Web Reference Architecture

Visualizzazione dell'Informazione Quantitativa

https://softeng.polito.it/courses/VIQ

SOftEng
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Acknowledgments

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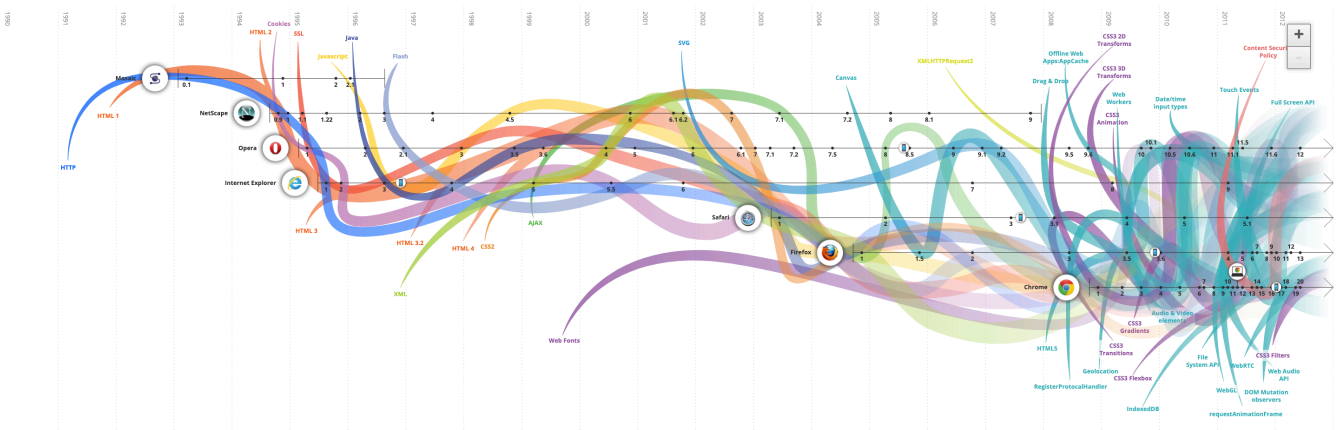
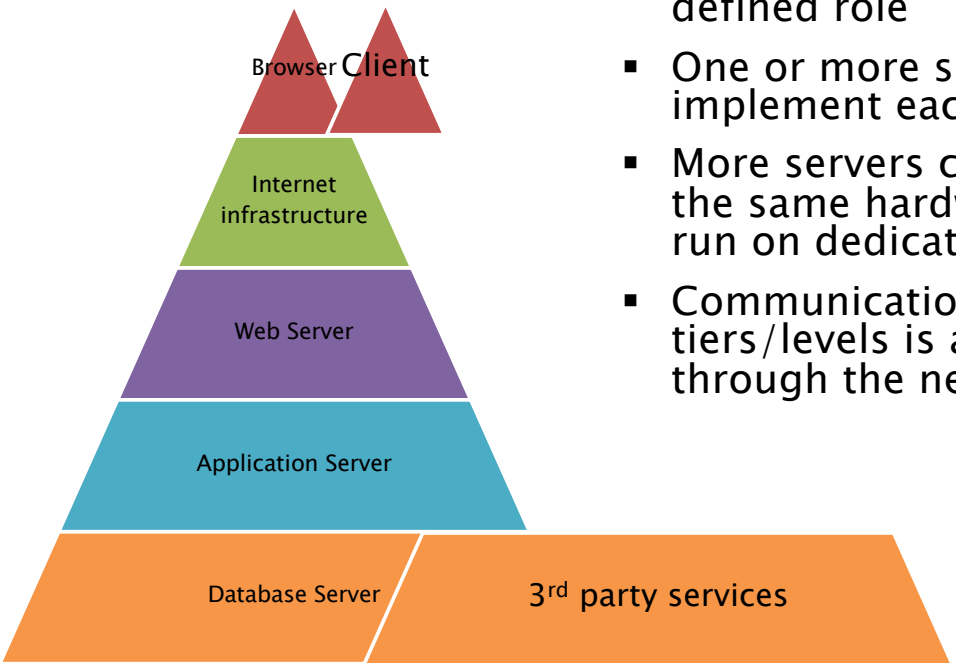
- Many thanks to Fulvio for kindly sharing his materials

Evolution of web architectures



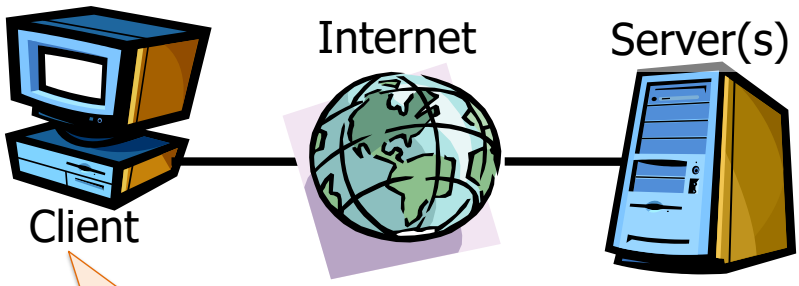
http://www.evolutionoftheweb.com

N-tier (N-level) architecture



- Each level/tier has a well defined role
- One or more servers implement each tier/layer
- More servers can share the same hardware or can run on dedicated devices
- Communication between tiers/levels is achieved through the network

General base architecture



Historically, a web browser.
Nowadays also:
- Mobile app
- Desktop app
- Other server application

Components

- One or more connections to the Internet by means of an Internet Service Provider (ISP).
- One or more servers implementing each tier/level of the architecture.
- One or more physical networks for interconnecting the servers.
- One or more network devices (router, firewall, switch) which implement communication and security policies.

Communication Protocol

- Set of rules to transfer information between two (or +) parties
  - Syntax and format
  - Semantics
  - General procedure (steps)
  - Synchronization mechanisms
  - Error recovery methods

Network Protocols Stack

- HTTP, HTTPS
  - Transfer of content
- TCP
  - Reliable transfer of variable length data
- IP
  - Allow transfer of data though a network
- WiFi, Ethernet, Bluetooth, USB
  - Local networking (logical access, medium access, physical details)

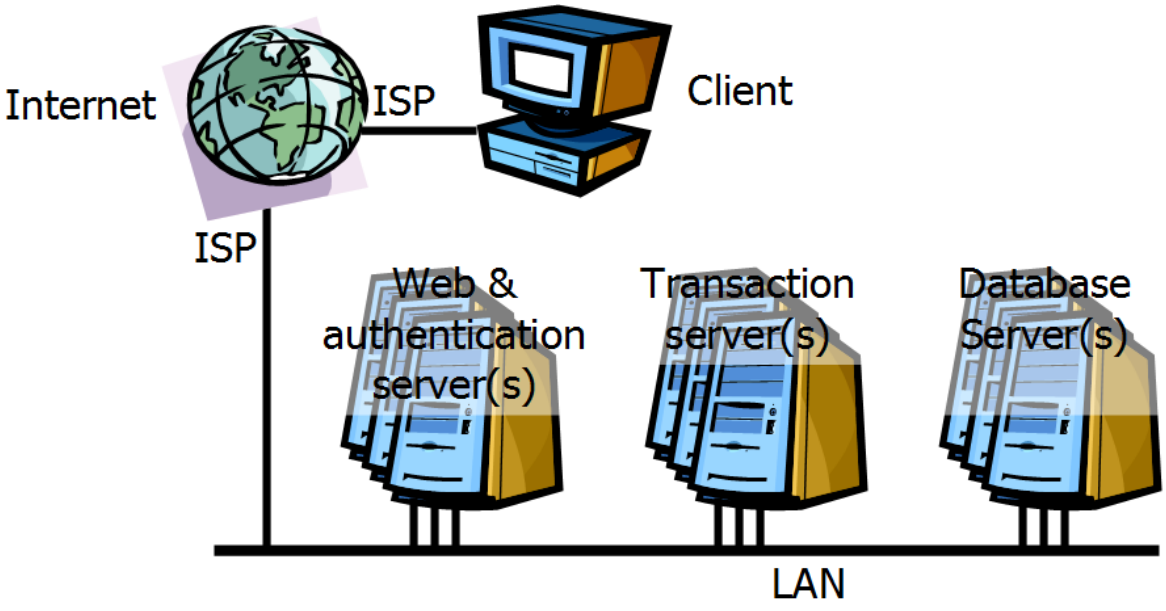
Definition

- “Server”may be defined as:
  - Logical definition:
    A process that runs on a host that relays information to a client upon the client sending it a request.
  - Physical definition:
    A host computer on a network that holds information (eg, Web sites) and responds to requests for information

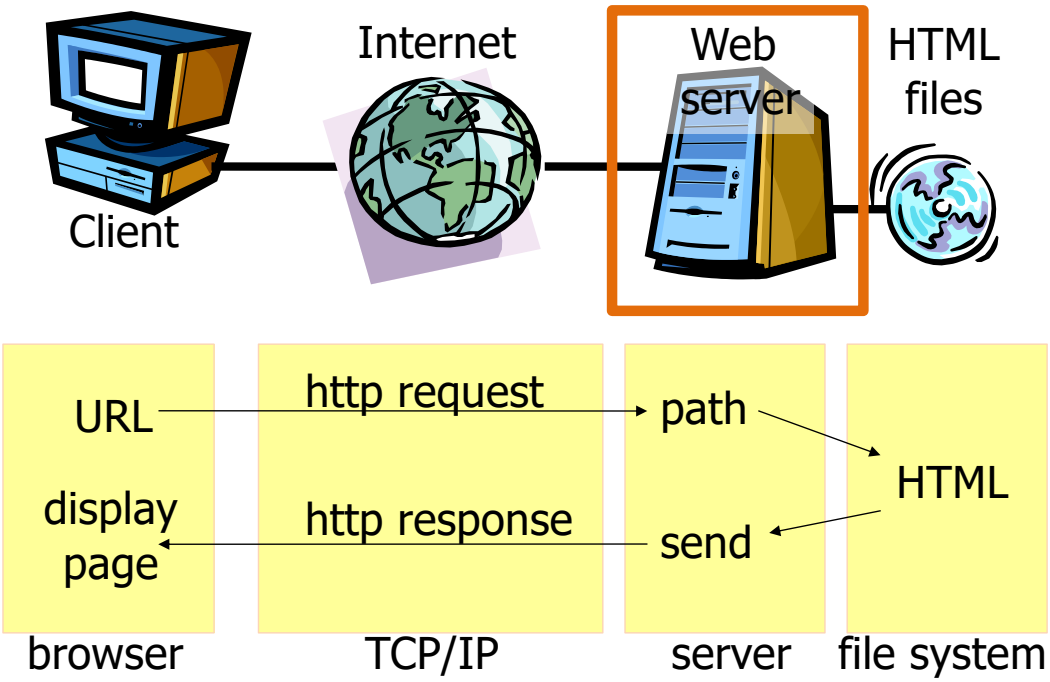
Web server

- Manages the HTTP protocol (handles requests and provides responses)
  - Receives client requests
  - Reads static pages from the file system
  - Activates the application server for dynamic pages (server-side)
  - Provides an HTML file back to the client
- One HTTP connection for each request
- Multi-process, Multi-threaded or Process pool

General Architecture



Example

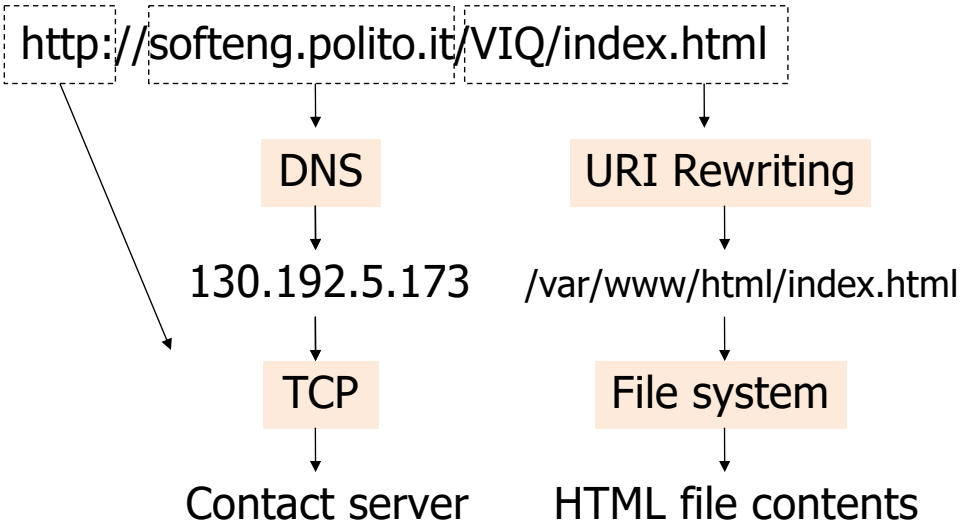


Adopted standards

- URL (uniform resource locator) for finding web pages
- HTTP (hyper text transfer protocol) for client-server interaction
- HTML (hyper text markup language) for writing web pages

URL

RFC 2396
http://www.w3.org/Addressing/



URI Basics

- http://www.sadev.co.za/users/1/contact
  (Scheme: http; Hostname: www.sadev.co.za; Query: /users/1/contact)
- http://www.sadev.co.za?user=1&action=contact
  (Scheme: http; Hostname: www.sadev.co.za; Query: ?user=1&action=contact)
- http://rob:pass@bbd.co.za:8044
  (Scheme: http; Userinfo: rob:pass; Hostname: bbd.co.za; Port: 8044)
- https://bbd.co.za/index.html#about
  (Scheme: https; Hostname: bbd.co.za; Query: /index.html; Fragment: about)

HTTP protocol

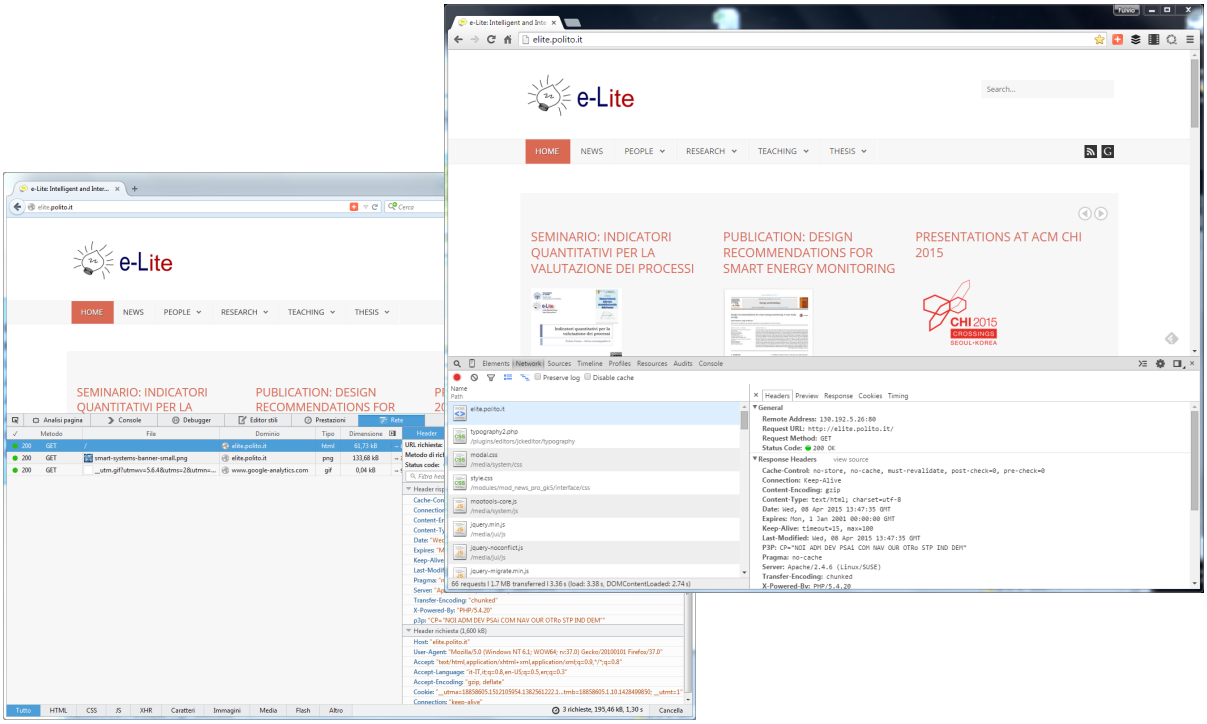
RFC 2616, RFC 2617
http://www.w3.org/Protocols

```
GET /VIQ/index.html HTTP/1.0
Accept: text/html
Accept: image/gif
User-Agent: FireChrome SuperBrowser 9.45
```

```
HTTP/1.0 200 OK
Date: Monday, 01-Jan-2001 00:00:00 GMT
Server: Apache 1.3.0
MIME-Version: 1.0
Last-Modified: 31-Dec-2000
Content-type: text/html
Content-length: 3021

<HTML> . . .
```


Browser developer tools



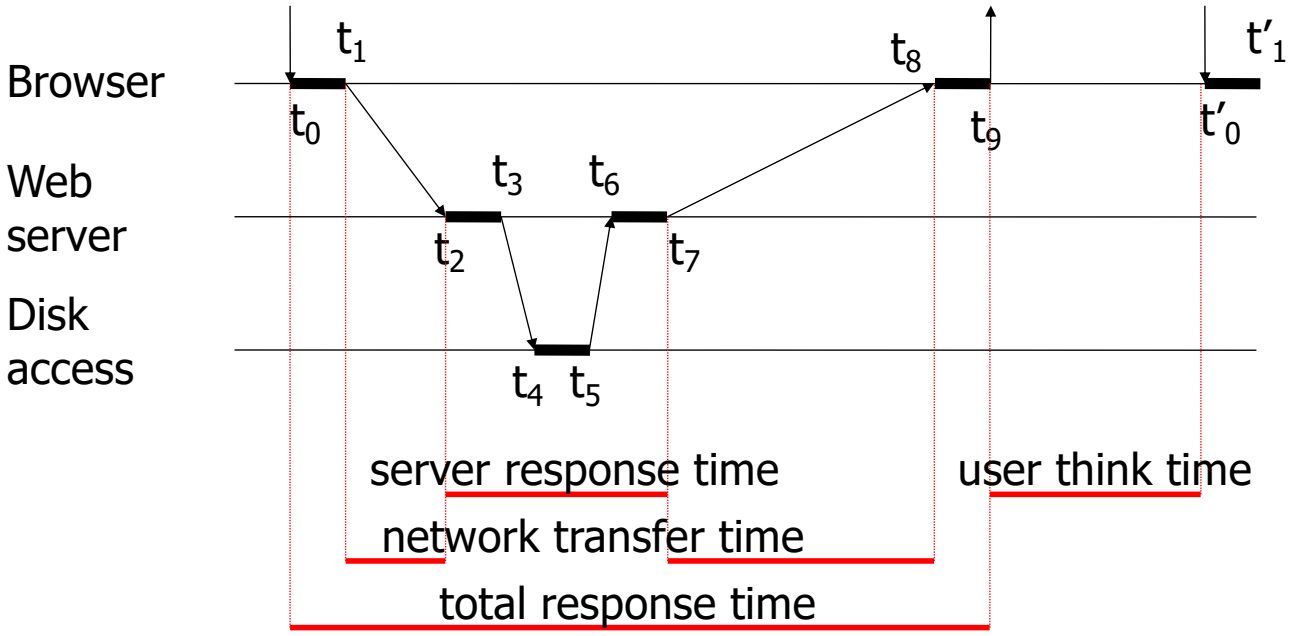
Performance measures

- Latency: time required for providing a 0 byte http page. Includes the server activation time, the request decoding time, the file access time, the transmission time and the time for closing the connection.
  - Unit of measure: http/s or s/http
- Throughput: maximum speed at which infinite-sized pages can be sent.
  - Unit of measure: Bytes (Mbytes)/s
- #Requests / s

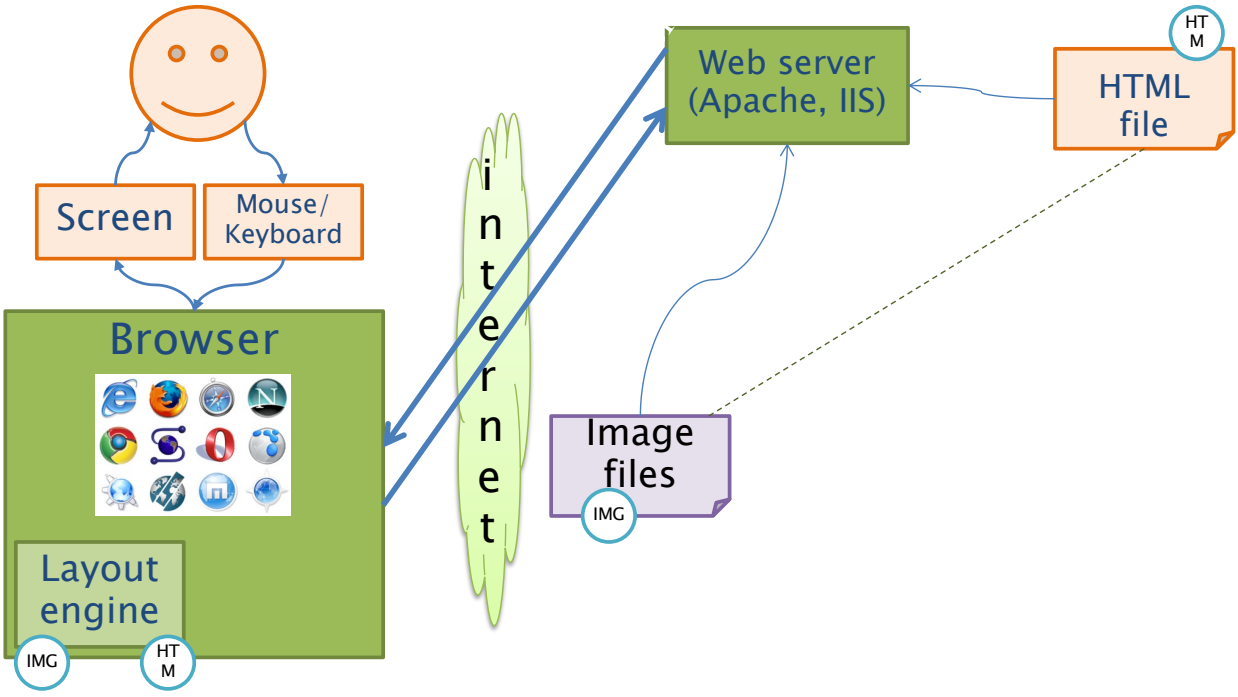
Delay time

- T = Latency + $Size_{HTML}$ / Throughput
- This equation is valid if:
  - The other architecture elements (I/O subsystem, network, ...) are not overloaded
  - The web server has not yet reached its maximum workload
- Example:
  - Latency: 0,1s
  - $Size_{HTML}$: 100kBytes
  - Throughput: 800kBytes/s
  - T= 0,1s+ 100KBytes / 800KBytes/s = 0,225s

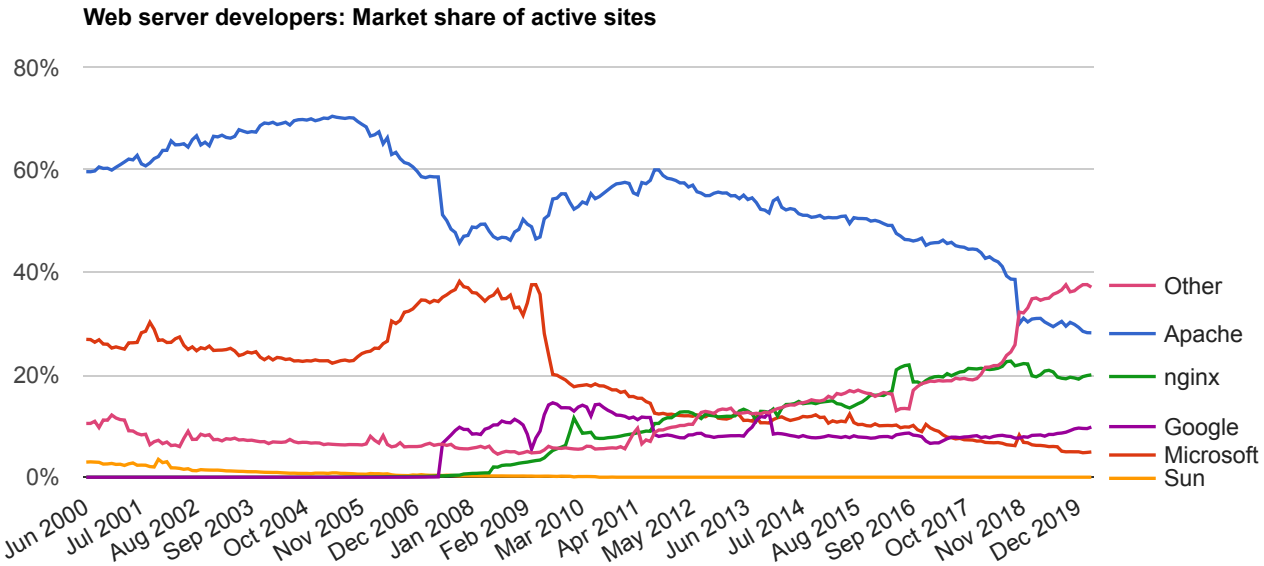
Static web transaction



General web architecture



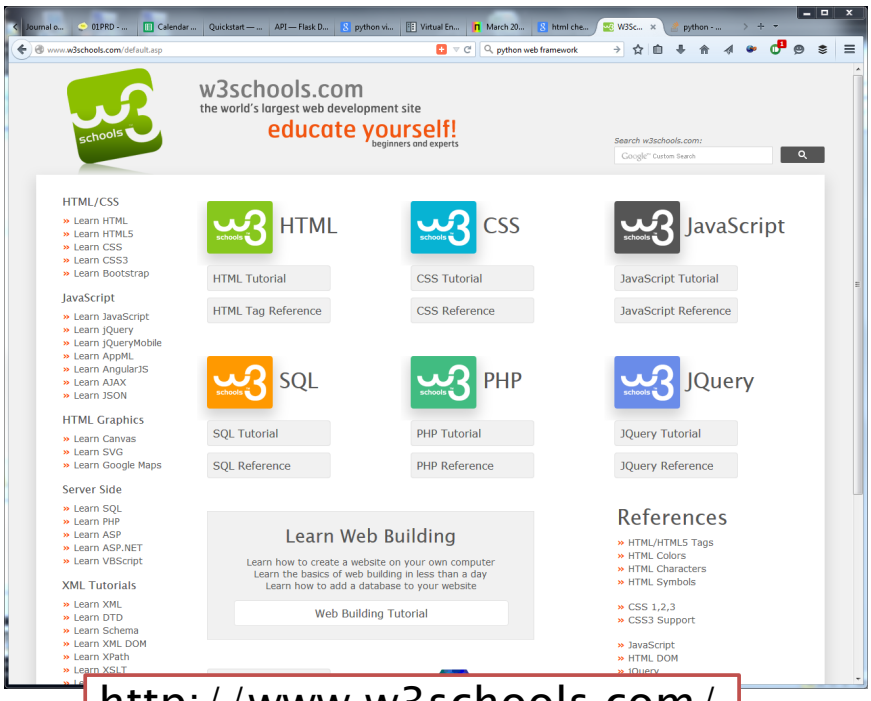
Market share of active sites



Adapted from: http://news.netcraft.com/

https://news.netcraft.com/archives/2020/03/20/march-2020-web-server-survey.html

HTML in 5 minutes

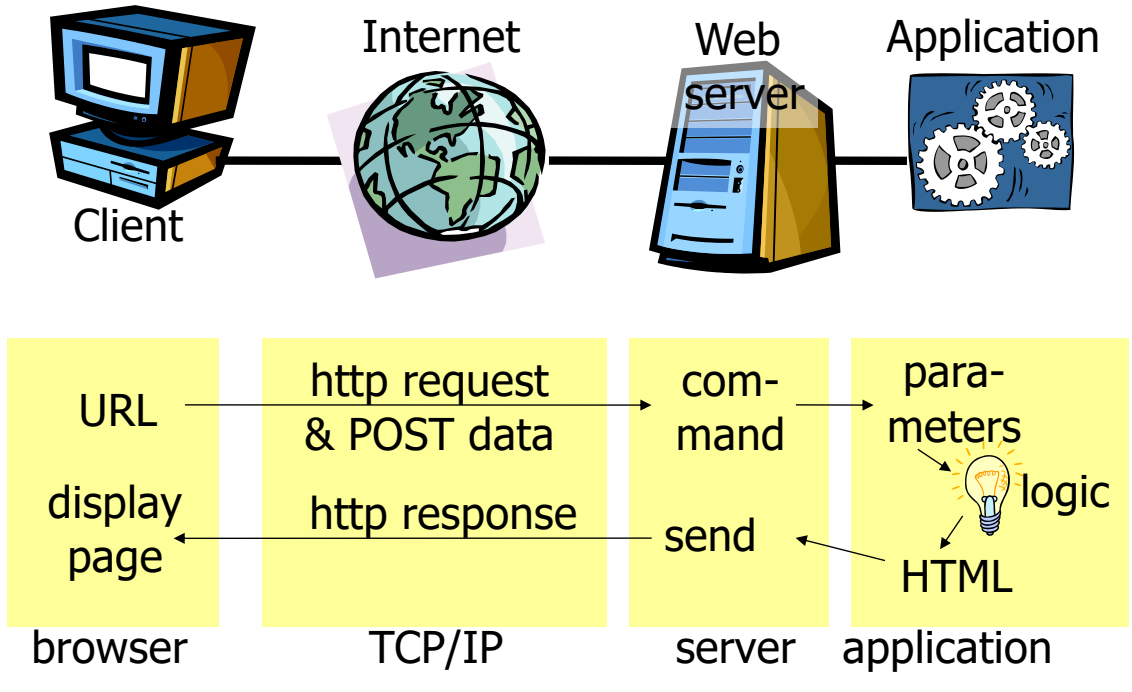


http://www.w3schools.com/

Application server

- Dynamic page generation
- Manages the site business logic
- It's the middle tier between the client browser and the data residing on a database
- Implements the session mechanisms
- Different technologies and architectures are available

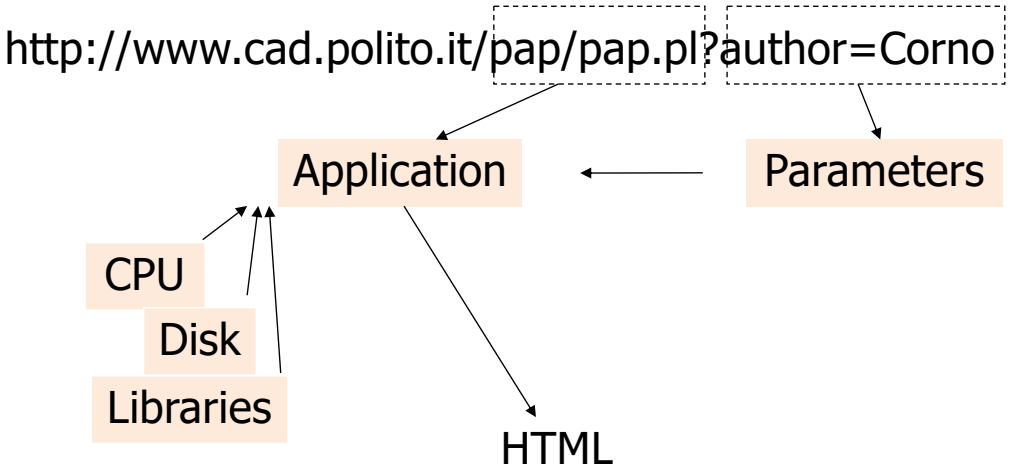
Dynamic web transaction



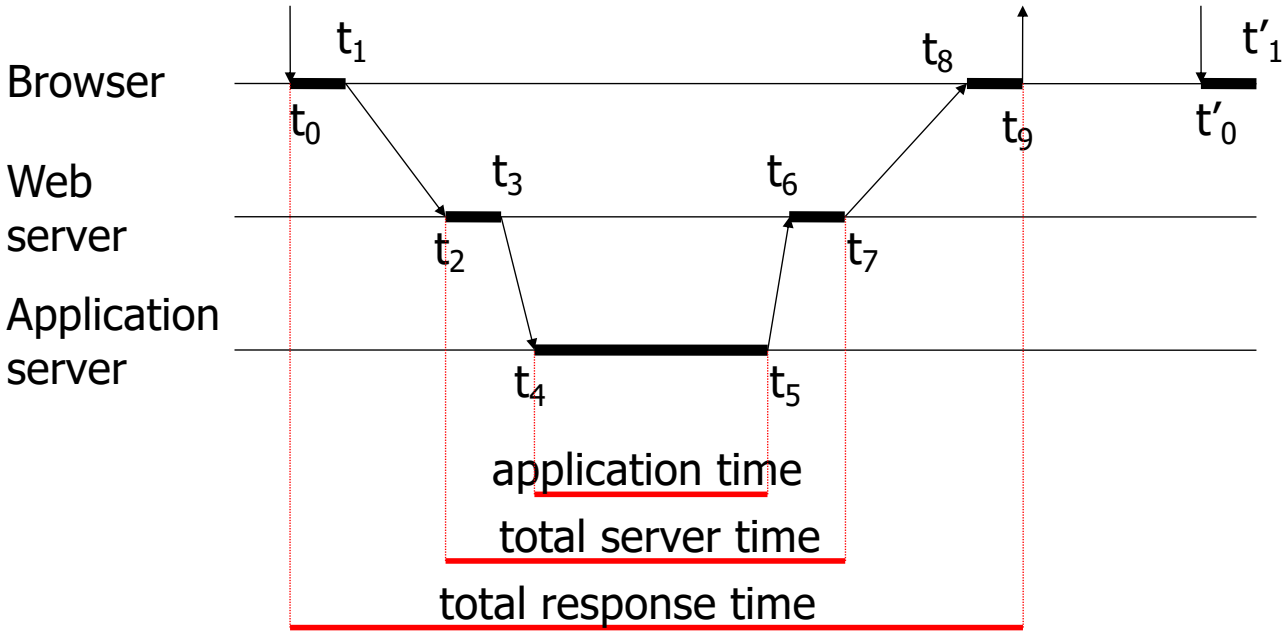
Adopted standards

- HTTP-POST for sending user-specified data
- CGI (common gateway interface), ISAPI (internet information server application programming interface), server-side script, java servlet for integrating application logic into web servers
- ASP (active server pages), PHP, PERL as new languages for application development

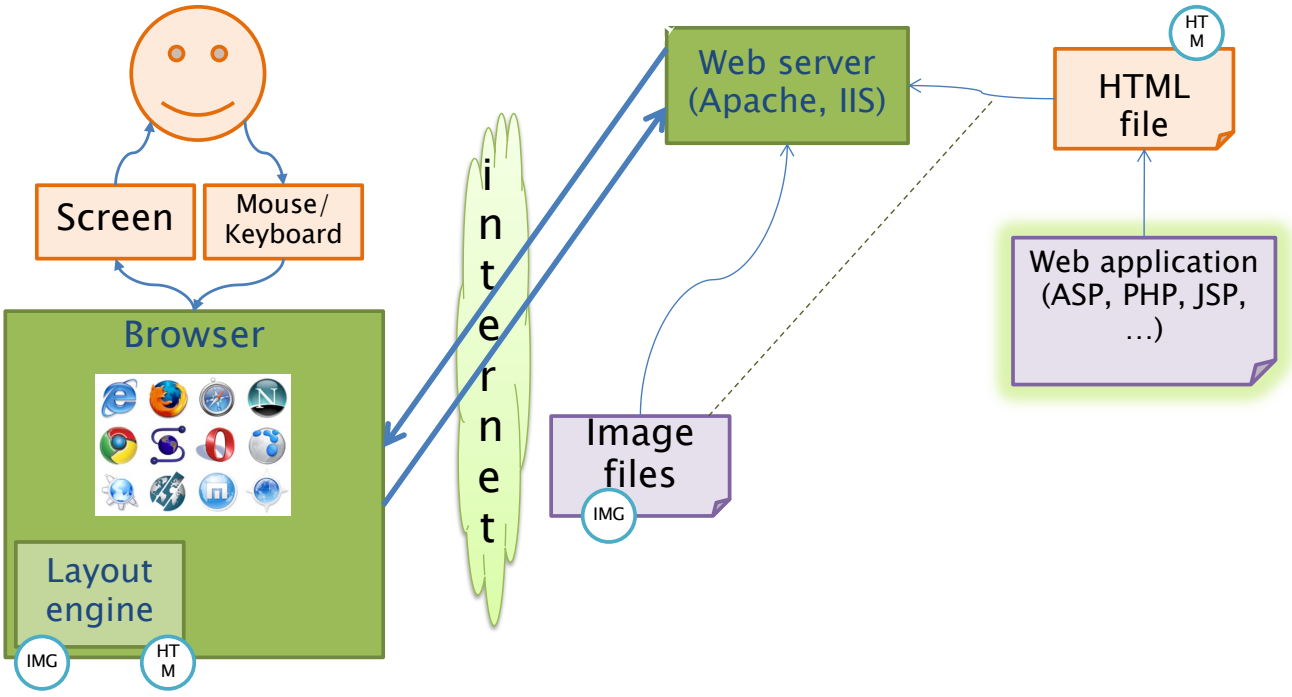
URL (HTTP GET)



Dynamic web transaction

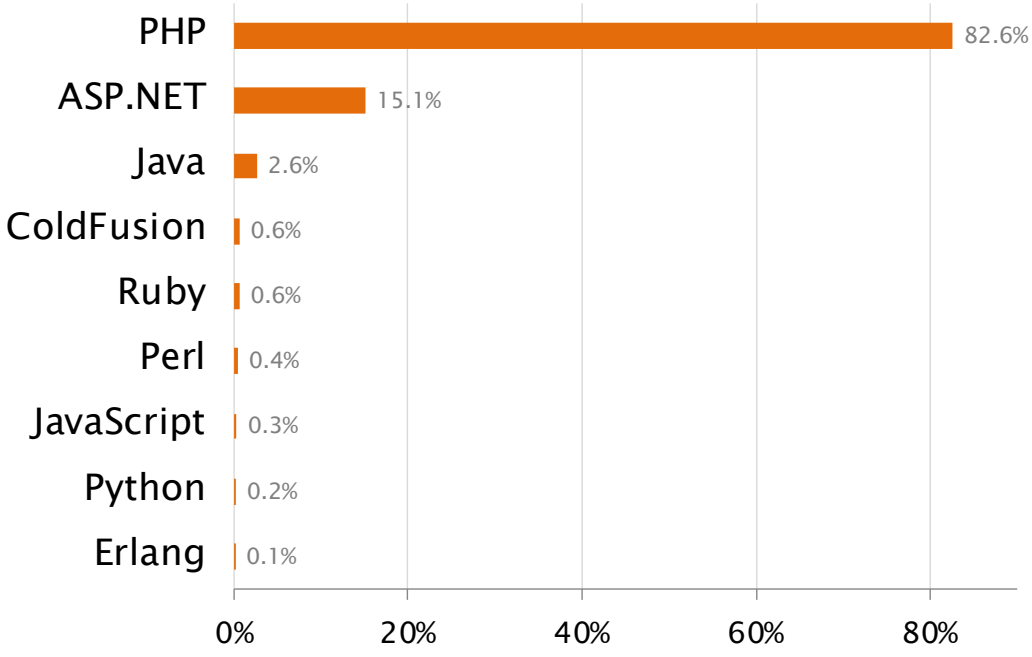


General web architecture



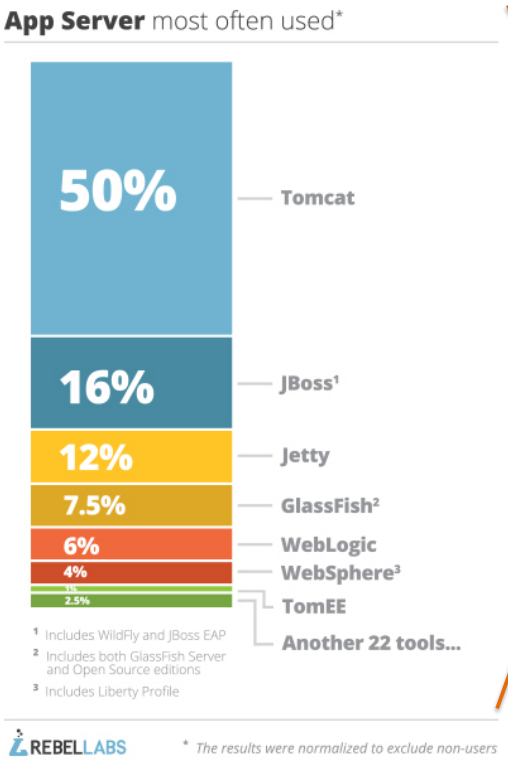
Application Servers

Percentages of websites using various server-side programming languages



https://w3techs.com/technologies/overview/programming_language/all

Application Servers

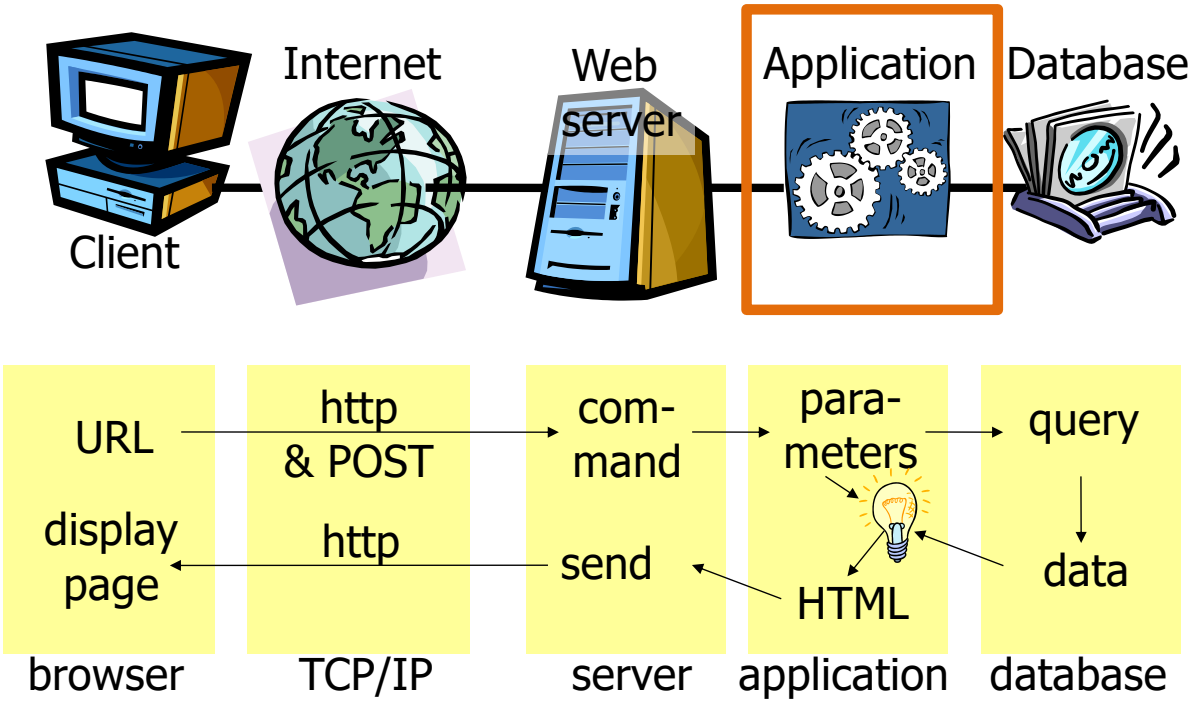


- Several different technologies
  - PHP
  - .Net
  - Java EE
  - Python
  - Ruby
  - Node.js

Database server

- Stores the data on which the application server works.
- Executes the queries issued by the application server:
  - Updates stored data
  - Inserts new data
  - Provides back query results
- The most frequent/complex queries can be implemented internally as stored procedures

Example



Adopted standards

- Cookies for storing the state of a session
- Java, JavaScript, ActiveX, Flash to program the user interface on the browser
- SQL (structured query language), ODBC (open database connectivity) to access data bases

Sessions

- A session is a set of related HTTP transactions performed by the same user
- They allow a continuous (state-full) interaction with the web application upon a state-less protocol such as HTTP
- They are usually based on cookies

Cookies

- A cookie is a pair name and value
- Cookies are sent by the web server
  - Usually upon the first interaction
- The browser keep a list of
  - Hostname – Cookie (name + value)
- Every time the browser makes an HTTP request to a host is sends along all the cookies previously sent by that host

Session cookies

- When the web server receives a request looks for a session cookie
- If none is received, then a new session must be started
  - A new unique session cookie is generated to identify the session
  - The cookie is sent back to the browser with the response
- If one is present, it means a session is already in progress
  - All the operations are linked to the current session

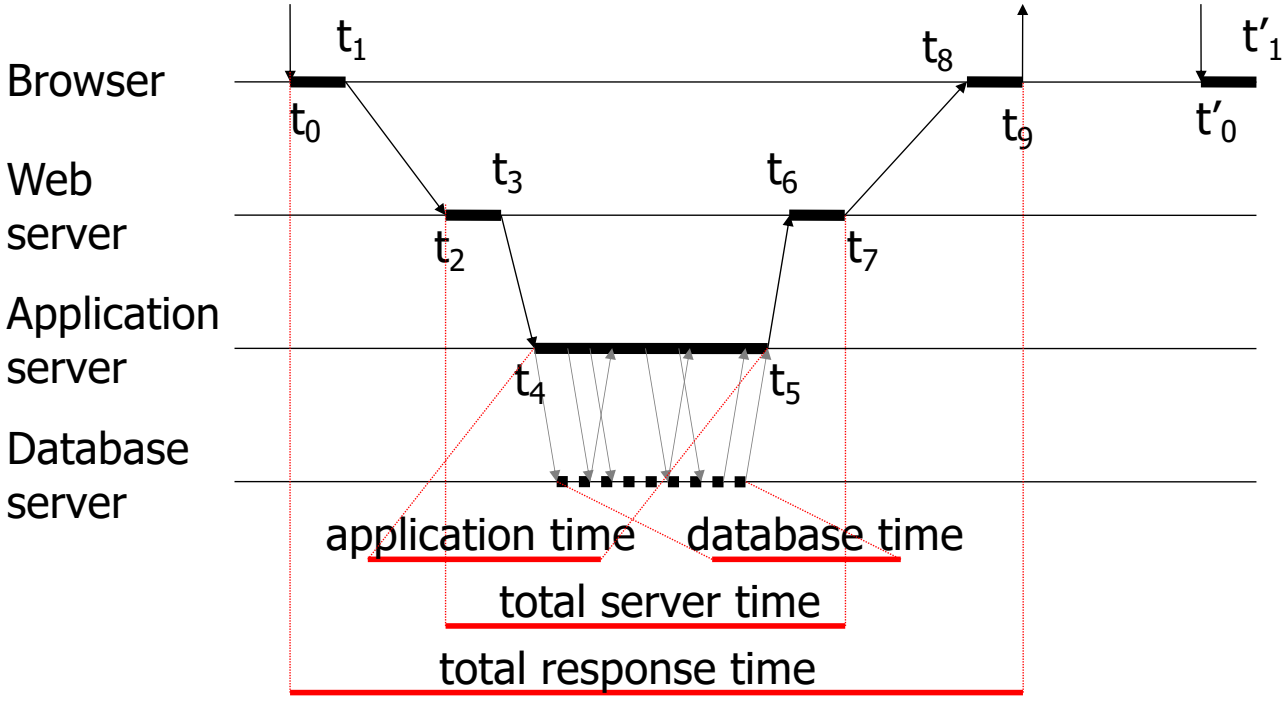
Session cookies

- When the user is identified (e.g. through a login) then the session is linked to the user
  - All following operations will be relative to the user linked to the session
- Cookie have an expiration time
  - After expiration they are not sent back to the server anymore
  - Thus sessions have a time limit

Database server

- Queries are almost always in SQL
  - `SELECT * FROM table;`
  - ....
- Often adopts the relational database model
  - Other models can be used
    - Object model
    - Triple model
- The most advanced/complete solutions are called Transaction servers

Database-driven transaction



Example (PHP)

The application composes the query

```
<?php
$query = "SELECT doc_id FROM key_doc_index, keywords WHERE
key_doc_index.key_id = keywords.id AND keywords.key =
$_REQUEST["query"];";
```

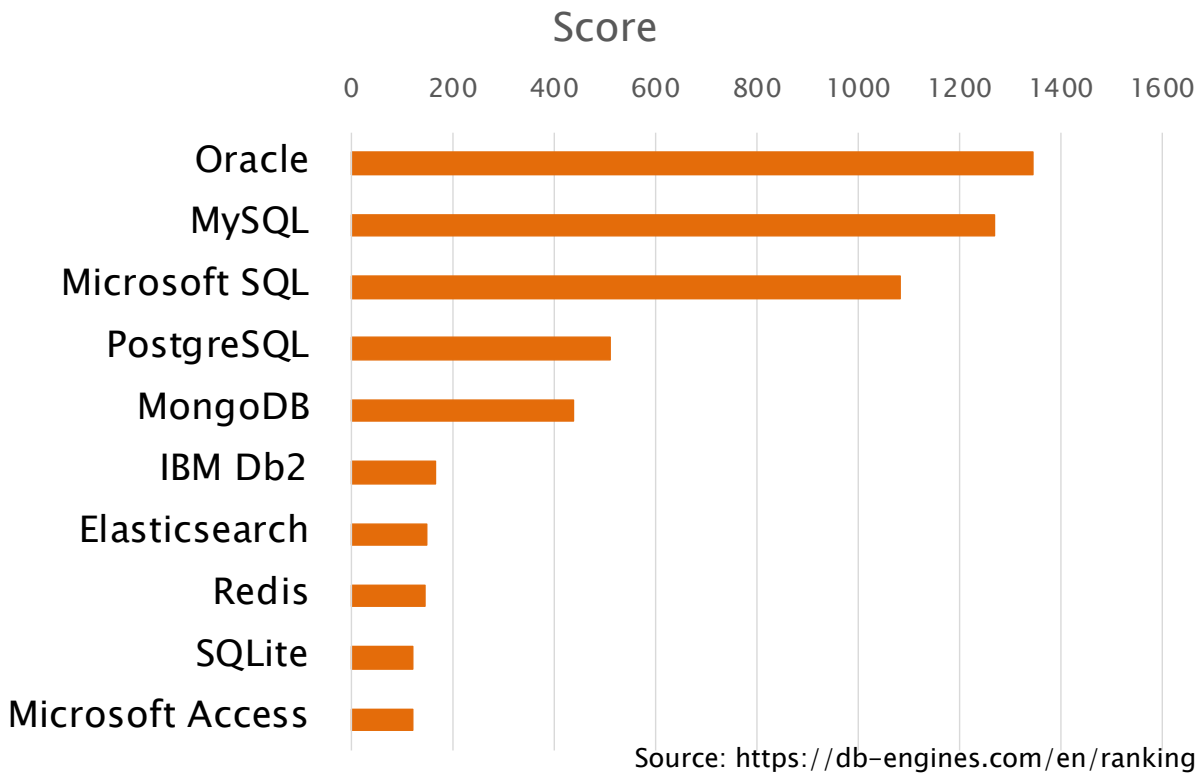
The query is sent to the db-server and a rowset containing the results is returned

```
$rowset = mysql_query($query);
```

```
while($row = mysql_fetch_row($rowset))
{
//elaborate data
}
?>
```

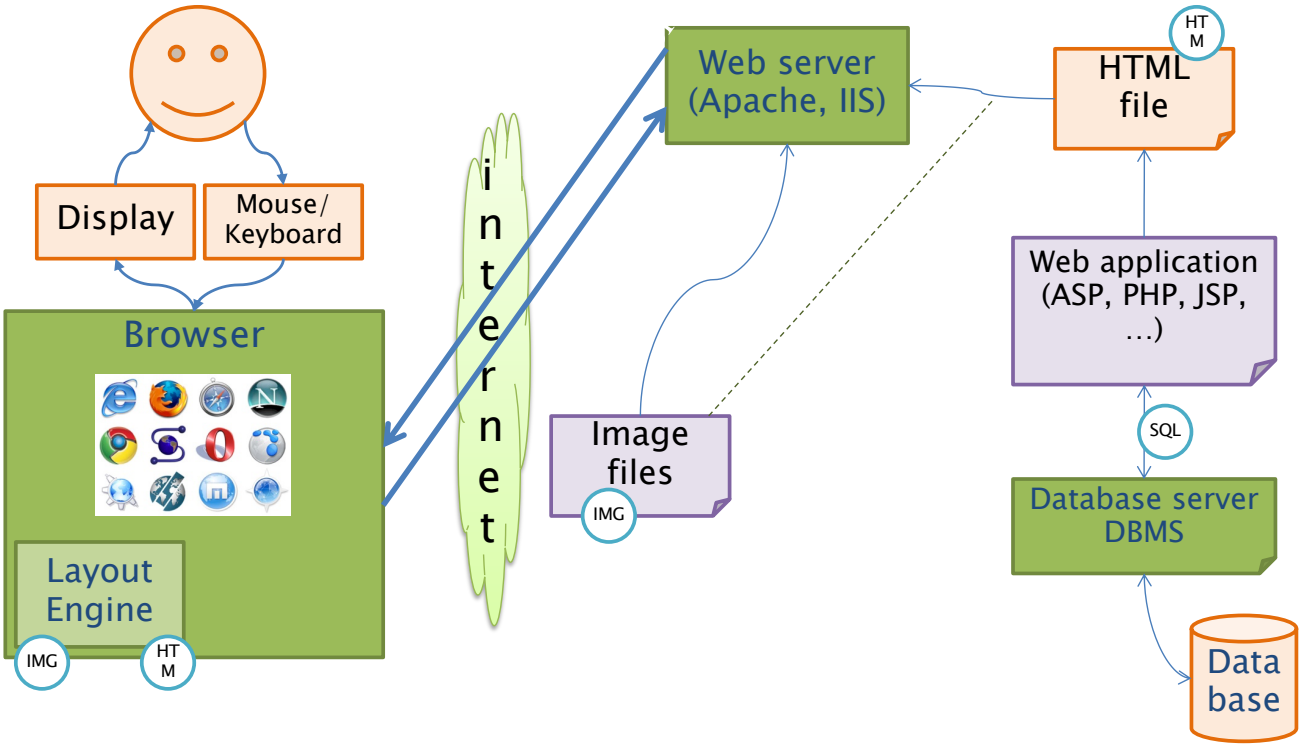
The application processes the data

DB Server diffusion



Source: https://db-engines.com/en/ranking

General web architecture



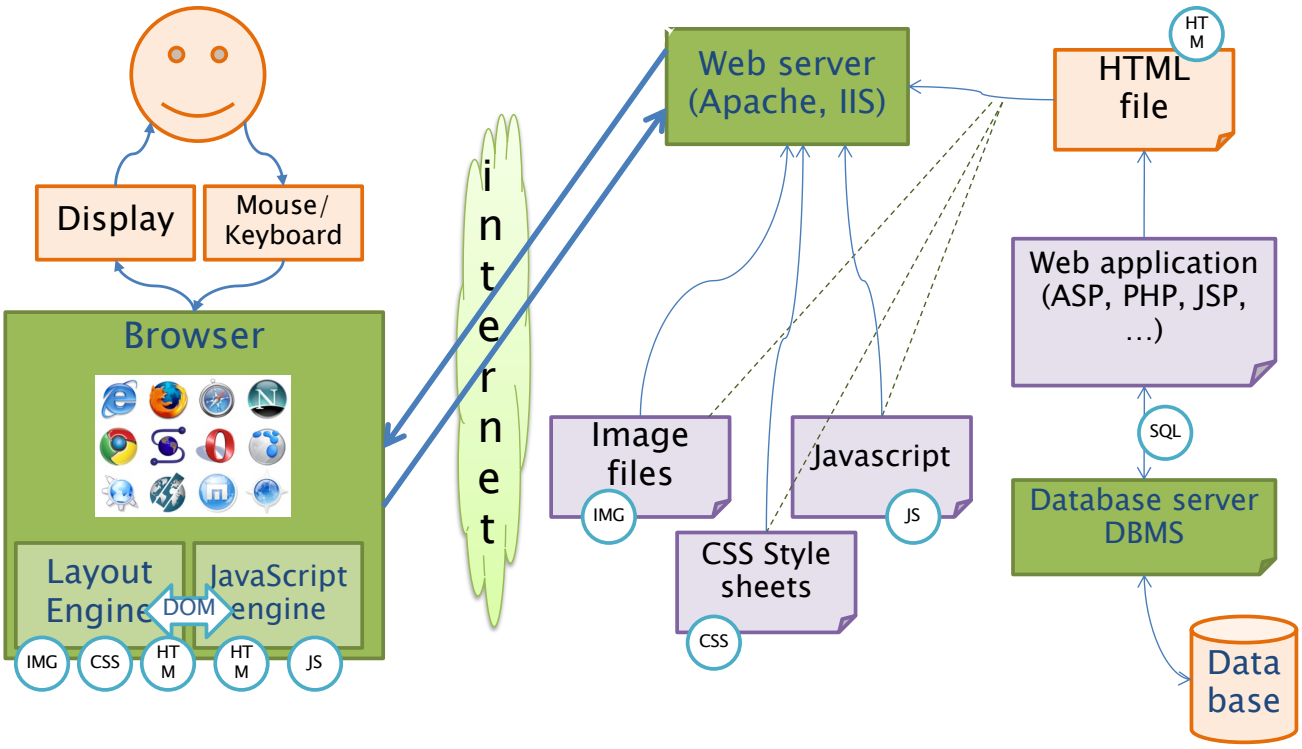
Client-side programming

- Making a web page dynamic
  - Able to change the page content **after** is was loaded by the server
  - Able to interact with the user, on the browser
  - Able to "augment" the default interactions offered by the browser
- Examples:
  - Animations on the page
    - e.g. menus, accordions, slideshows, hide/show, …
  - Form validation

Client-side programming

- Requires:
  - A programming language accepted by all browsers
  - A program embedded in the web page
  - An execution engine in the browser
- Limitations:
  - All data needed by the program must be known beforehand (when the page is loaded)
  - The program must have a restricted access to the execution environment

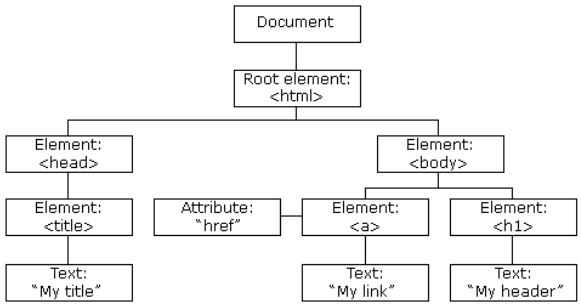
General web architecture



Document Object Model (DOM)

- Standard data structure for representing the web page content
- Supported by all browsers
- Javascript programs can read & modify the DOM
- Abstracts
  - Browser
  - HTML
- The HTML DOM is a standard for how to get, change, add, or delete HTML elements

"The W3C Document Object Model (DOM) is a platform and language-neutral interface that allows programs and scripts to dynamically access and update the content, structure, and style of a document."

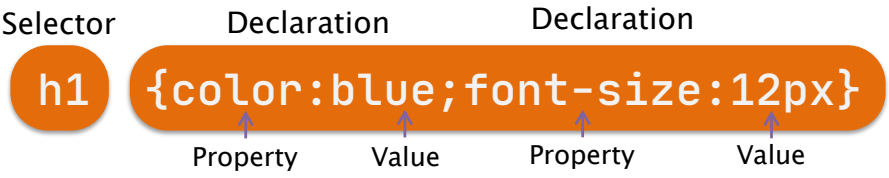


Separating layout from content

- Goals:
  - Allow the definition of complex layouts
  - Adapt web pages to different resolutions
  - Adapt web pages to different devices (e.g., mobile)
  - Adapt web pages to different preferences (e.g., color schemes)
  - Adapt web pages to different media (e.g., text vs video)
  - In a standard way
- 'Adapt' means:
  - Resize, Reflow, Show/Hide, Substitute, Animate, Highlight, Move, …
- Solution: Cascading Style Sheets (CSS)

CSS

- "Declarations" applied to some "Selector"
  - **Selectors** identify portions of the ~~web page~~ DOM
  - **Declarations** set the value of some "properties"
  - **Properties** control aspect, position, layout, behavior



Client-side, server-side, databases

Programming languages used in most popular websites*

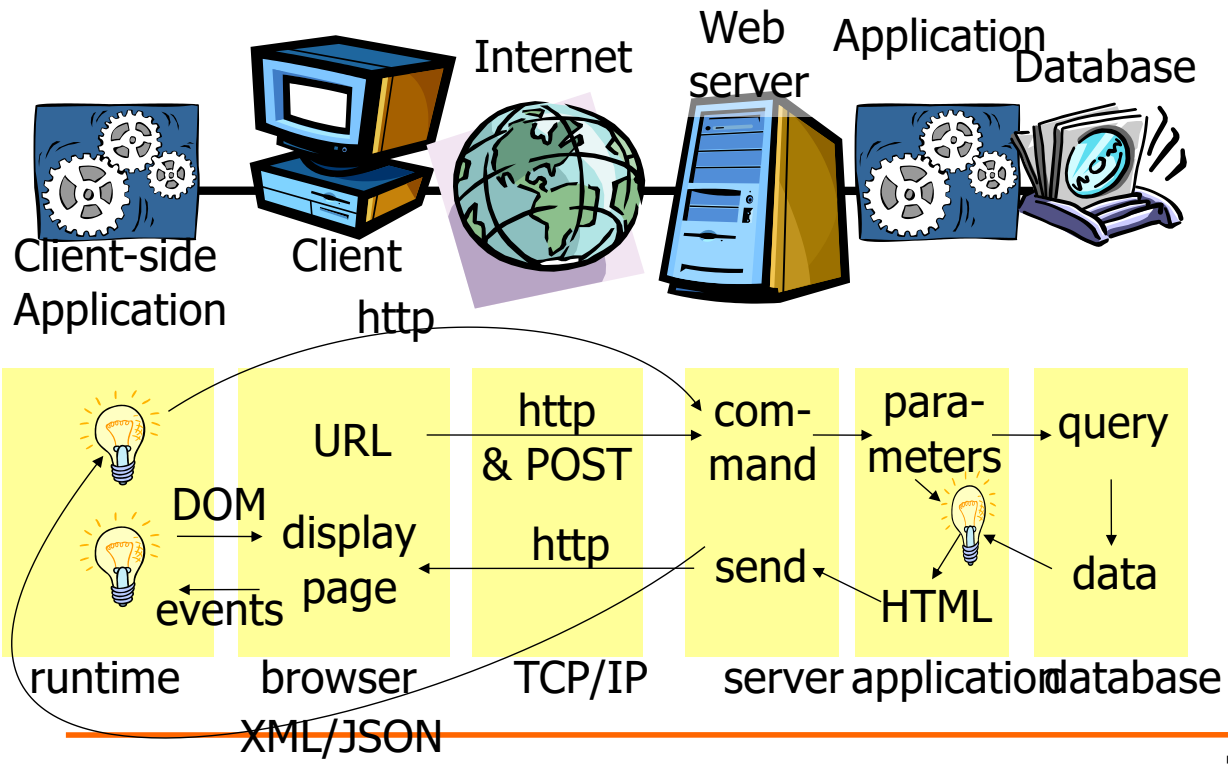
Websites	Popularity (unique visitors per month)[1]	Front-end (Client-side)	Back-end (Server-side)	Database
Google.com[2]	1,600,000,000	JavaScript	C, C++, Go,[3] Java, Python	BigTable,[4] MariaDB[5]
Facebook.com	1,100,000,000	JavaScript	Hack, PHP (HHVM), Python, C++, Java, Erlang, D,[6] Xhp,[7] Haskell[8]	MariaDB, MySQL,[9] HBase Cassandra[10]
YouTube.com	1,100,000,000	JavaScript	C, C++, Python, Java,[11] Go[12]	BigTable, MariaDB[5][13]
Yahoo	750,000,000	JavaScript	PHP	MySQL, PostgreSQL[14]
Amazon.com	500,000,000	JavaScript	Java, C++, Perl[16]	Oracle Database[17]
Wikipedia.org	475,000,000	JavaScript	PHP, Hack	MySQL[citation needed], MariaDB[18]
Twitter.com	290,000,000	JavaScript	C++, Java, Scala, Ruby on Rails[19]	MySQL[20]
Bing	285,000,000	JavaScript	ASP.NET	Microsoft SQL Server
eBay.com	285,000,000	JavaScript	Java,[21] JavaScript[22]	Oracle Database
MSN.com	280,000,000	JavaScript	ASP.NET	Microsoft SQL Server
Microsoft	270,000,000	JavaScript	ASP.NET	Microsoft SQL Server
Linkedin.com	260,000,000	JavaScript	Java, JavaScript,[23] Scala	Voldemort[24]
Pinterest	250,000,000	JavaScript	Django (a Python framework),[25] Erlang	MySQL, Redis [26]
WordPress.com	240,000,000	JavaScript	PHP, JavaScript [27] (Node.js)	MariaDB, MySql

https://en.wikipedia.org/wiki/Programming_languages_used_in_most_popular_websites

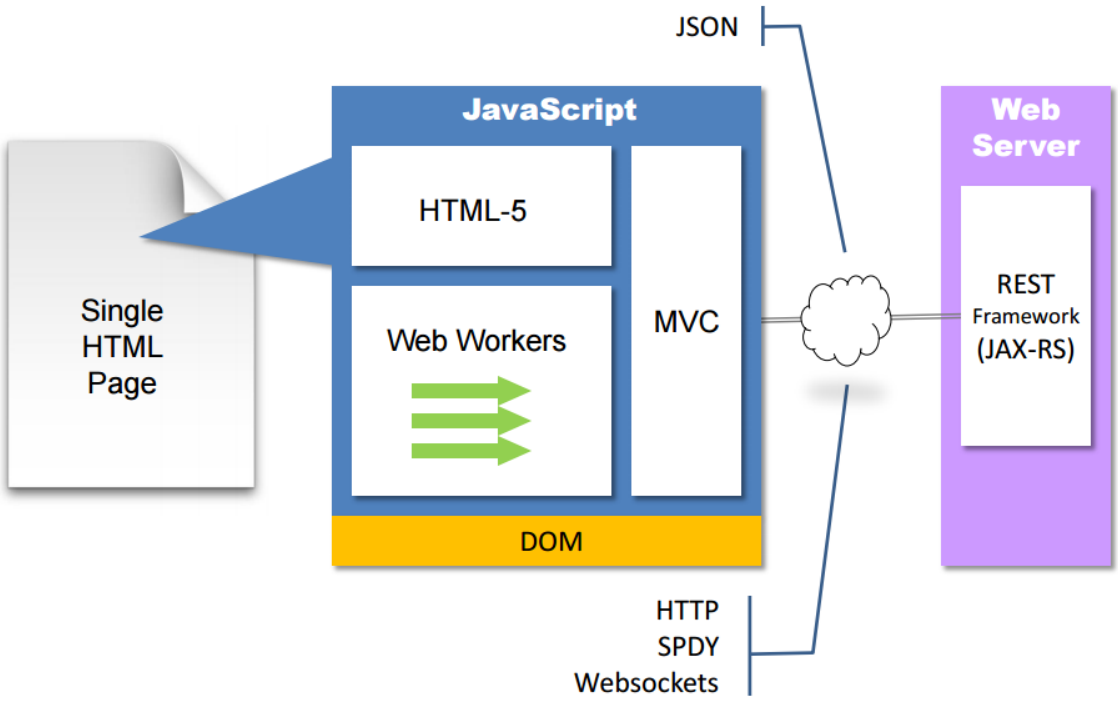
Web 2.0

- Web applications support social interaction models
- Peer exchange and user-contributed content instead of rigid publisher/reader pattern
  - Online communities
- Rich, dynamic, interactive user interfaces
- Integration of contents across web sites (mashups)

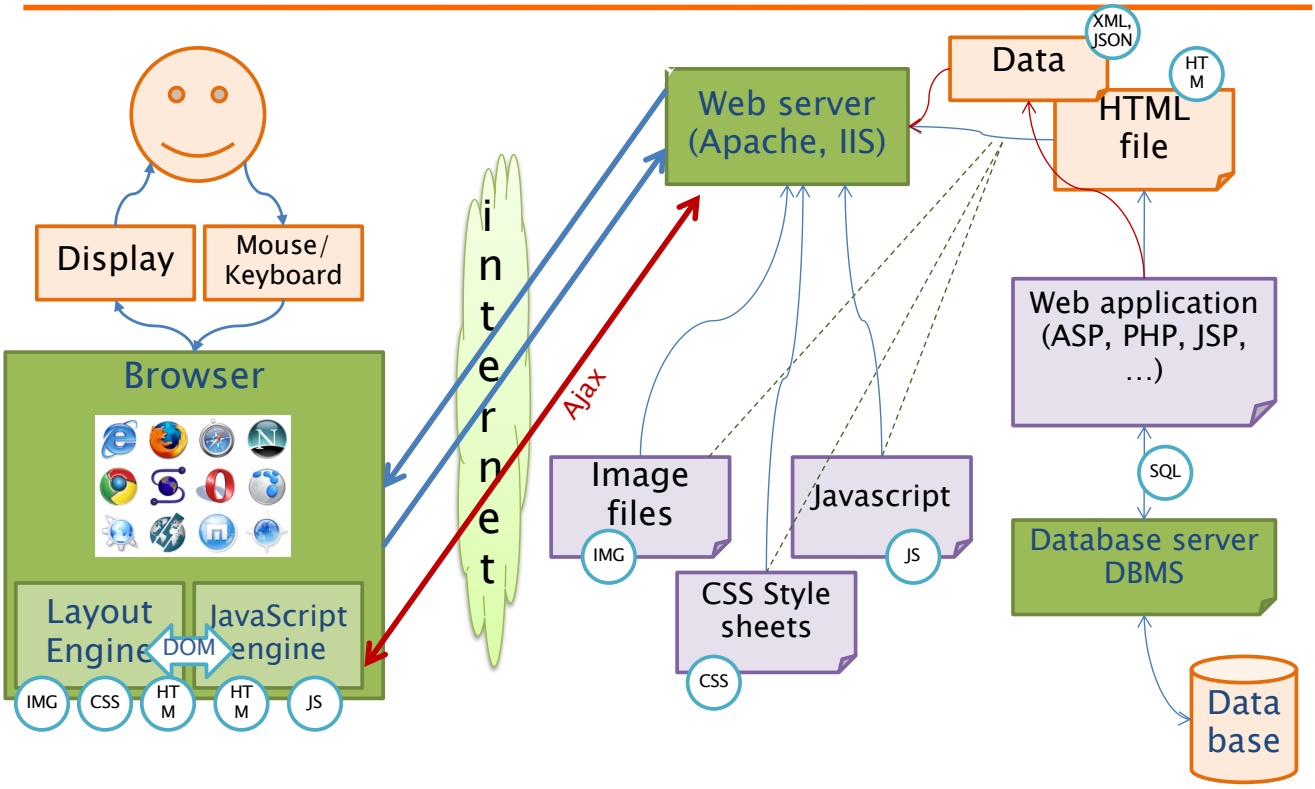
Rich-Client Asynchronous Transactions



Single Page Applications (SPA)



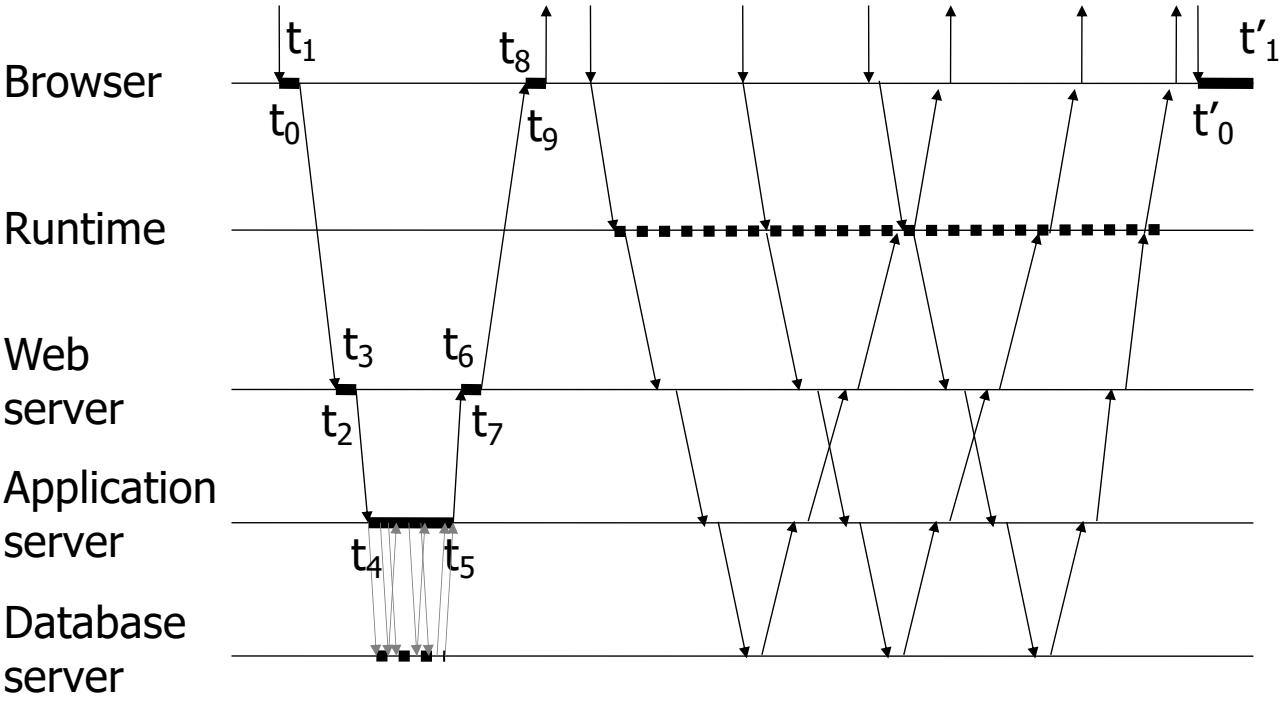
General web architecture



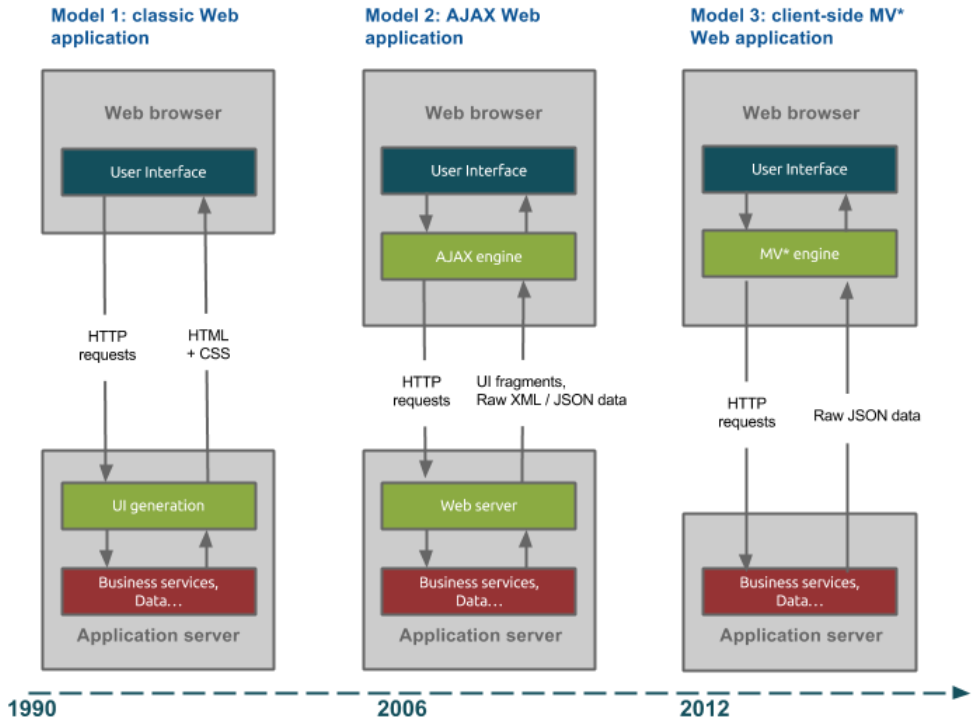
Adopted standards

- Dynamic HTML: DOM, Javascript, CSS
  - JavaScript, Flash to handle a runtime environment on the browser
  - DOM (XHTML Document Object Model) to allow on-the fly modification of the web page
  - CSS 2.1 to modify attribute and handle objects
- AJAX: Asynchronous Javascript and XML
  - XMLHttpRequest for asynchronous communication to the server
  - Data transfer formats: JSON, XML, RDF, RSS, Atom, FOAF, ...
- Mash-up technology

Rich-client transaction



Web application architectures



http://blog.octo.com/en/new-web-application-architectures-and-impacts-for-enterprises-1/

The real word is different...

- The users
- Functionality
- Flexibility
- Portability
- Reliability
- Security
- Integrity
- Maintenance
- Performance
- Scalability

- Costs
- Maintainance
- Development times
- Interactions with existing systems
- Interactions with the “physical” world

References

- Aa.Vv. "Come Funzione Internet" EDRi Papers, Centro Nexa
  - http://nexa.polito.it/nexafiles/ComeFunzionaInternet.pdf
- RFC 2396 - Uniform Resource Identifiers (URI): Generic Syntax
  - https://www.ietf.org/rfc/rfc2396.txt
- RFC 2616 - Hypertext Transfer Protocol – HTTP/1.1
  - https://www.w3.org/Protocols/rfc2616/rfc2616.html