Host: www.google.com <CRLF><CRLF>

Note: A Host header is required for HTTP 1.1 connections, though not for HTTP 1.0

HTTP Request Example #1



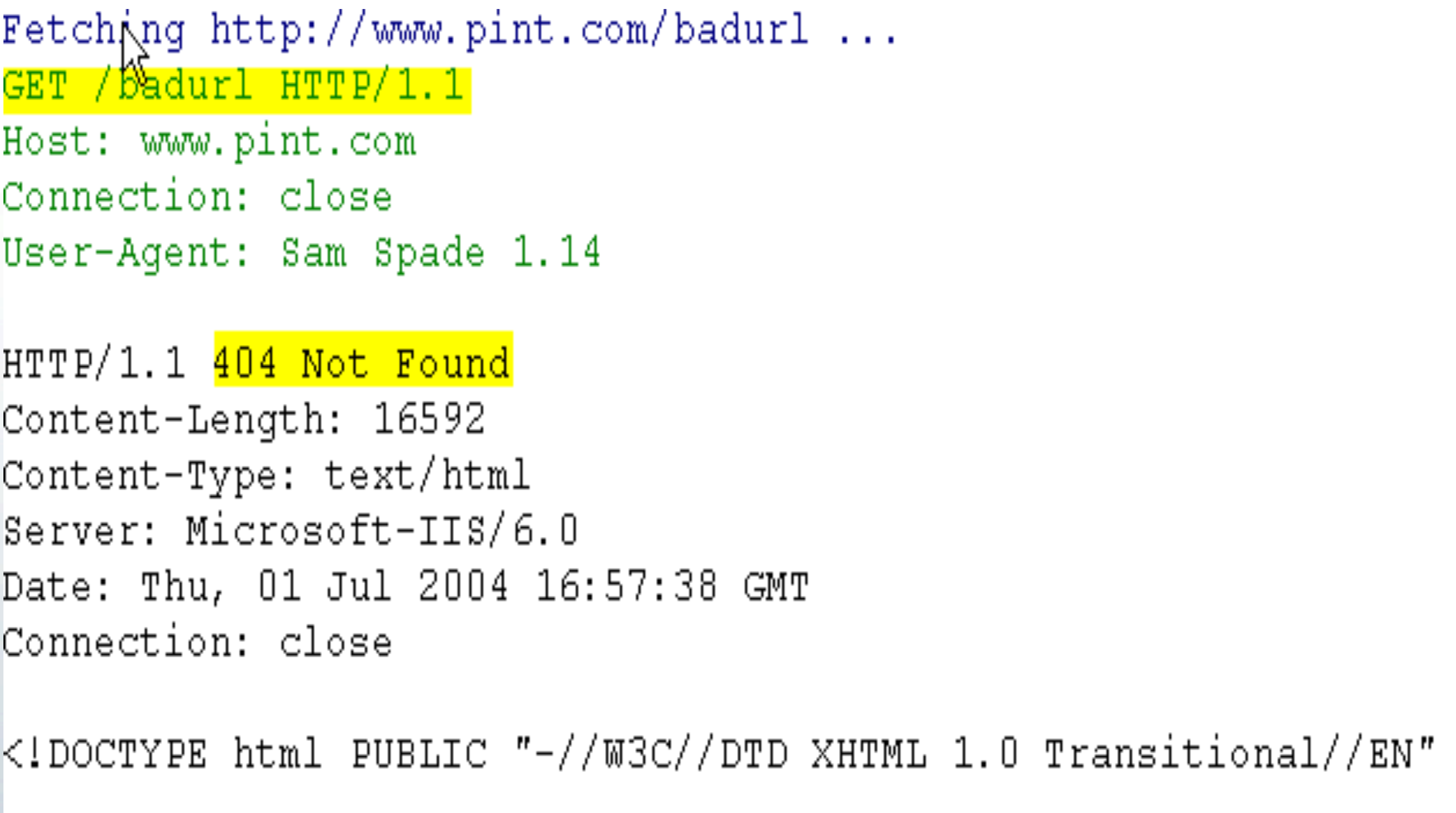
```
07/01/04 09:07:02 Browsing http://www.ucsd.edu
Fetching http://www.ucsd.edu/ ...
GET / HTTP/1.1
Host: www.ucsd.edu
Connection: close
User-Agent: Sam Spade 1.14

HTTP/1.1 200 OK
Date: Thu, 01 Jul 2004 16:07:00 GMT
Server: Apache/1.3.27 (Unix)
Last-Modified: Thu, 01 Jul 2004 16:01:00 GMT
ETag: "c992b-77df-40e4353c"
Accept-Ranges: bytes
Content-Length: 30687
Connection: close
Content-Type: text/html


<!doctype html public "-//W3C//DTD HTML 4.0 Transitional//EN">
<html lang="en">
<head>
<base href="http://www.ucsd.edu/">
<title>University of California, San Diego</title>
<meta name="generator" content="">
<meta name="author" content="UCSD Libraries, Information Technology Depar
<meta name="keywords" content="">
```

Request Headers

Response Headers

Response data

HTTP Request Example #2



```
Fetching http://www.pint.com/badurl ...
GET /badurl HTTP/1.1
Host: www.pint.com
Connection: close
User-Agent: Sam Spade 1.14

HTTP/1.1 404 Not Found
Content-Length: 16592
Content-Type: text/html
Server: Microsoft-IIS/6.0
Date: Thu, 01 Jul 2004 16:57:38 GMT
Connection: close

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
```

A Closer Look at the Request Line

- Consists of three major parts
  - The Request Method followed by a space
    - Methods in HTTP 1.1 include: GET, POST, HEAD, TRACE, OPTIONS, PUT, DELETE and CONNECT
    - GET, POST, and HEAD are the most common
    - Extension methods such as those specified by WebDav (RFC 2518)
  - The Request URI followed by a space
    - The URL associated with the resource to be fetched or acted upon
  - The HTTP Version followed by the CRLF
    - 0.9, 1.0, 1.1

A Closer Look at the Request Methods

- GET
  - By far most common method
  - Retrieves a resource from the server
  - Supports passing of query string arguments
- HEAD
  - Retrieves only the Headers associated with a resource but not the entity itself
  - Highly useful for protocol analysis, diagnostics
- POST
  - Allows passing of data in entity rather than URL
  - Can transmit of far larger arguments that GET
  - Arguments not displayed on the URL

More Request Methods

- OPTIONS
  - Shows methods available for use on the resource (if given a path) or the host (if given a "*")
- TRACE
  - Diagnostic method for assessing the impact of proxies along the request-response chain
- PUT, DELETE
  - Used in HTTP publishing (e.g., WebDav)
- CONNECT
  - A common extension method for Tunneling other protocols through HTTP
- There's even more methods if you look at WebDav

Why do I care?

- Well if you are doing doing Web programming you may have to form raw requests with headers ourselves.
  - Example in JavaScript using Ajax you will have to form raw HTTP requests using GET and POST (or even HEAD if you like) to transmit your data

```
 xmlhttp = ajaxhttp();
  xmlhttp.open("POST", url, true);
  xmlhttp.setRequestHeader("Content-Type", "application/x-
www-form-urlencoded");
  xmlhttp.send("ret=" + escape(param));
```

  - Also in HTML forms when you set the action attribute <form action=“GET|POST” > you are specifying the HTTP method to transmit the data

A Closer Look at the Request URI

- Absolute URI vs. Absolute Path
  - Explicit Proxies Require Absolute URIs
    - Client is connected directly to the proxy
    - Protocol and host name needed to resolve request
    - You might need full URLs too esp. for Web services
      - Watch out for www vs. no www issues
  - Grammar of the Absolute Path
    - Like Absolute URI minus the "http://hostname"
    - Initial "/" equivalent of the host's document root
    - In HTTP 1.1 with *name-based virtual hosting* Host header directs request to appropriate document root

The HTTP Response

- Response status line consists of three major parts
  - The HTTP Version followed by a space
  - Status Code followed by a SP
    - 5 groups of 3 digit integers indicating the result of the attempt to satisfy the request
    - 1xx are informational
    - 2xx are success codes
    - 3xx are for alternate resource locations (redirects)
    - 4xx indicate client side errors
    - 5xx indicate server side errors
  - The “Reason Phrase” followed by the CRLF

Observation – One Way Requests and 204s

- There are many details to HTTP that people don’t consider but are highly useful one example is 204 responses which send back no data
- Observe Google using this in its search results page to send what I dub a “flare gun” request to see what exactly the user clicked on
  - The purpose of this is for improving search quality and defeating those folks who reverse engineer the Google algortithm – “The human filter if you like”

HTTP Headers

- Headers come in four major types, some for requests, some for responses, some for both:
  - General Headers
    - Provide info about messages of both kinds
  - Request Headers
    - Provide request-specific info
  - Response Headers
    - Provide response-specific info
  - Entity Headers
    - Provide info about request and response entities
  - Extension headers are also possible

A Closer Look at General Headers

- Connection – lets clients and servers manage connection state
  - Connection: Keep-Alive (HTTP 1.0)
  - Connection: close (HTTP 1.1)
- Date – when the message was created
  - Date: Sat, 31-May-03 15:00:00 GMT
- Via – shows proxies that handled message
  - Via: 1.1 www.myproxy.com (Squid/1.4)
- Cache-Control – Among the most complex of headers, enables caching directives
  - Cache-Control: no-cache

Why do I care? – Unfriendly Caches

- If you are issuing a GET request and you do it again the browser will not bother to talk to the server (depending on browser settings including defaults), but instead will pull the data from cache. This can cause lots of screw-ups
  - Example – someone looking at stale content
  - Example – Problems with Ajax style apps never waking up because browser using cached data
- Obvious solution to "stale caches" is to add cache control headers (or to change resource names) but then again that does defeat the value
  - Better to know about caching and do it properly
  - Consider typical Web pages what would you want to cache?

A Closer Look at Request Headers

- Host – The hostname (and optionally port) of server to which request is being sent
  - Required for name-based virtual hosting
  - Host: www.port80software.com
- Referer – The URL of the resource from which the current request URI came
  - Misspelled in the specification
  - Referer: http://www.host.com/login.asp
- User-Agent – Name of the requesting application, used in browser sensing
  - User-Agent: Mozilla/4.0 (Compatible; MSIE 6.0)

Some More Request Headers

- Accept and its variants – Inform servers of client's capabilities and preferences
  - Enables *content negotiation*
  - Accept: image/gif, image/jpeg;q=0.5
  - Accept- variants for Language, Encoding, Charset
- If-Modified-Since and other *conditionals*
  - Frequently used by browsers to manage caches
  - If-Modified-Since: Sat, 31-May-03 15:00:00 GMT
- Cookie – How clients pass cookies back to the servers that set them
  - Cookie: id=23432;level=3

Using Request Headers: Browser Sniffing

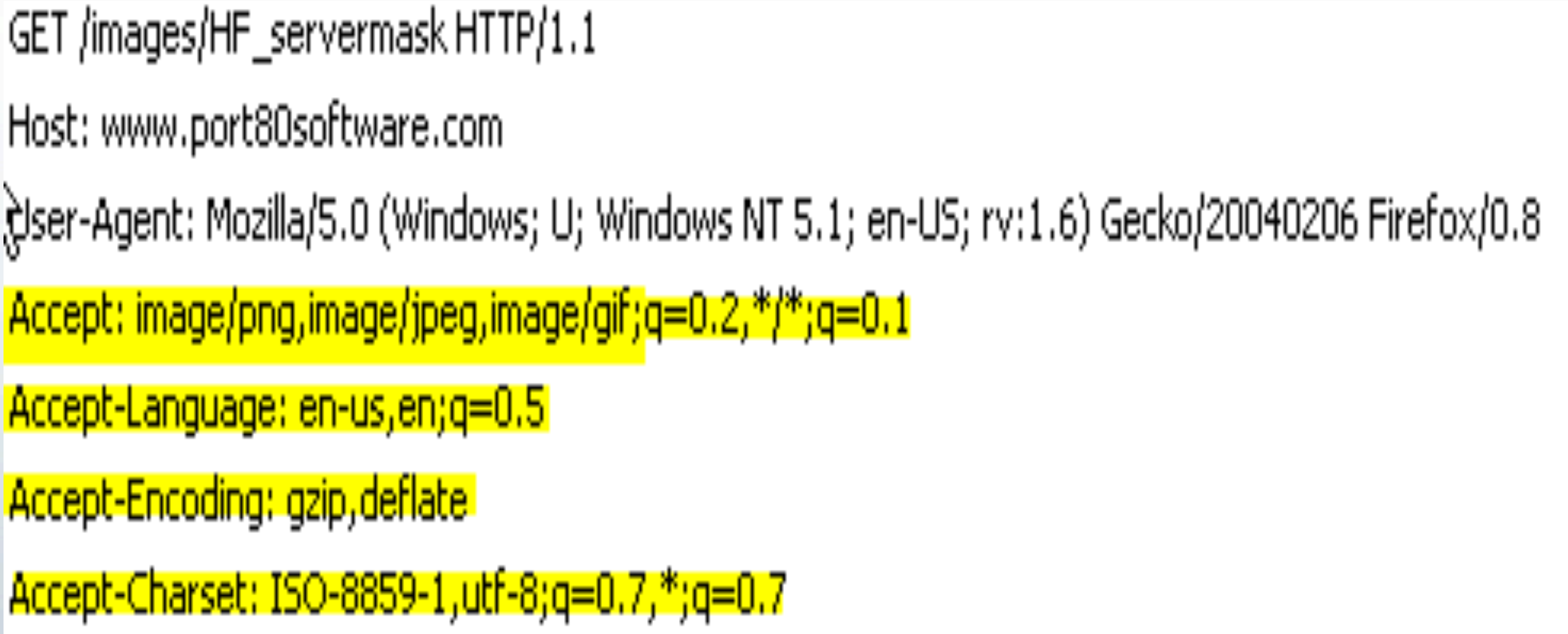
- User-agent is often used in browser detection to serve different type of page to different type of accessing agent
  - Similarity problem
    - Everything looks like old “Mozilla”
  - Spoofing or removing problem
- Better approach is to take this and add in an injected script or program that profiles the device.
- In the long run as device diversity grows the concept of browser will evolve significantly

Using Request Headers: Anti-Leeching

- Often times people may leech your bandwidth with direct hotlinking to your object (GIF, Flash, etc.) without fetching the other related objects
  - This certainly would be bad if your biz model was about people seeing the related ads around the 'stolen' object
- Since the referer header is sent from the base page a simple form of anti-leeching is to check for it before sending a dependent object
- Of course the bad guy now moves to forge the header
- Class Question: can you think of other countermeasures?

Using Request Headers: Content Negotiation

- User-agent sends accept header indicating type of content it can handle



```
GET /images/HF_servermask HTTP/1.1
Host: www.port80software.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.6) Gecko/20040206 Firefox/0.8
Accept: image/png,image/jpeg,image/gif;q=0.2,*/*;q=0.1
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
```

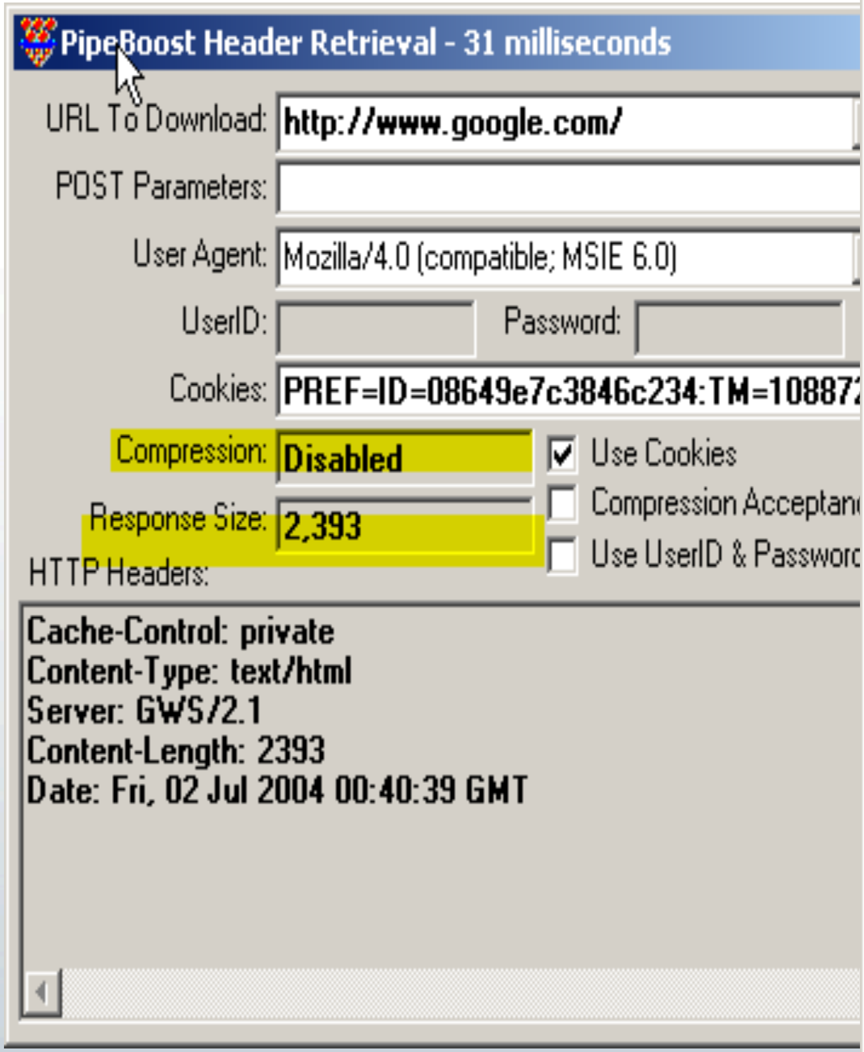
Using Request Headers: Content Negotiation

- A “q-rating” can indicate the preference the user agent has for the data requested
- Content negotiation allows us to ask for something like “logo” and then get the appropriate image (PNG, JPG, etc.) based upon what the device can handle.
  - This leads to extensionless URLs which aids in long term maintainability
  - We’ll see the file extensions don’t mean much really
- Content negotiation can also allow language to be automatically negotiated.

Using Request Headers: HTTP Compression

- Compressed HTTP is enabled via Accept headers
- User agent sends header indicating compression acceptance (gzip or deflate).Server using mod_gzip, httpZip, etc. sends compressed content or not.
- Works only on text (HTML, CSS, JS) but with compression up to 70% or more
- Time to first byte increased so high speed connections may not see as much benefit, though bandwidth is saved. Low speed clearly sees benefit.

HTTP Compression Example



PipeBoost Header Retrieval - 31 milliseconds

URL To Download: http://www.google.com/

POST Parameters:

User Agent: Mozilla/4.0 (compatible; MSIE 6.0)

UserID: Password:

Cookies: PREF=ID=08649e7c3846c234:TM=10887

Compression: Disabled

Response Size: 2,393

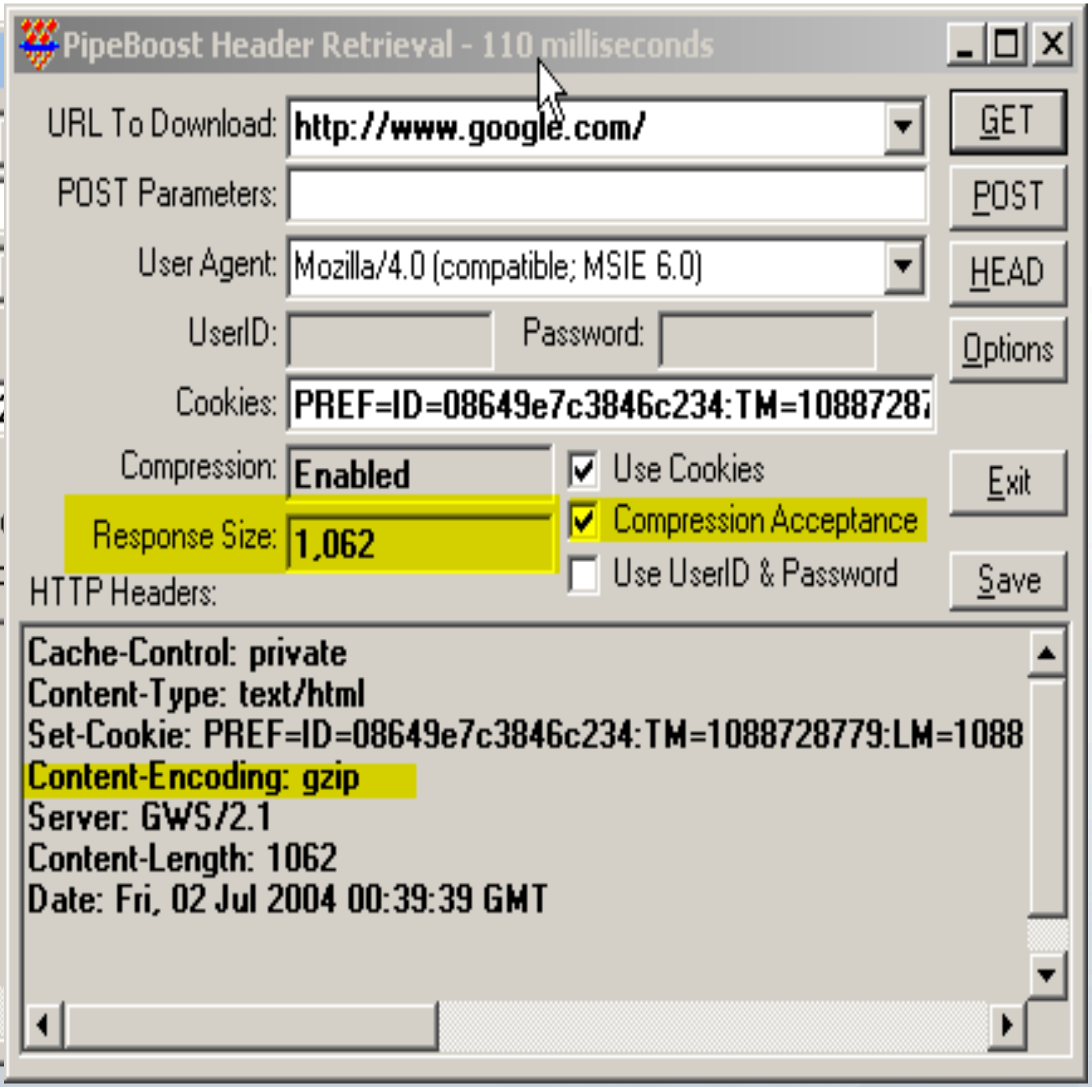
☑ Use Cookies

□ Compression Acceptan

□ Use UserID & Passworc

HTTP Headers:

```
Cache-Control: private
Content-Type: text/html
Server: GWS/2.1
Content-Length: 2393
Date: Fri, 02 Jul 2004 00:40:39 GMT
```



PipeBoost Header Retrieval - 110 milliseconds

URL To Download: http://www.google.com/

POST Parameters:

User Agent: Mozilla/4.0 (compatible; MSIE 6.0)

UserID: Password:

Cookies: PREF=ID=08649e7c3846c234:TM=1088728

Compression: Enabled

Response Size: 1,062

☑ Use Cookies

☑ Compression Acceptance

□ Use UserID & Password

HTTP Headers:

```
Cache-Control: private
Content-Type: text/html
Set-Cookie: PREF=ID=08649e7c3846c234:TM=1088728779:LM=1088
Content-Encoding: gzip
Server: GWS/2.1
Content-Length: 1062
Date: Fri, 02 Jul 2004 00:39:39 GMT
```

Compression Considerations

- Increased origin server CPU – or wasted cycles?
- TTFB vs TTLB consideration and LANs
- Decompress times
- Nasty little bugs
    - http://support.microsoft.com/default.aspx?scid=kb;en-us;823386&Product=ie600
    - *In Internet Explorer, … The bytes that remain to be decoded in the buffer may be small (8 bytes or less) and the data contained in the buffer decompresses to 0 bytes. … When Mshtml receives 0 bytes, it thinks that all the data is read and closes the data stream. As a result, the HTML page sometimes appears truncated.* ***Typically, if it is for a referenced file such as a .js or a .css file type, the HTTP connection stops responding.***
  - Most solved by commercial server-side implementations
- People in the know use this stuff

Response Headers

- Server – The server's name and version
  - Server: Microsoft-IIS/5.0
  - Can be problematic for security reasons
  - Security by obscurity?
- Vary – Tells client & proxy caches which headers were used for content negotiation
  - Vary: User-Agent, Accept
- Set-Cookie – This is how a server sets a cookie on a client
  - Set-Cookie: id=234; path=/shop; expires=Sat, 31-May-03 15:00:00 GMT; secure

A Closer Look at Entity Headers

- Allow – Lists the request methods that can be used on the entity
  - Allow: GET, HEAD, POST
- Location – Gives the alternate or new location of the entity
  - Used with 3xx response codes (redirects)
  - Location: http://www.ibm.com/us/
- Content-Encoding – specifies encoding performed on the body of the response
  - Corresponds to Accept-Encoding request header
  - Content-Encoding: gzip

More Entity Headers

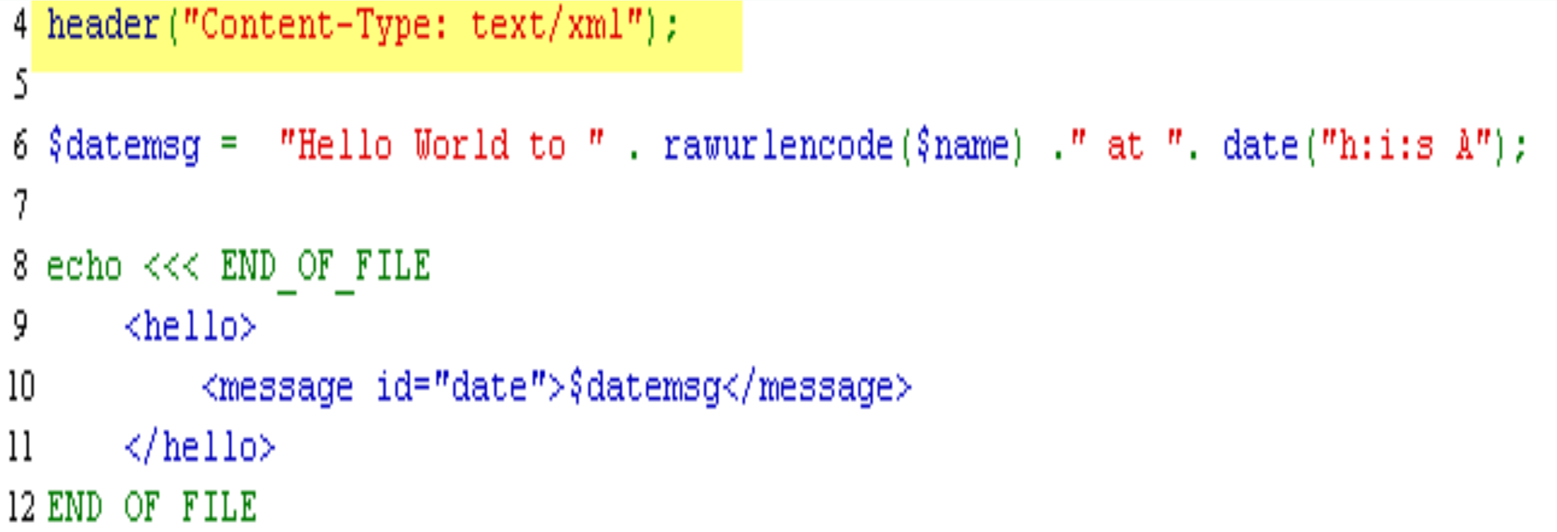
- Content-Length – The size of the entity body in bytes
  - Value shrinks when compression is applied
  - Content-Length: 24000
- Content-Location – The actual URL of the resource if different than its request URL
  - Often used to show the index or default page
  - Content-Location: http://www.foo.com/home.html

More Entity Headers

- Content-Type – specifies Media (MIME) type of the entity body
  - Corresponds to Accept header
  - Content-Type: image/png
- This is the most important header to the browser. The data in this header tells the browser what it is receiving. Now it should make sense why file extensions don’t really matter and are arbitrary.
  - Server: file extension -> Mime type
  - Browser: Mime type -> Action (display, download, etc.)
- *Note: Without HTTP browser relies on file extension - example loading a file off local disk.*

Why do I care?

- Because sometimes you need to stamp outgoing data on the server-side with the appropriate MIME type



```
header("Content-Type: text/xml");

$datemsg =  "Hello World to " . rawurlencode($name) ." at ". date("h:i:s A");

echo <<< END_OF_FILE
    <hello>
        <message id="date">$datemsg</message>
    </hello>
END_OF_FILE
```

More Entity Headers : Caching Related

- Expires – Gives expiration for the instance of the resource for use in caching
  - Expires: Sat, 31-May-03 19:00:00 GMT
- Last-Modified – Date/time the entity was last changed (or created)
  - Last-Modified: Fri 30-May-03 09:00:00 GMT

More Entity Headers : Caching Related

- Etag – Uniquely identifies a particular instance of a given resource
  - Used with conditional request headers to validate cached instances of the resource
    - If-Match, If-None-Match
  - Etag: adkskdashjgk07563AF

Why do I care?

- Well you could go beyond basic cache-control and pragma headers and do Expires and other forms of cache hints.
- Ultimately you may be forced to use a query string or alternate file name to force misconfigured caches to stop causing you problems

Sending data via HTTP

- Data can be sent to a server-application in two primary ways:

1. Query String sent via a GET request
2. Data body sent via a POST request

- In both cases the data is encoded in a special manner called x-www-form-urlencoded which replaces spaces with + symbols, special characters with %hex values equivalent to the particular special character being "escaped" and separates individual arguments to be passed with ampersands (&) characters.

- *Note: Data may be sent via HTTP headers mostly in the form of cookie based data. Though other HTTP headers such as user-agent, referrer, etc. can be tapped, but this is generally not user supplied but instead constitutes the environment in which the Web transaction takes place.*

Sending Data with GET

- In the case of GET we see submitted data (often from a fill-in form though may be hard coded in links) with the actual request URL
- The passed data is called the query string and follows a ? Character in the URL
  - Example: http://www.pint.com/cgi-bin/doit.pl?name=Thomas
  - Example: http://www.pint.com/cgi-bin/toit.pl?x=5&y=7
- These "dirty URLs" have potential downsides including:
  - Technology exposure – "visual reconnaissance"
  - Easy fiddling of parameters
  - Poor usability (may be a good thing as well)
  - Lack of long term maintainability
  - Size limit is dependent on URL size limits
- However, GET string based URLs are portable – you can bookmark them, send to friends, etc.

Sending Data with GET Contd.

- The GET based data can be submitted in one of two ways
  - Hard-coded into a link

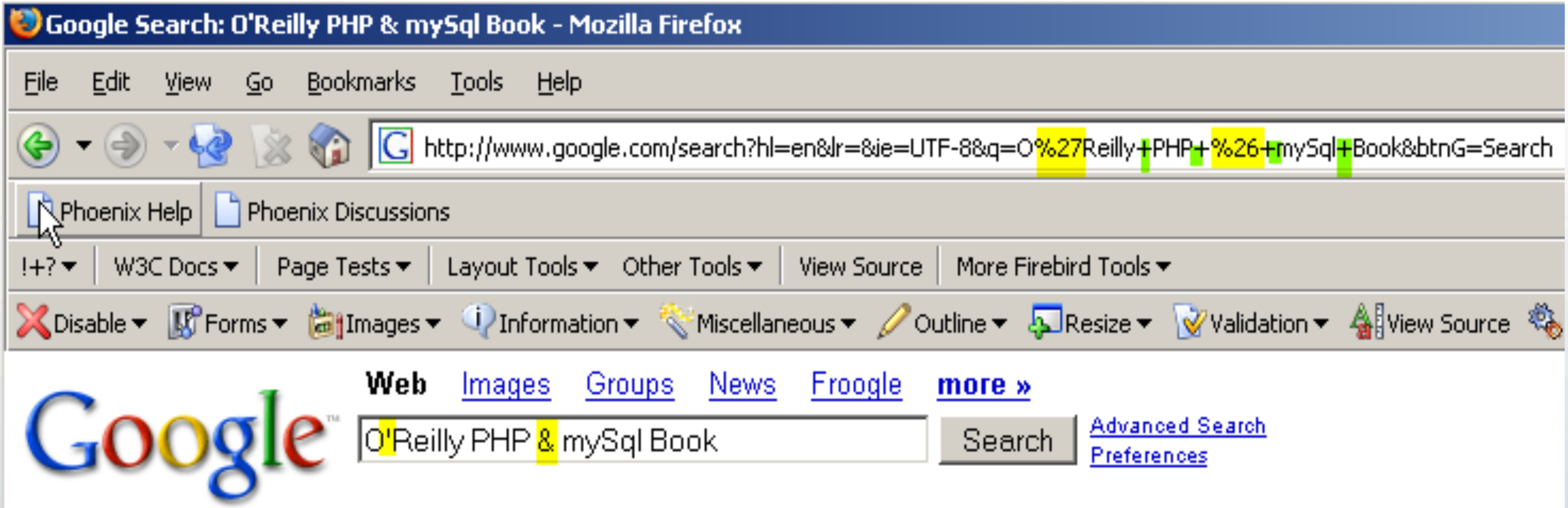
```
<a
href=“http://www.google.com/search?q=Web+server+softw
are”>Run query</a>
```

  - As a result of a form submission

```
<form action=“http://www.google.com/search”
method=“get”>
<label>Query: <input type=“text” name=“q”></label>
<input type=“submit” value=“Submit”>
</form>
```

Sending Data with GET Contd.

- Now it should start to make sense what query strings mean and how they are formed



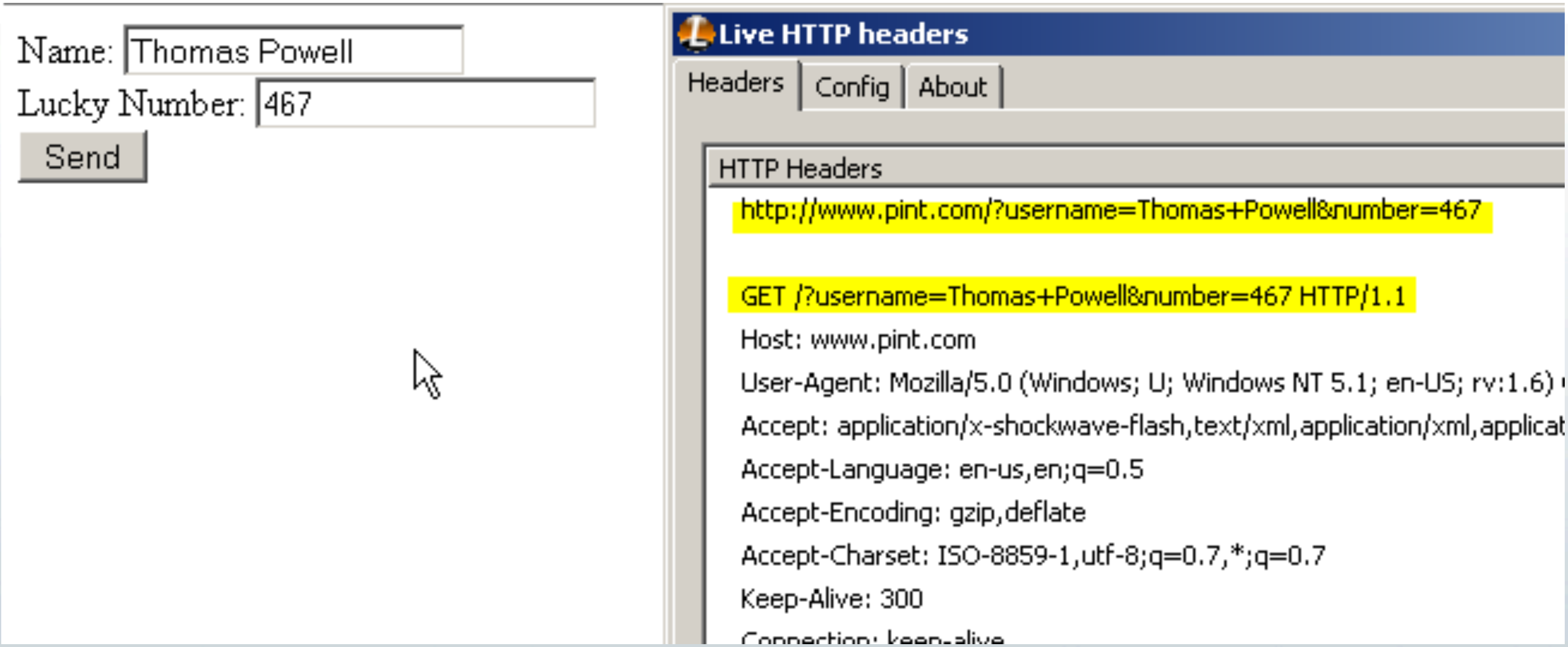
Google Search: O'Reilly PHP & mySql Book - Mozilla Firefox

http://www.google.com/search?hl=en&lr=&ie=UTF-8&q=O%27Reilly+PHP+%26+mySql+Book&btnG=Search

O'Reilly PHP & mySql Book

Sending Data with GET Contd.

- Behind the scenes you see that indeed the data is transmitted in the request method itself



Name: Thomas Powell

Lucky Number: 467

HTTP Headers

```
http://www.pint.com/?username=Thomas+Powell&number=467

GET /?username=Thomas+Powell&number=467 HTTP/1.1
Host: www.pint.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.6)
Accept: application/x-shockwave-flash,text/xml,application/xml,applicat
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
```

Sending Data with Post

- In the case of POST you always generate the request either programmatically or more likely with a form

```
<form action=“http://www.example.com/programs/submit-
 query” method=“post”>
 Query: <input type=“text” name=“query”>
 <input type=“submit” value=“Submit”>
 </form>
```

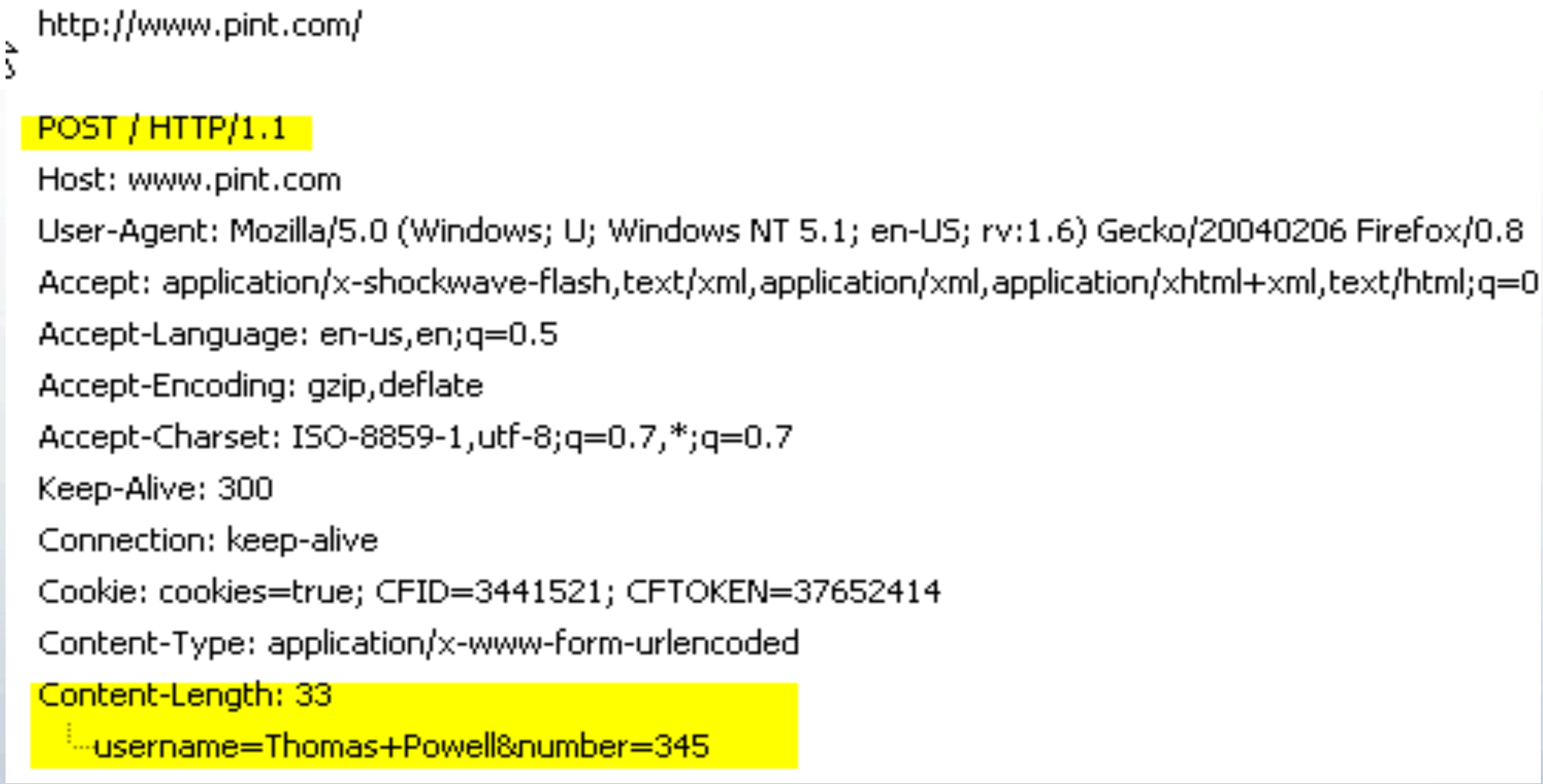
- The POST request sends the data in the message body but does so in x-www-form-urlencoded as well so we might have a message body like

```
Name=Al+Smith&Age=30&Sex=male
```

- No size limit, but issues with browsers have to address lack of redos “Repost form data?”

Sending Data with Post Contd.

- The network trace shows the difference between POST and GET



```
http://www.pint.com/

POST / HTTP/1.1
Host: www.pint.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.6) Gecko/20040206 Firefox/0.8
Accept: application/x-shockwave-flash,text/xml,application/xml,application/xhtml+xml,text/html;q=0
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Cookie: cookies=true; CFID=3441521; CFTOKEN=37652414
Content-Type: application/x-www-form-urlencoded
Content-Length: 33
  username=Thomas+Powell&number=345
```

Why do I care?

- GET and POST have different uses
- GET used when request is idempotent - meaning multiple requests return same result. POST should be used when you change the state of the server
- Lots of folks will often use GET for state changes because of ease of coding
  - Downsides – inadvertent state changes by spiders, browsers, etc.

HTTP Considerations

- HTTP is a stateless protocol
  - No “memory” from one request to the next
- Question: How can you keep track of information from one page to the next?
- Answer:
  - Hidden Form fields that are posted backed to the server
    - E.g. Microsoft’s VIEWSTATE value in .NET
  - Data posted in dirty URL strings
  - Cookies
    - Two types – memory or “session cookies” and persistent or “disk cookies”
- Many programming environments go to significant ends to make provide for easy state management – more on this later!

HTTP Futures

- It is clear (particularly when we look later at performance and security) that HTTP is a bit too simple for our modern Web needs.
- What should we do?
  - HTTP 2 or SPDY – yep that’s working right now
    - Tunnel over SSL, it’s really the only way and it works today!
    - Reality Check – watch out!
  - Parallel protocol for app part
    - See Web Sockets
  - If you could own both ends you could do some rather interesting things … I’m no fortuneteller but, …