Web Server Design

Lecture 4 – Long-lived Connections, Pipelines

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Original slides by Michael L. Nelson

History…

- In the prehistoric days, we used “inetd” to start net services
  - http://en.wikipedia.org/wiki/Inetd

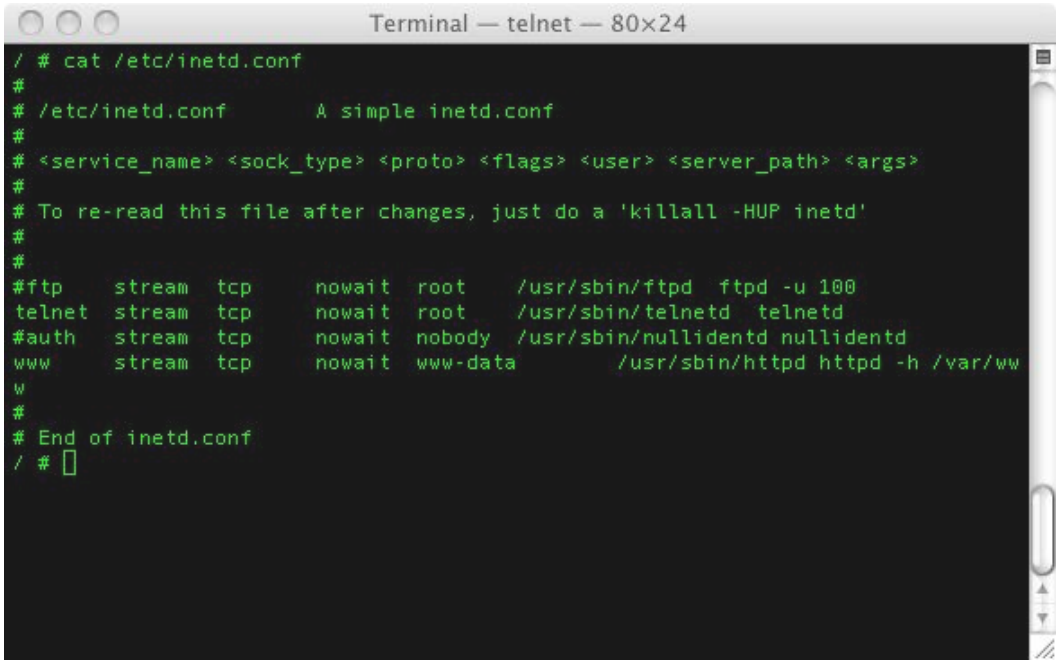


Image from: http://moviecubehacks.wordpress.com/2010/12/10/setting-up-the-ftp-server/

HTTP/1.0 Keep-Alive

- In the very early days, web pages had few images, so 1 TCP connection per URL was not so bad
- HTTP/1.0
  - Keep-Alive extension added (but unevenly supported) to say “don’t hang up”
  - See Roy Fielding's early note:
    - http://ftp.ics.uci.edu/pub/ietf/http/hypermail/1995q4/0063.html
    - Now 404, see: http://web.archive.org/web/20081008002735/http://ftp.ics.uci.edu/pub/ietf/http/hypermail/1995q4/0063.html

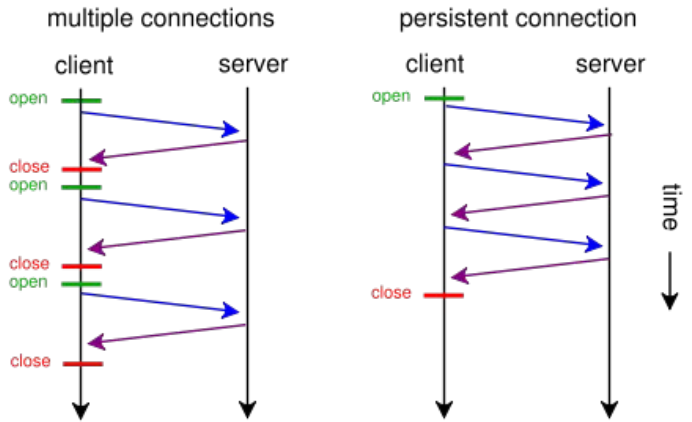


Image from: http://en.wikipedia.org/wiki/File:HTTP_persistent_connection.svg

Latency in HTTP/1.0

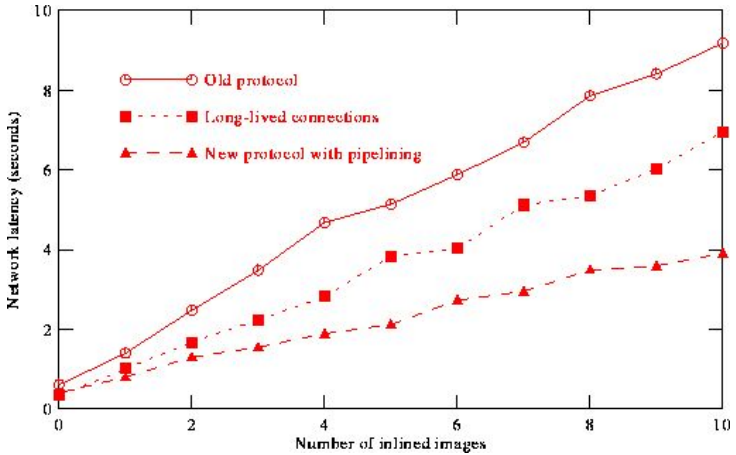


image size = 2.5k

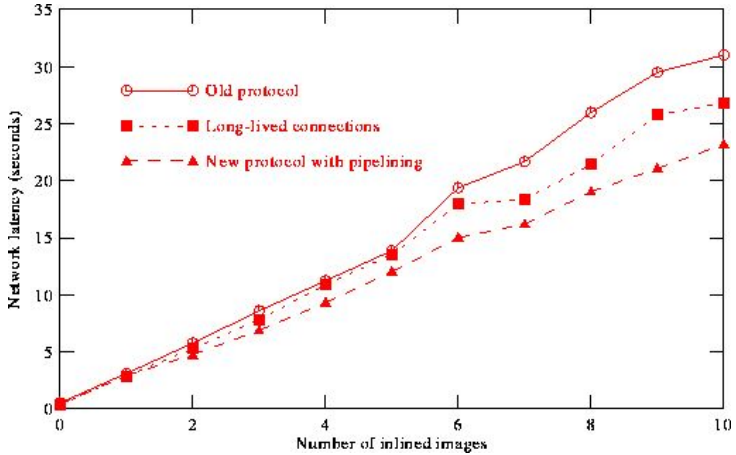
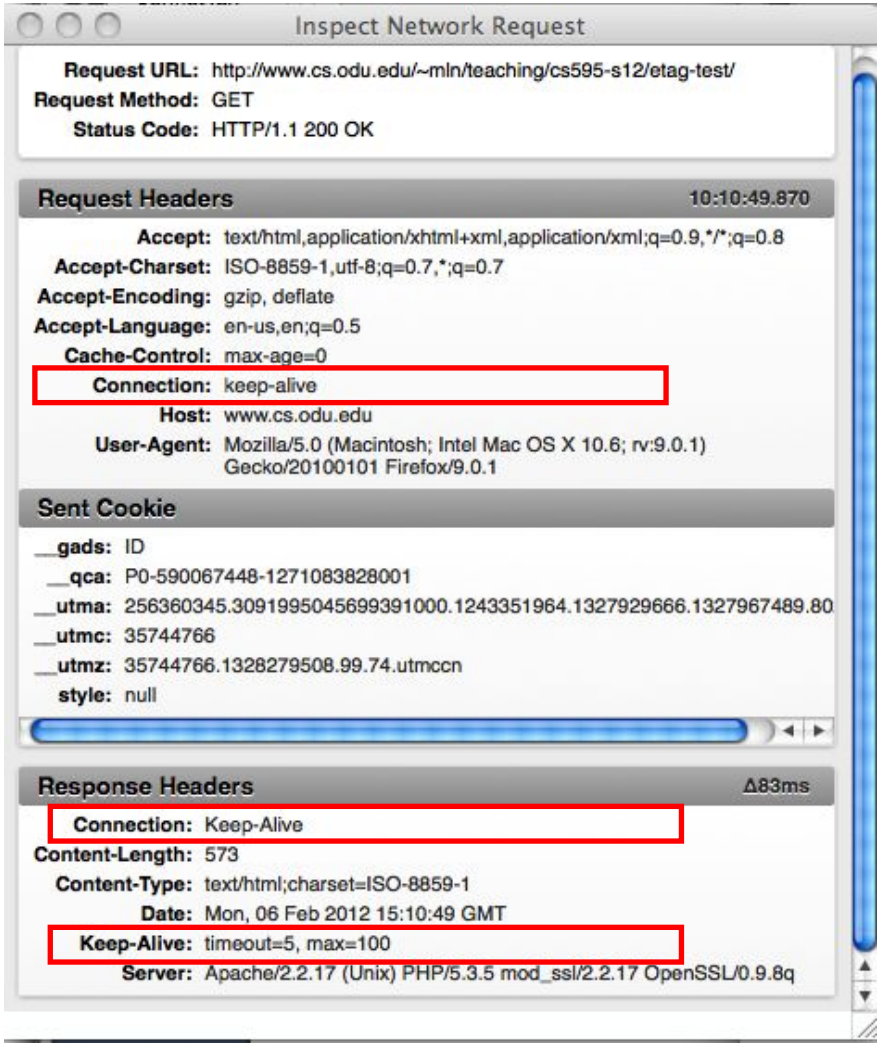


image size = 45k

Figs 6-1 & 6-2 from Padmanabhan & Mogul, “Improving HTTP Latency”, Proceedings of 2nd WWW Conference, 1994
http://dx.doi.org/10.1016/0169-7552(95)00106-1
http://scholar.google.com/scholar?cluster=3197526926814035 02&hl=en&as_sdt=0,47

HTTP/1.1 Keep-Alive is Default

- HTTP/1.1
  - Persistent connections (as they are now called) are the norm
    - See section 19.7.1, RFC 2068; section 19.6.2, RFC 2616, sections 6.1 and A.1.2, RFC 7230
  - You now have to specify a non-persistent connection with `Connection: close`



Old Headers Die Hard…

(FF 9.0.1)

Common Method Properties

Safe	GET, HEAD, OPTIONS, and TRACE
Idempotent	Safe methods + PUT and DELETE
Cacheable	GET, HEAD, and POST

Long-lived Connections

- If the client does not send a "`Connection: close`" header, the server can assume the client wishes to maintain the TCP connection
- If the server sends a "`Connection: close`" header, the session is over

Long-lived Connections

```
$ telnet www.cs.odu.edu 80 | tee 6-1.out
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
```

request

```
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu
```

response

```
HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 20:58:49 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html
```

request

```
HEAD /~mln/teaching/cs595-s06/a1-test/1/ HTTP/1.1
Host: www.cs.odu.edu
```

response

```
HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 20:58:55 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html
```

request

```
HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu
```

response

```
HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 20:59:01 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Last-Modified: Sun, 29 Jan 2006 18:43:15 GMT
ETag: "1f4de2-790-43dd0cc3"
Accept-Ranges: bytes
Content-Length: 1936
Content-Type: text/html
X-Pad: avoid browser bug
```

```
Connection closed by foreign host.
```

Long-lived Connections

```
$ openssl s_client -connect www.cs.odu.edu:443
CONNECTED(00000003)
[much, much SSL deletia]
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:19:41 GMT
Content-Type: text/html;charset=UTF-8
Connection: keep-alive
Front-End-Https: on

HEAD /~mln/teaching/cs595-s06/a1-test/1/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:19:46 GMT
Content-Type: text/html;charset=UTF-8
Connection: keep-alive
Front-End-Https: on

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu
Connection: close

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:20:09 GMT
Content-Type: text/html
Connection: close
Vary: Accept-Encoding
Front-End-Https: on

closed
```

(Does not change with SSL)

Pipelining Requests

6.3.2. Pipelining

A client that supports persistent connections MAY "pipeline" its requests (i.e., send multiple requests without waiting for each response). A server MAY process a sequence of pipelined requests in parallel if they all have safe methods (Section 4.2.1 of [RFC7231]), but it MUST send the corresponding responses in the same order that the requests were received.

(more retry/failure guidance in this section)

Pipelined Requests

3 Requests

3 Responses

```
$ telnet www.cs.odu.edu 80 | tee 6-2.out
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/1/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 21:08:44 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html

HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 21:08:44 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html

HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 21:08:44 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Last-Modified: Sun, 29 Jan 2006 18:43:15 GMT
ETag: "1f4de2-790-43dd0cc3"
Accept-Ranges: bytes
Content-Length: 1936
Content-Type: text/html
X-Pad: avoid browser bug

Connection closed by foreign host.
```

Pipelined Requests

```
$ openssl s_client -connect www.cs.odu.edu:443
CONNECTED(00000003)
[much, much SSL deletia]
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/1/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu
Connection: close

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:46:24 GMT
Content-Type: text/html;charset=UTF-8
Connection: keep-alive
Front-End-Https: on

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:46:24 GMT
Content-Type: text/html;charset=UTF-8
Connection: keep-alive
Front-End-Https: on

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:46:24 GMT
Content-Type: text/html
Connection: close
Vary: Accept-Encoding
Front-End-Https: on

closed
```

(Also does not change with SSL)

Error on a safe method? Keep processing…

```
$ telnet www.cs.odu.edu 80 | tee 6-3.out
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/XASDFASDASDF/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 21:19:37 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html

HTTP/1.1 404 Not Found
Date: Sun, 12 Feb 2006 21:19:37 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Content-Type: text/html; charset=iso-8859-1

HTTP/1.1 200 OK
Date: Sun, 12 Feb 2006 21:19:38 GMT
Server: Apache/1.3.26 (Unix) ApacheJServ/1.1.2 PHP/4.3.4
Last-Modified: Sun, 29 Jan 2006 18:43:15 GMT
ETag: "1f4de2-790-43dd0cc3"
Accept-Ranges: bytes
Content-Length: 1936
Content-Type: text/html
X-Pad: avoid browser bug


Connection closed by foreign host.
```

This error does not terminate the session

Error on a non-idempotent method? Keep processing…

```
$ telnet www.cs.odu.edu 80
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

POST /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Date: Mon, 06 Feb 2012 15:27:35 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Content-Type: text/html;charset=ISO-8859-1

HTTP/1.1 404 Not Found
Date: Mon, 06 Feb 2012 15:27:35 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Content-Length: 348
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
[deletia]
</body></html>

HTTP/1.1 200 OK
Date: Mon, 06 Feb 2012 15:27:35 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Last-Modified: Sun, 29 Jan 2006 18:43:15 GMT
ETag: "790-40b83b3fa76c0"
Accept-Ranges: bytes
Content-Length: 1936
Content-Type: text/html

Connection closed by foreign host.
```


This error does not terminate the session (and why is it 404?! -- *probably* should be a 405 – or a 400?)

Error on an unsafe but idempotent method? Keep processing…

```
$ openssl s_client -connect www.cs.odu.edu:443
CONNECTED(00000003)
[much, much SSL deletia]
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

PUT /~mln/teaching/cs595-s06/a1-test/1/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu
Connection: close

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:59:00 GMT
Content-Type: text/html;charset=UTF-8
Connection: keep-alive
Front-End-Https: on

HTTP/1.1 405 Method Not Allowed
Server: nginx
Date: Tue, 02 Oct 2018 18:59:00 GMT
Content-Type: text/html; charset=iso-8859-1
Transfer-Encoding: chunked
Connection: keep-alive
Allow: GET,HEAD,POST,OPTIONS

[html deletia]

HTTP/1.1 200 OK
Server: nginx
Date: Tue, 02 Oct 2018 18:59:00 GMT
Content-Type: text/html
Connection: close
Vary: Accept-Encoding
Front-End-Https: on

closed
```


This error does not terminate the session since PUT is idempotent (also note the correct 405)

Unknown method? Stop processing

```
$ telnet www.cs.odu.edu 80
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
HEAD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

NOTAMEHTOD /~mln/teaching/cs595-s06/a1-test/ HTTP/1.1
Host: www.cs.odu.edu

HEAD /~mln/teaching/cs595-s06/a1-test/2/ HTTP/1.1
Host: www.cs.odu.edu

HTTP/1.1 200 OK
Date: Mon, 06 Feb 2012 15:25:41 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Content-Type: text/html;charset=ISO-8859-1

HTTP/1.1 501 Method Not Implemented
Date: Mon, 06 Feb 2012 15:25:41 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Allow: GET,HEAD,POST,OPTIONS
Content-Length: 362
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head>
<title>501 Method Not Implemented</title>
</head><body>
<h1>Method Not Implemented</h1>
<p>NOTAMEHTOD to /~mln/teaching/cs595-s06/a1-test/ not supported.<br />
</p>
<hr>
<address>Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q Server
at www.cs.odu.edu Port 80</address>
</body></html>
Connection closed by foreign host.
```


This error **does** terminate the session

Timeout Not Specified in RFCs 2616 or 7230
(But see 6.5 of 7230)

KeepAliveTimeout Directive

Description: Amount of time the server will wait for subsequent requests on a persistent connection
Syntax: KeepAliveTimeout seconds
Default: KeepAliveTimeout 15
Context: server config, virtual host
Status: Core
Module: core

The number of seconds Apache will wait for a subsequent request before closing the connection. Once a request has been received, the timeout value specified by the Timeout directive applies.

Setting KeepAliveTimeout to a high value may cause performance problems in heavily loaded servers. The higher the timeout, the more server processes will be kept occupied waiting on connections with idle clients.

http://httpd.apache.org/docs/2.0/mod/core.html#keepalivetimeout

Apache Gives a 400 on Timeout

```
$ telnet www.cs.odu.edu 80
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
GET / HTTP/1.1
Host: www.cs.odu.edu
HTTP/1.1 400 Bad Request
Date: Mon, 06 Feb 2012 04:56:12 GMT
Server: Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q
Content-Length: 344
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head>
<title>400 Bad Request</title>
</head><body>
<h1>Bad Request</h1>
<p>Your browser sent a request that this server could not understand.<br />
</p>
<hr>
<address>Apache/2.2.17 (Unix) PHP/5.3.5 mod_ssl/2.2.17 OpenSSL/0.9.8q Server at
www.cs.odu.edu Port 80</address>
</body></html>
Connection closed by foreign host.
```

After waiting the timeout value, Apache just gives up and sends a 400

Now it seems to do nothing…

(in both examples below the magic blank line is not sent)

After waiting the timeout value, Apache now just gives up

```
$ telnet www.cs.odu.edu 80
Trying 128.82.4.2...
Connected to xenon.cs.odu.edu.
Escape character is '^]'.
HEAD / HTTP/1.1
Host: www.google.com
Connection closed by foreign host.
```

```
$ openssl s_client -connect www.cs.odu.edu:443
CONNECTED(00000003)
[much, much SSL deletia]
HEAD /~mln/teaching/cs595-s06/a1-test/
HTTP/1.1
Host: www.cs.odu.edu
read:errno=0
```

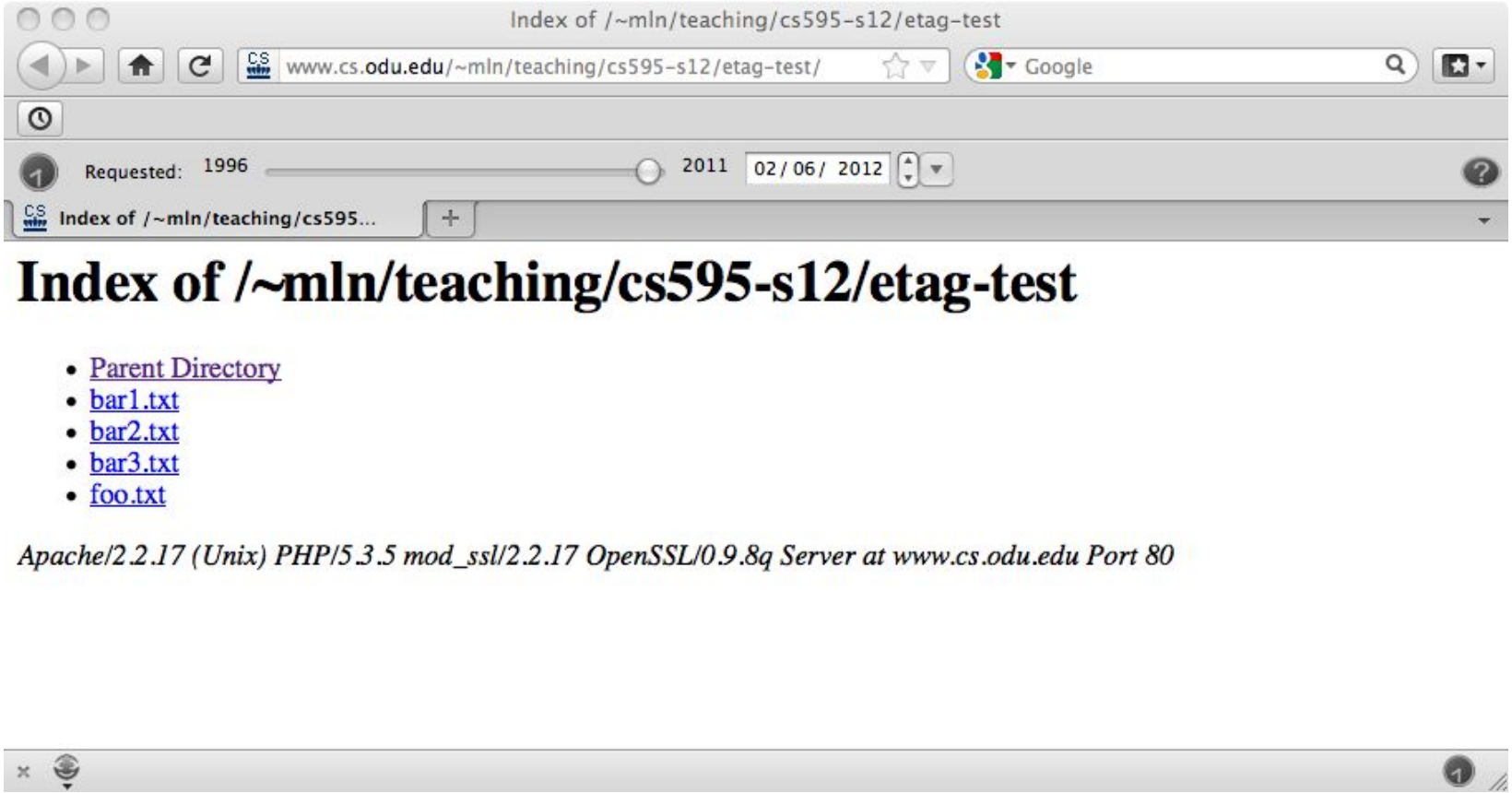
Why Not a 408?

6.5.7. 408 Request Timeout

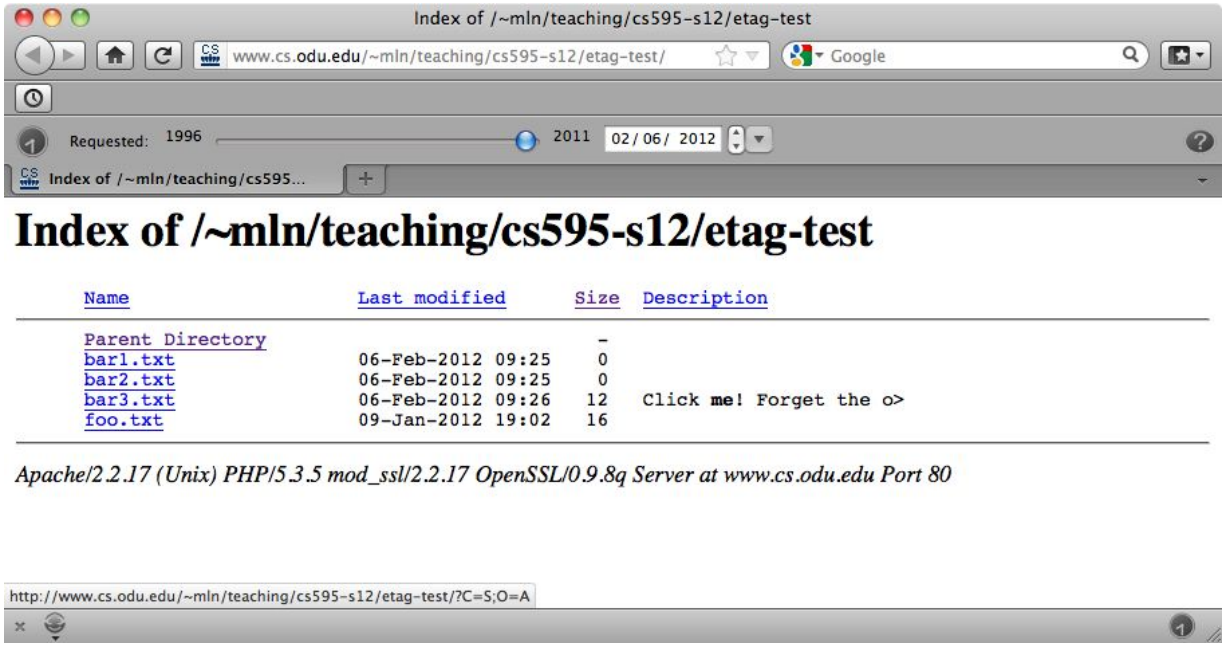
The 408 (Request Timeout) status code indicates that the server did not receive a complete request message within the time that it was prepared to wait. A server SHOULD send the "close" connection option (Section 6.1 of [RFC7230]) in the response, since 408 implies that the server has decided to close the connection rather than continue waiting. If the client has an outstanding request in transit, the client MAY repeat that request on a new connection.

I haven't seen a 408 in the wild, but we will implement it in A2

Directory Listings



Fancy Directory Listings



http://www.cs.odu.edu/~mln/teaching/cs595-s12/etag-test/

http://httpd.apache.org/docs/current/mod/mod_autoindex.html

```
$ pwd
/home/mln/public_html/teaching/cs595-s12/etag-test
$ cat .htaccess
FileETag INode MTime Size
IndexOptions FancyIndexing
AddDescription "Click <b>me</b>! Forget the other files!" bar3.txt
```