Distributed Computing

Lesson 10: HTTP

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Outline

website

Overview

- We now know HTML, web pages, and how they can be “located” in the internet via URLs.
- But how does the concent of a web page come from the web server to our computer?
- We will learn about HTTP, the protocol existing for this purpose.
- How is HTTP related to TCP sockets and what we’ve learned so far?

Client/Server

- Client/Server systems are the most common application structure in the internet and corporate networks

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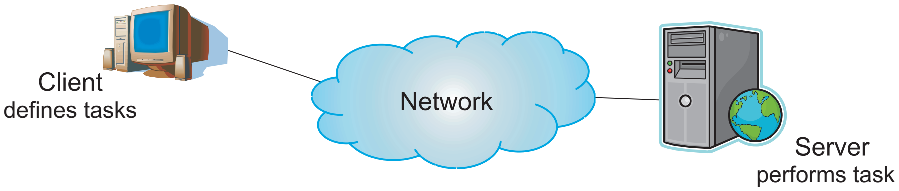

Client/Server

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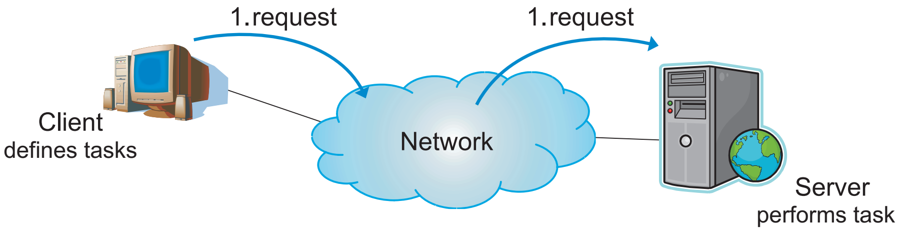

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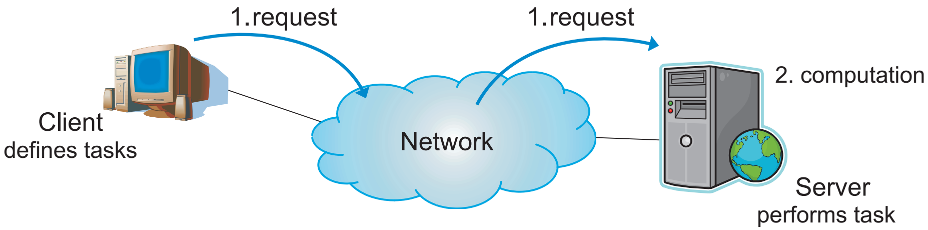

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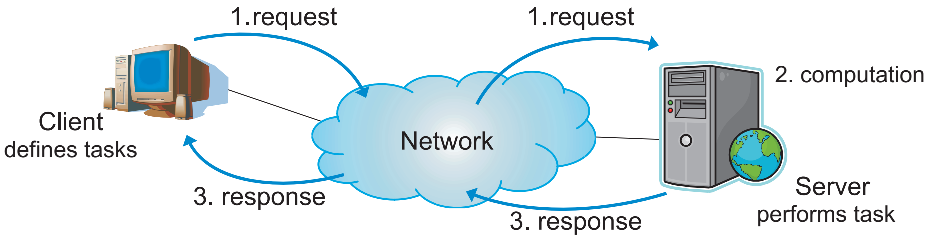
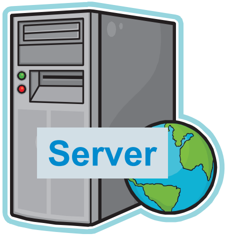
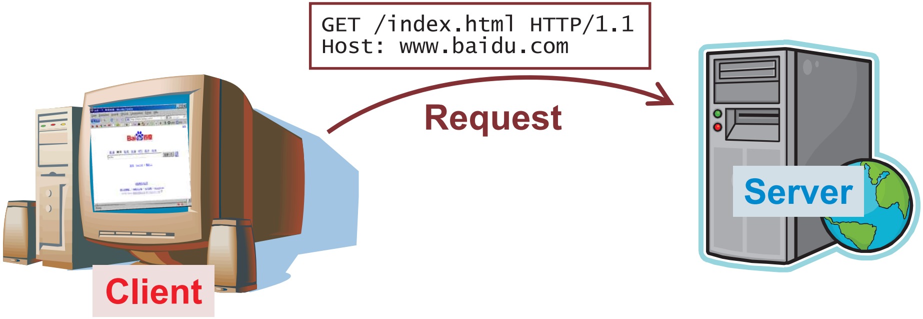


Browser/Web Server

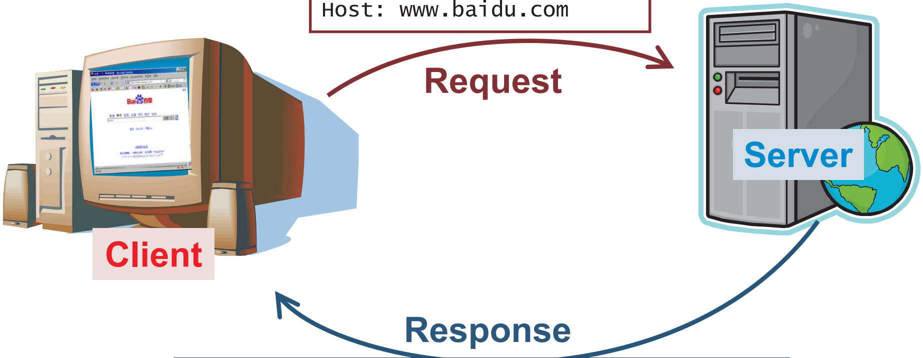


Browser/Web Server



```
GET /index.html HTTP/1.1
Host: www.baidu.com
```

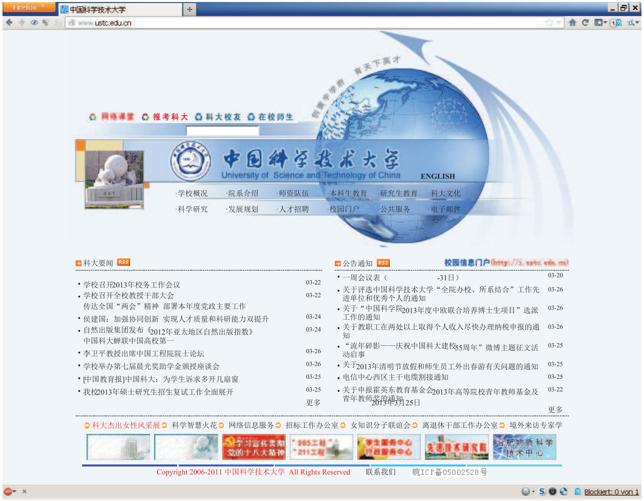
Browser/Web Server



```
GET /index.html HTTP/1.1
Host: www.baidu.com
```

```
HTTP/1.1 200 OK
...
<html><head><meta http-equiv=Content-Type
content="text/html;charset=gb2312"><title>百度
一下，你就知道</title><style>body{margin:4px...
```

Hypertext Structure



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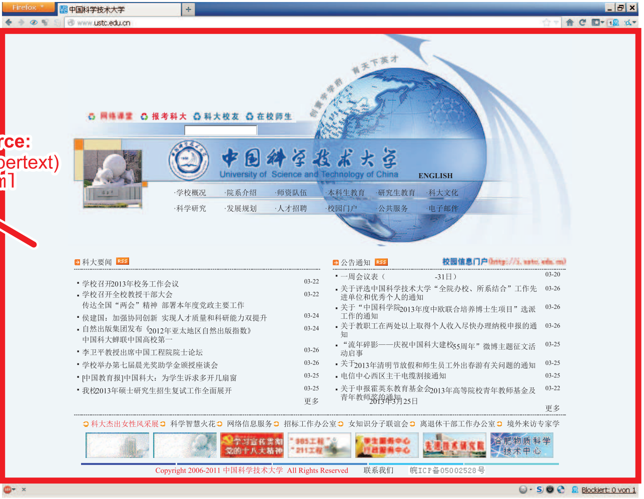
Hypertext Structure

Main Resource:
HTML Code (hypertext)
`index.html`



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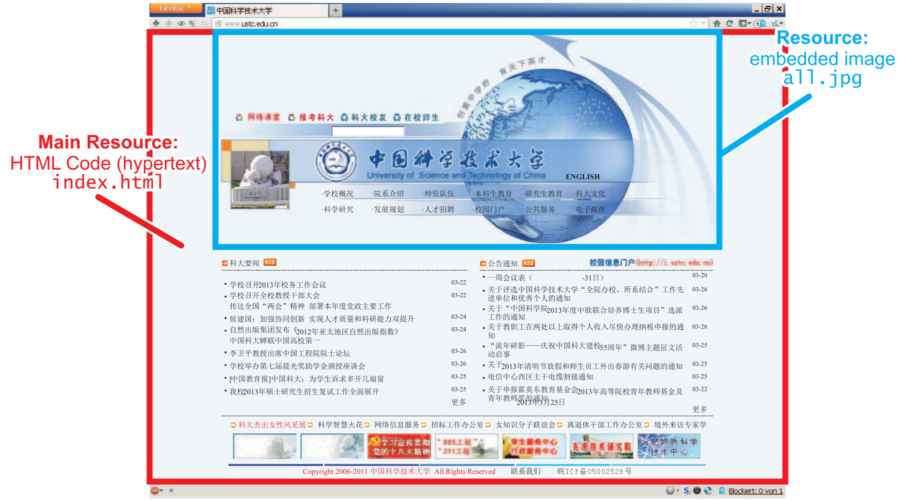

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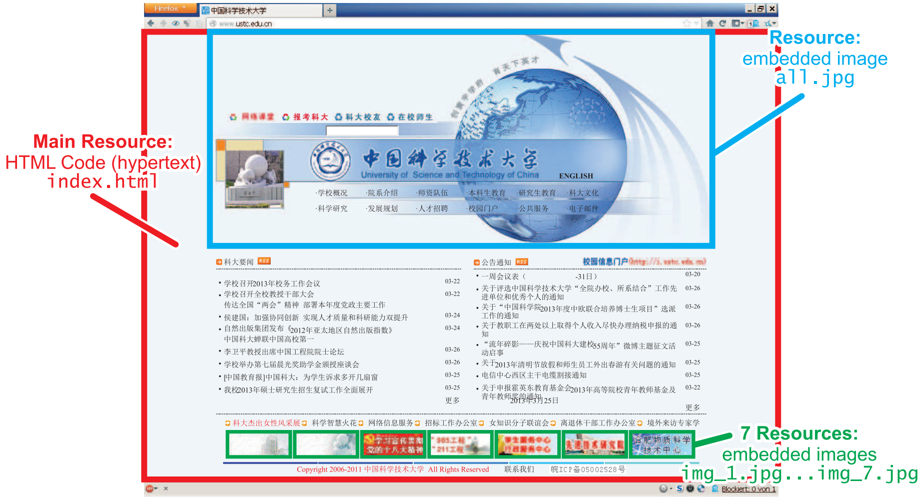

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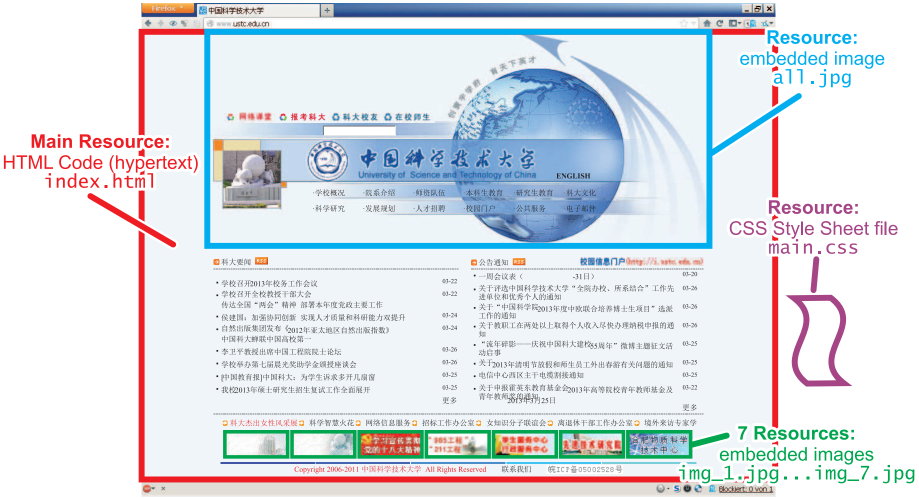

Main Resource:
HTML Code (hypertext)
index.html
Resource:
embedded image
all.jpg
Resource:
CSS Style Sheet file
main.css
7 Resources:
embedded images
img_1.jpg...img_7.jpg
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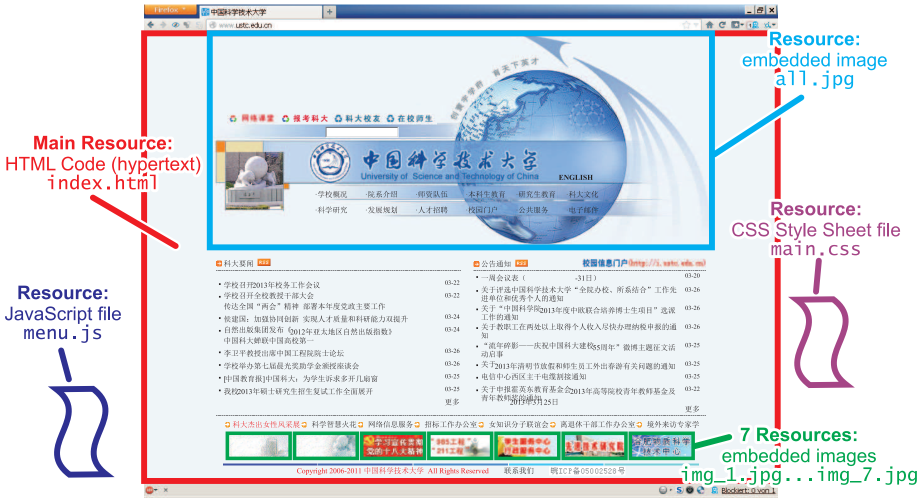

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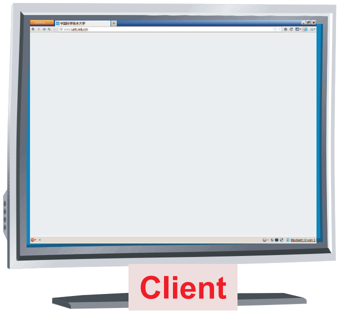

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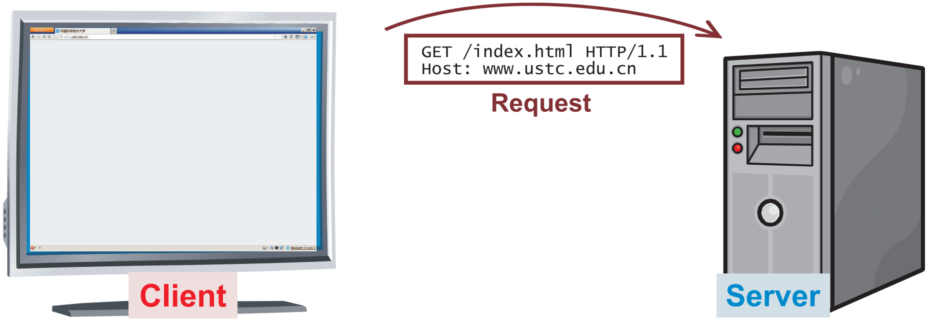
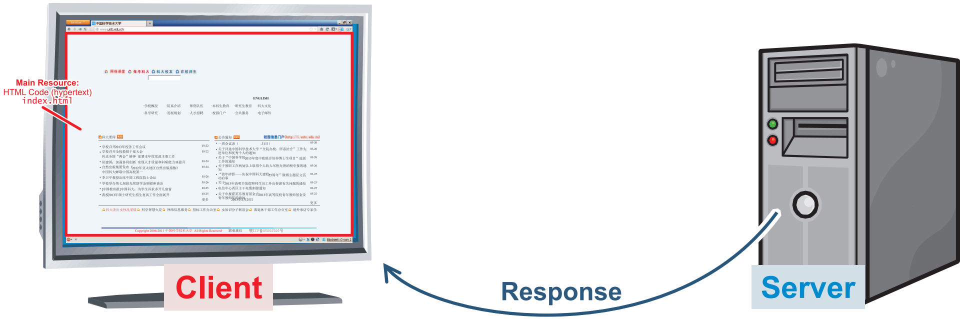


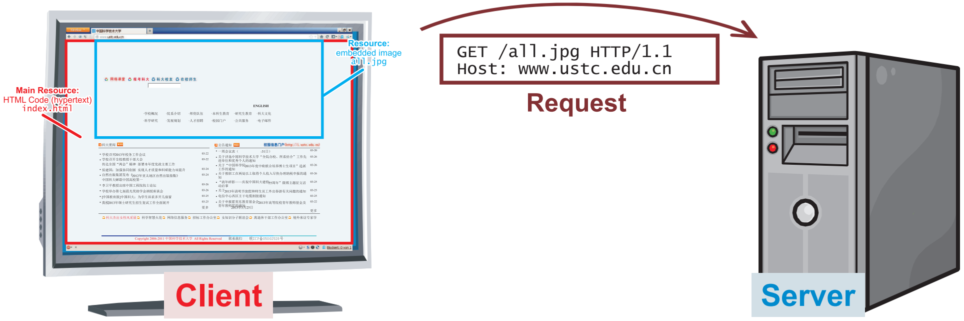
```
GET /index.html HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



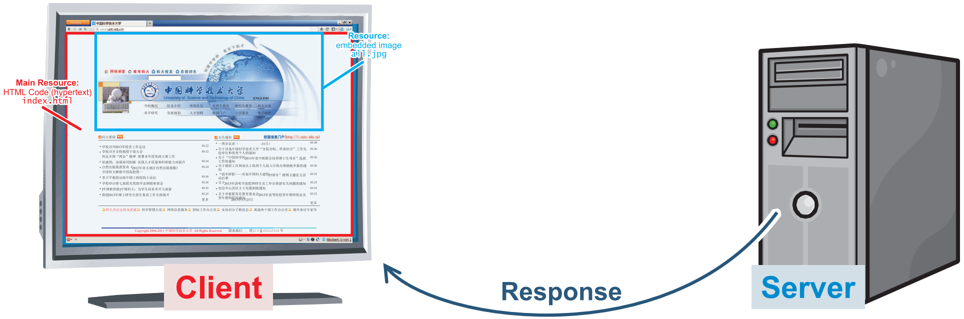
```
HTTP/1.1 200 OK
...
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML lang=zh-CN xmlns="http://www.w3.org/1999/xhtml">
<HEAD>
<link rel="shortcut icon" href="ustc.ico" type="image/x-icon">
<link rel="icon" href="ustc.ico" type="image/x-icon">
<META content="text/html; charset=utf-8" http-equiv=Content-Type>
<TITLE>中国科学技术大学</TITLE>
...
```

Browser loads Website



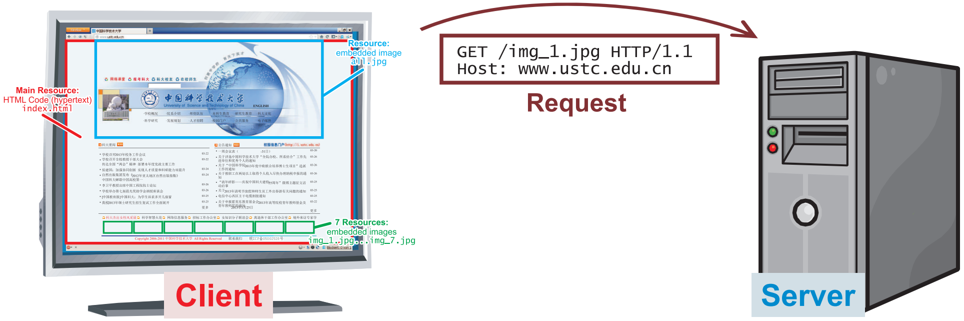
```
GET /all.jpg HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



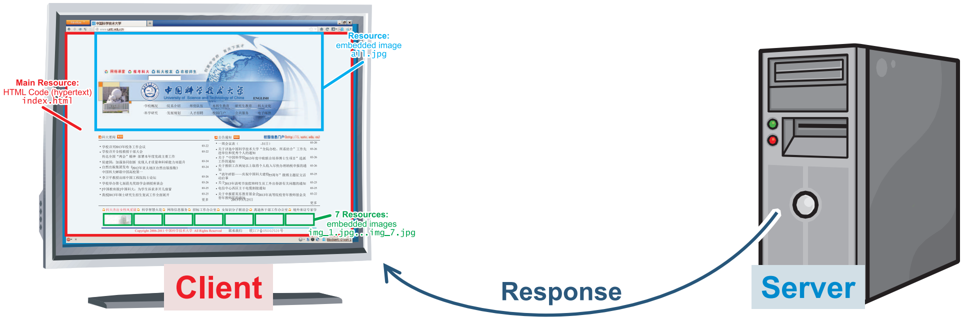
```
HTTP/1.1 200 OK
...
<binary data>
...
```

Browser loads Website



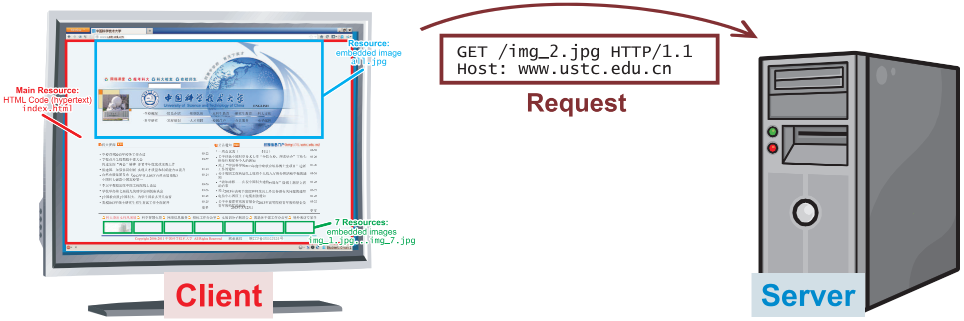
```
GET /img_1.jpg HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



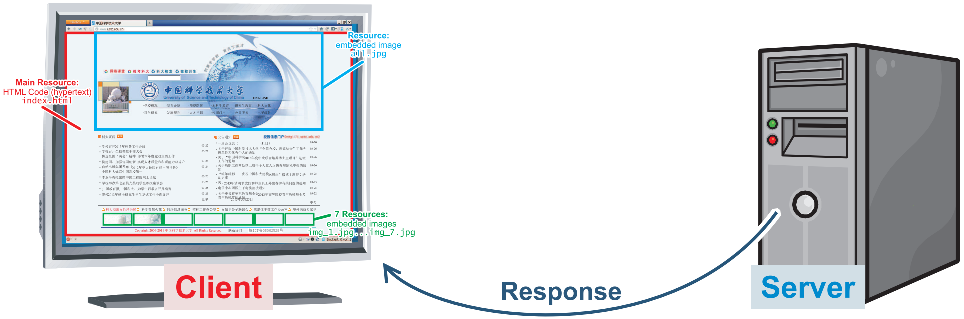
```
HTTP/1.1 200 OK
...
<binary data>
...
```

Browser loads Website



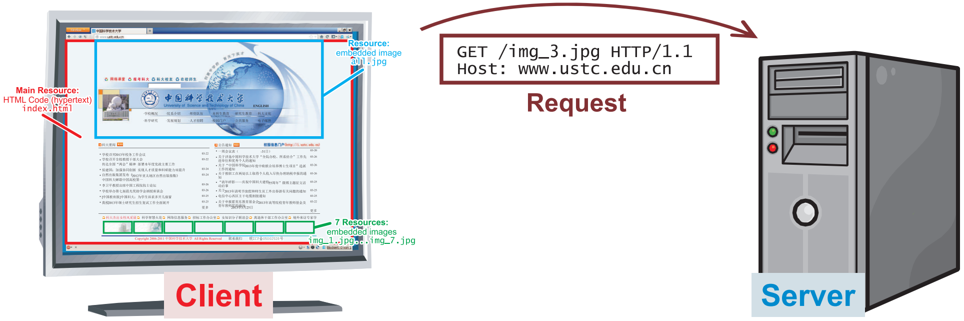
```
GET /img_2.jpg HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



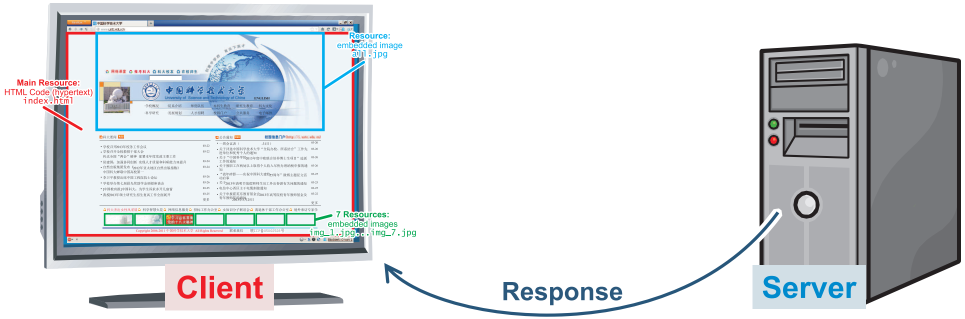
```
HTTP/1.1 200 OK
...
<binary data>
...
```

Browser loads Website



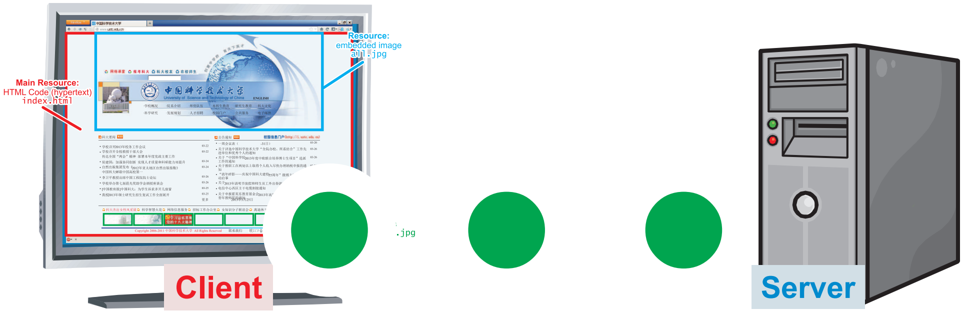
```
GET /img_3.jpg HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



```
HTTP/1.1 200 OK
...
<binary data>
...
```

Browser loads Website



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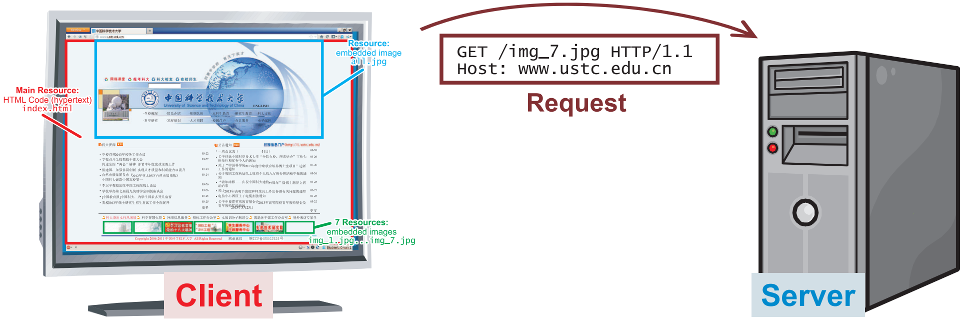
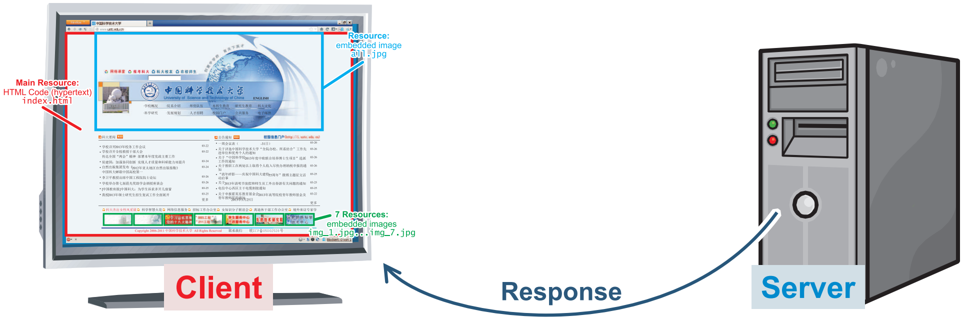


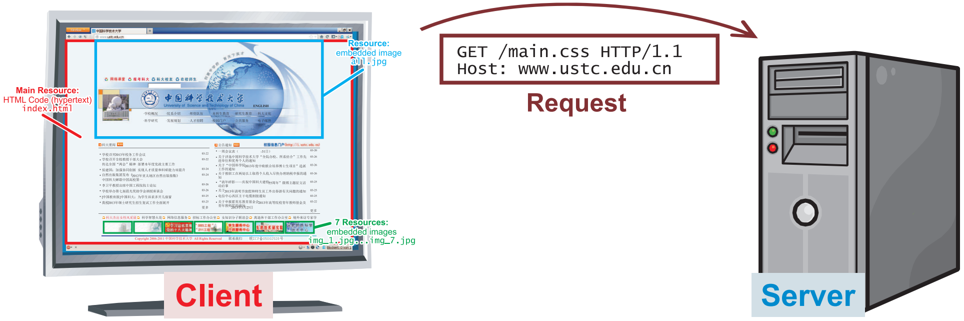
```
GET /img_7.jpg HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



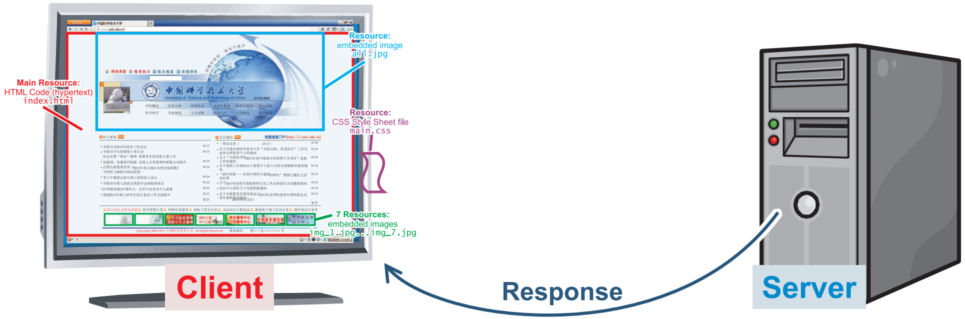
```
HTTP/1.1 200 OK
...
<binary data>
...
```

Browser loads Website



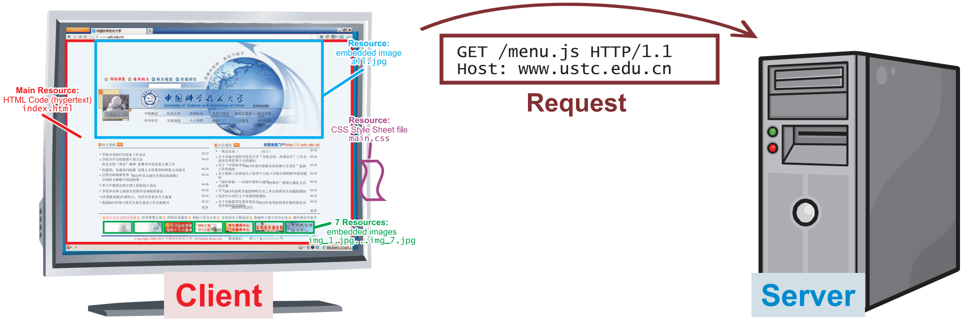
```
GET /main.css HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



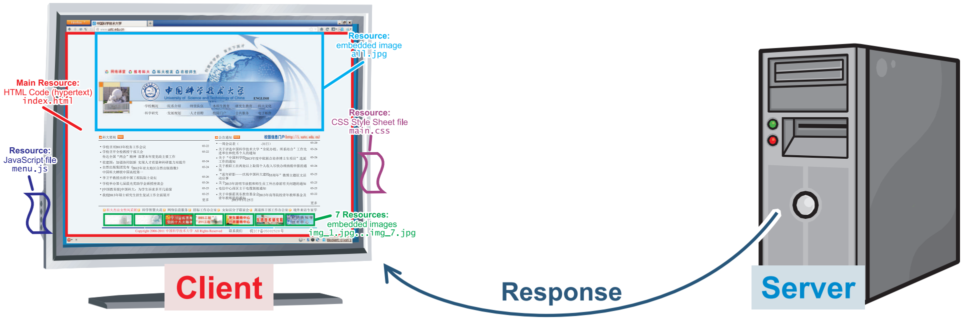
```
HTTP/1.1 200 OK
...
body{background-color:white;color:black;
font-family:sans-serif;}img{background-color
:transparent;border-style:none;}a{background
-color:transparent;border-style:none;text
-decoration:none;color:blue;}a:hover{text...
```

Browser loads Website



```
GET /menu.js HTTP/1.1
Host: www.ustc.edu.cn
```

Browser loads Website



```
HTTP/1.1 200 OK
...
function menuFix(menuid) {
var sfEls = document.getElementById(menuid).getElementsByTagName...
for (var i=0; i<sfEls.length; i++) {
  sfEls[i].onmouseover=function() {
  this.className+=(this.className.length>0? " ": "") + "sfhover";
  }
sfEls[i].onMouseDown=function() {
  this.className+=(this.className.length>0? " ": "") + "sfhover";
```

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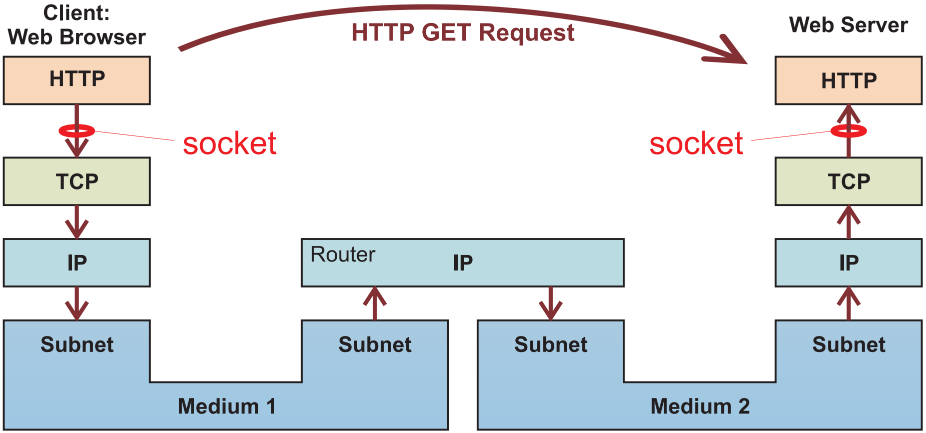
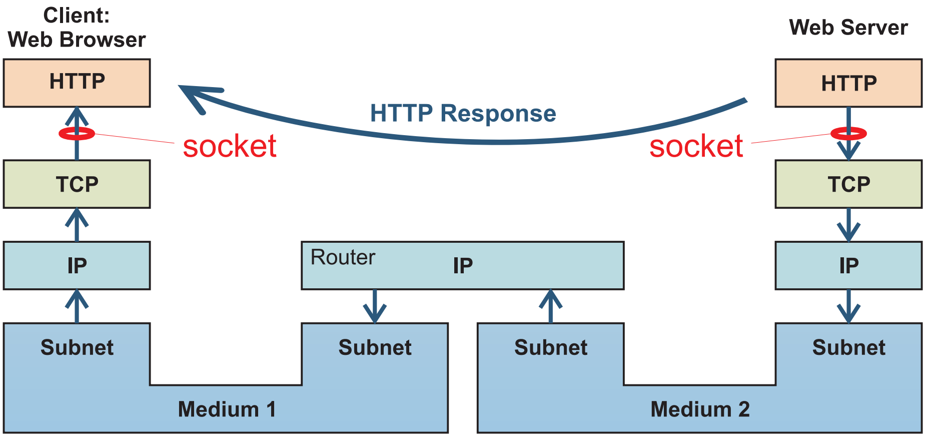
HTTP & Protocol Layers



HTTP & Protocol Layers



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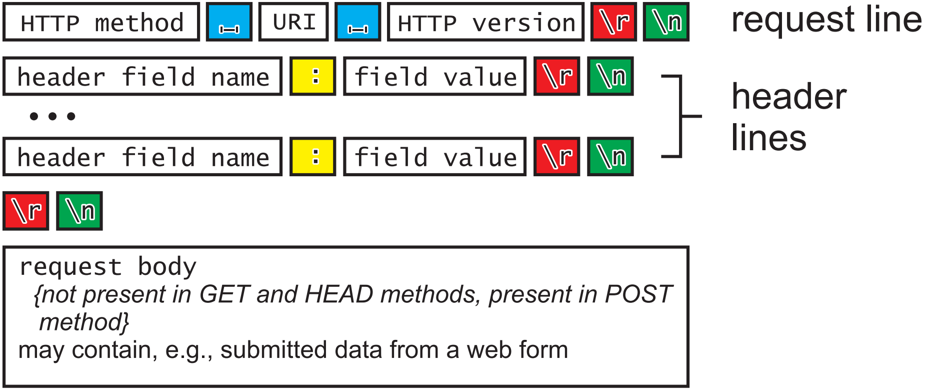
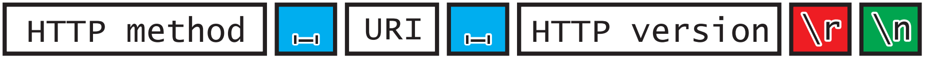
  - TCP connections can be re-used (good for inline resources/images in HTML)

HTTP Request



request body
{not present in GET and HEAD methods, present in POST method}
may contain, e.g., submitted data from a web form

HTTP Request: Request Line



- `HTTP method`

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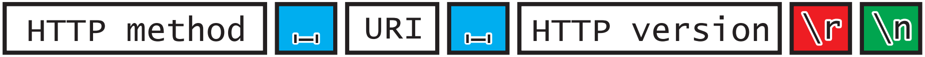

- `HTTP method`:
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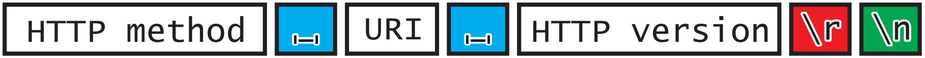

- `HTTP method`:
  - `GET`: download the data that belongs to a specified resource (can include parameters), e.g., a web page
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HTTP Request: Request Line

`HTTP method` `␣` `URI` `␣` `HTTP version` `\r` `\n`

- `HTTP method`:
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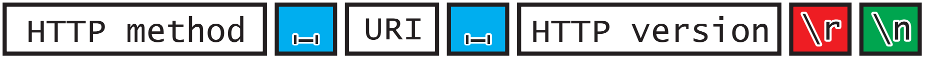

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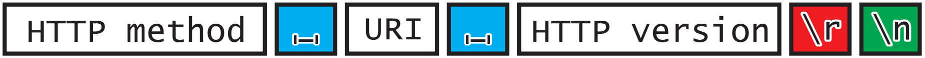

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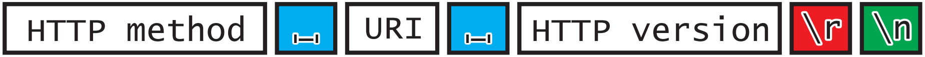

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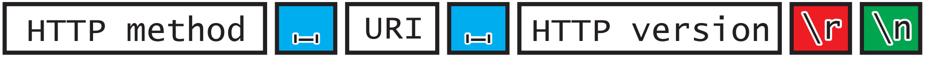
HTTP Request: Request Line



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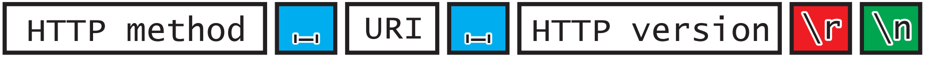

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- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]

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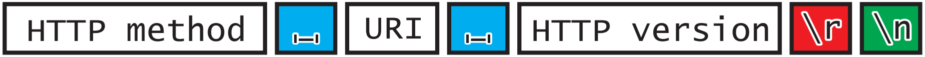

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  - PUT: upload a representation of the specified resource
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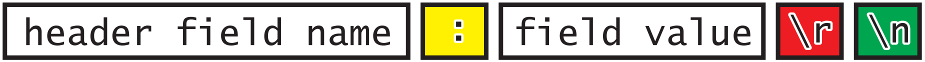
- relative part of URI: identifies a resource relative to server
- HTTP version:
  - HTTP/1.1 for HTTP 1.1 [2]
  - HTTP/1.0 for HTTP 1.0 [1]

HTTP Request: Request Header



- Different header fields, each has its own format

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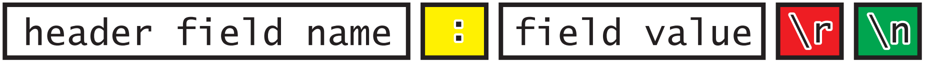

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- Examples

HTTP Request: Request Header

`header field name`	`:`	`field value`	`\r`	`\n`

- Different header fields, each has its own format
- Examples
  - `Accept: text/html`

HTTP Request: Request Header

```
header field name : field value \r \n
```

- Different header fields, each has its own format
- Examples
  - `Accept: text/html`
  - `Accept: image/jpg`

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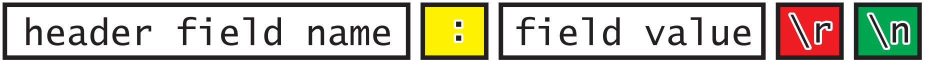

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- Examples
    - `Accept: text/html`
    - `Accept: image/jpg`
    - `Accept-Language: zh-CN`

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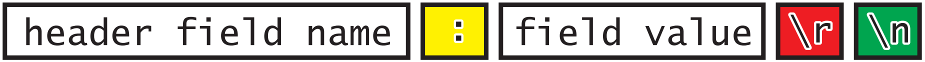

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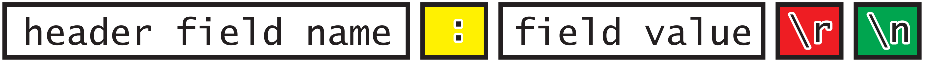
  - `Accept-Charset: utf-8, gb2312`



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  - `Accept: image/jpg`
  - `Accept-Language: zh-CN`
  - `Accept-Charset: utf-8, gb2312`
  - `If-Modified-Since: Wed, 27 Mar 2013 12:01:32 GMT`

HTTP Request Printing Server

- Let's look how requests generated by web browsers look like

HTTP Server Printing Requests

Listing: HTTPServerPrintingRequests.java

```java
import java.io.BufferedReader;          import java.io.BufferedWriter;      import java.io.InputStreamReader;
import java.io.OutputStreamWriter;      import java.net.ServerSocket;       import java.net.Socket;

public class HTTPServerPrintingRequests {
  public static final void main(final String[] args) {
    String s;     StringBuilder sb;

    try (ServerSocket server = new ServerSocket(9995)) { //create server socket
      try (Socket client = server.accept()) { //accept incoming client

        sb = new StringBuilder(); //allocate buffer

        try (InputStreamReader ir = new InputStreamReader(client.getInputStream());//request=character stream
             BufferedReader    br = new BufferedReader(ir)) { //read request line-by-line
          while ((s = br.readLine()) != null) { //as long as lines can be read...
            sb.append(s);                       //append them to the buffer
            sb.append("<br/>");                 //add HTML line breaks
            if(s.length()<=0) { break; } // the final newline of the header
          }
          client.shutdownInput(); //no more input is requests

          try (OutputStreamWriter pw = new OutputStreamWriter(client.getOutputStream())) {
            pw.write("HTTP/1.1␣200␣OK\r\n\r\n<html><body><pre>"); //now write the answer: HTTP OK + HTML document
            pw.write(sb.toString()); //buffered content
            pw.write("</pre></body></html>"); //close the HTML document
          }
        }
      }
    } catch (Throwable t) {
      t.printStackTrace();
    }
  }
}
```

HTTP Request: Example

We run the `HTTPServerPrintingRequests` locally and access `localhost:9995` with Firefox

HTTP Request: Example

We run the `HTTPServerPrintingRequests` locally and access `localhost:9995` with Firefox:

```
GET / HTTP/1.1
Host: localhost:9995
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:19.0) Gecko/20100101 Firefox/19.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-us,en;q=0.8,de-de;q=0.5,de;q=0.3
Accept-Encoding: gzip, deflate
DNT: 1
Connection: keep-alive
Cache-Control: max-age=0
```

HTTP Request: Example

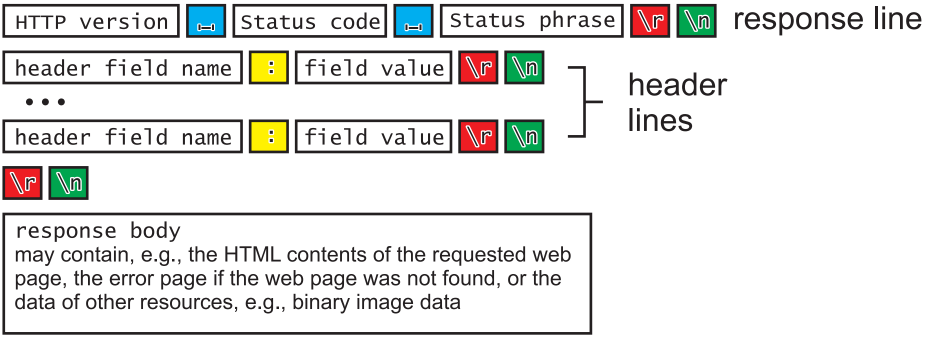
We run the `HTTPServerPrintingRequests` locally and access `http://localhost:9995` with Internet Explorer

HTTP Request: Example

We run the HTTPServerPrintingRequests locally and access http://localhost:9995 with Internet Explorer:

```
GET / HTTP/1.1
Accept: application/x-ms-application, image/jpeg, application/xaml+xml, image/gif,...
Accept-Language: de-DE
User-Agent: Mozilla/4.0 (compatible; MSIE 8.0; Windows NT 6.1; WOW64; Trident/4.0;;...
Accept-Encoding: gzip, deflate
Host: localhost:9995
Connection: Keep-Alive
```

HTTP Response



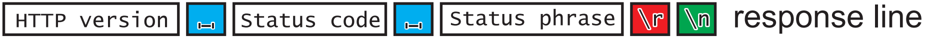
HTTP version
␣
Status code
␣
Status phrase
\r
\n
response line
header field name
:
field value
\r
\n
...
header field name
:
field value
\r
\n
header lines
\r
\n
response body
may contain, e.g., the HTML contents of the requested web page, the error page if the web page was not found, or the data of other resources, e.g., binary image data

HTTP Response: Response Line

`HTTP version` ␣ `Status code` ␣ `Status phrase` `\r` `\n` response line

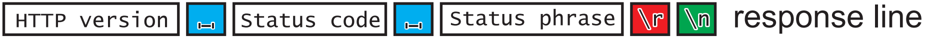
- `HTTP version`

HTTP Response: Response Line



- `HTTP version`:
    - `HTTP/1.1` for HTTP 1.1 [2]

HTTP Response: Response Line



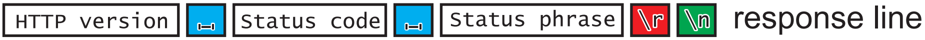
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]

HTTP Response: Response Line

`HTTP version` `␣` `Status code` `␣` `Status phrase` `\r` `\n` response line

- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`

HTTP Response: Response Line



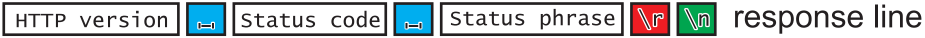
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing

HTTP Response: Response Line

`HTTP version` `␣` `Status code` `␣` `Status phrase` `\r` `\n` response line

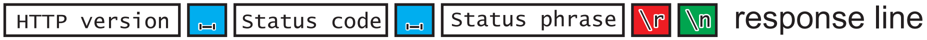
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing

HTTP Response: Response Line



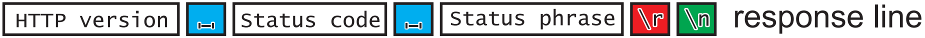
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1 Information

HTTP Response: Response Line



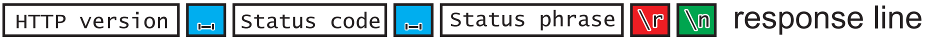
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success

HTTP Response: Response Line



- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success
  3. Redirection

HTTP Response: Response Line



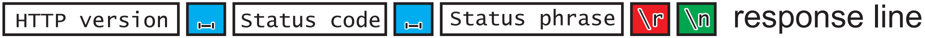
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success
  3. Redirection
  4. Error on client side (e.g., wrong URI)

HTTP Response: Response Line

`HTTP version` `␣` `Status code` `␣` `Status phrase` `\r` `\n` response line

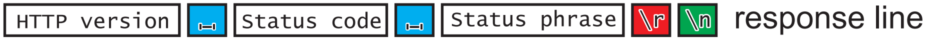
- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success
  3. Redirection
  4. Error on client side (e.g., wrong URI)
  5. Error on server side

HTTP Response: Response Line



- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success
  3. Redirection
  4. Error on client side (e.g., wrong URI)
  5. Error on server side
- `Status phrase`

HTTP Response: Response Line



- `HTTP version`:
  - `HTTP/1.1` for HTTP 1.1 [2]
  - `HTTP/1.0` for HTTP 1.0 [1]
- `Status code`: three digits, with the first digit representing
  1. Information
  2. Success
  3. Redirection
  4. Error on client side (e.g., wrong URI)
  5. Error on server side
- `Status phrase`: short textual representation of status code, e.g., `OK`

HTTP Status Codes

- Some examples for status codes

HTTP Status Codes

- Some examples for status codes
    - 200 OK

HTTP Status Codes

- Some examples for status codes
  - 200 OK
  - 301 Moved Permanently

HTTP Status Codes

- Some examples for status codes
  - 200 OK
  - 301 Moved Permanently
  - 400 Bad Request

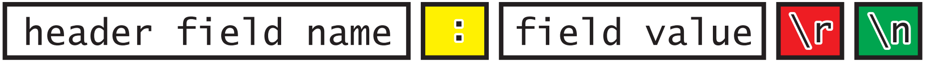
HTTP Status Codes

- Some examples for status codes
  - 200 OK
  - 301 Moved Permanently
  - 400 Bad Request
  - 404 Not Found

HTTP Status Codes

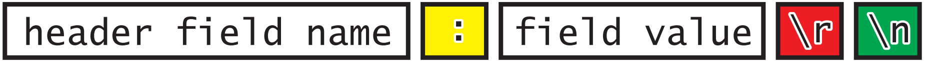
- Some examples for status codes
  - 200 OK
  - 301 Moved Permanently
  - 400 Bad Request
  - 404 Not Found
  - 505 HTTP Version Not Supported

HTTP Response: Response Header



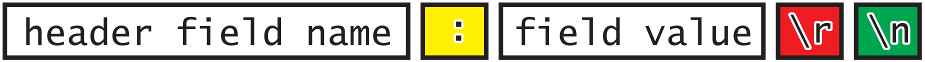
- Different header fields, each has its own format

HTTP Response: Response Header



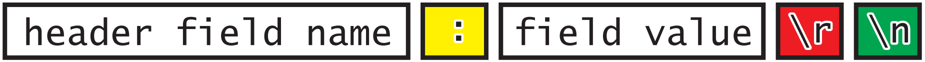
- Different header fields, each has its own format
- Examples

HTTP Response: Response Header



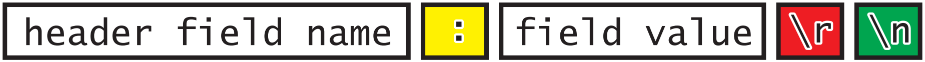
- Different header fields, each has its own format
- Examples
    - `Content-Type: text/html`

HTTP Response: Response Header



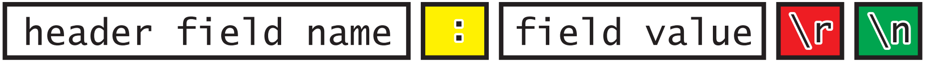
- Different header fields, each has its own format
- Examples
  - `Content-Type: text/html`
  - `Content-Length: 16384`

HTTP Response: Response Header



- Different header fields, each has its own format
- Examples
  - `Content-Type: text/html`
  - `Content-Length: 16384`
  - `Language: zh-CN;`

HTTP Response: Response Header



- Different header fields, each has its own format
- Examples
  - `Content-Type: text/html`
  - `Content-Length: 16384`
  - `Language: zh-CN;`
  - `Last-modified: 28 Mar 2013`

HTTP Response Printing Client

- Let's look how responses generated by web servers look like

HTTP Client Printing Server's Response

Listing: MinHTTPClientJava17.java Min HTTP Client + Try-With-Resource

```java
import java.io.BufferedReader;          import java.io.InputStreamReader;
import java.io.OutputStreamWriter;      import java.net.Socket;

public class MinHTTPClientJava17 {//this is a minimum web client; see lesson 07 coming later
  public static final void main(final String[] args) {
    String dest, request, response;

    dest    = "www.baidu.com";      // a random example for a Chinese host
    request = "GET␣/index.html␣HTTP/1.1\nHost:␣" + dest + "\n\n\n";

    try(Socket sock = new Socket(dest, 80)) { // web servers are usually listening at port 80
      try(OutputStreamWriter w = new OutputStreamWriter(sock.getOutputStream())) {
      w.write(request);             // write the HTTP request [1–3]
      w.flush();                    // make sure that all data has been sent
      sock.shutdownOutput();        // closing down the channel for sending data to the server

      try (InputStreamReader is = new InputStreamReader(sock.getInputStream());
          BufferedReader     r  = new BufferedReader(is)) { // Baidu uses UTF-8 encoding
          while ((response = r.readLine()) != null) { // read strings line-by-line until connection closed by serve
            System.out.println(response);             // print to output
          }
        }
      }
    } catch (Throwable t) {
      t.printStackTrace();
    }
  }
}
```

HTTP Response: Example

To `www.baidu.com`, we send

HTTP Response: Example

To `www.baidu.com`, we send:

```
GET /index.html HTTP/1.1
Host: www.baidu.com
```

HTTP Response: Example

To `www.baidu.com`, we send:

```
GET /index.html HTTP/1.1
Host: www.baidu.com
```

and get the response:

```
HTTP/1.1 200 OK
Date: Wed, 27 Mar 2013 23:44:43 GMT
Server: BWS/1.0
Content-Length: 10319
Content-Type: text/html;charset=utf-8
Cache-Control: private
Expires: Wed, 27 Mar 2013 23:44:43 GMT
Set-Cookie: H_PS_PSSID=2097_1430_2132_1945_1788; path=/; domain=.baidu.com
Set-Cookie: BAIDUID=1BBB7C987D5159BE0741B675A88B3E0C:FG=1; expires=Wed, 27-Mar-43...
P3P: CP=" OTI DSP COR IVA OUR IND COM "
Connection: Keep-Alive

<!DOCTYPE html><!--STATUS OK-->    <html><head>  <meta http-equiv="content-type"
content="text/html;charset=utf-8">  <title>...
```

Summary

- HTTP is a general, text-based protocol to request resources.
- Web pages are served by web servers which implement the HTTP protocol.
- Such servers can be implemented with the simple stuff we have learned about sockets.
- Actually, several Java-based web servers use exactly the technologies we have learned so far.

谢谢

Thank you

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Caspar David Friedrich, “Der Wanderer über dem Nebelmeer”, 1818
http://en.wikipedia.org/wiki/Wanderer_above_the_Sea_of_Fog

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3. David Gourley and Brian Totty. *HTTP: The Definitive Guide*. Definitive Guide. Sebastopol, CA, USA: O'Reilly Media, Inc., 2002. ISBN 1565925092 and 9781565925090. URL `http://books.google.de/books?id=qEoOl9bcV_cC`.