Web Applications

LBAW . Databases and Web Applications
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Sérgio Nunes
DEI, FEUP, U.Porto

Outline

- **The Internet**
  Overview, main concepts and technologies

- **The World Wide Web**
  History, core technologies and evolution

- **Web Applications**
  History, concepts, architectures and technologies

- **Next Artefacts**

Introduction

Web and Internet

- What is the Internet?

- What is the Web?

- The **Internet** is the worldwide communication network made of interconnected physical networks — a network of networks.

- The **World Wide Web** is a distributed information system that runs over the Internet.

Who is who?

Web Applications

- What are Web Applications?

- A **Web Application**, or web app, is a software system, based on web standards and technologies, that is accessible through a web browser.

- Web applications changed significantly over time due to technological advancements, namely asynchronous interactions (AJAX), JavaScript developments, the new HTML5 standards, and the broad adoption of mobile devices.

- Examples: GMail, Google Search, Facebook, SIGARRA.

- Why web applications? Advantages and disadvantages?

Pros of Web Apps

- Platform independence.
- Easier updates & bug fixes.
- Only one version of the application.
- Access from anywhere.
- No piracy.
- No installation hurdles.
- Developers can measure user interaction in real-time.

Cons of Web Apps

- Depends on network connectivity.
- Less sophisticated UIs.
- Limited hardware access.
- Reduced OS integration (e.g. drag&drop).
- Need to address browser versions.
- Harder to debug.
- Higher security risks.
- Infrastructure costs.

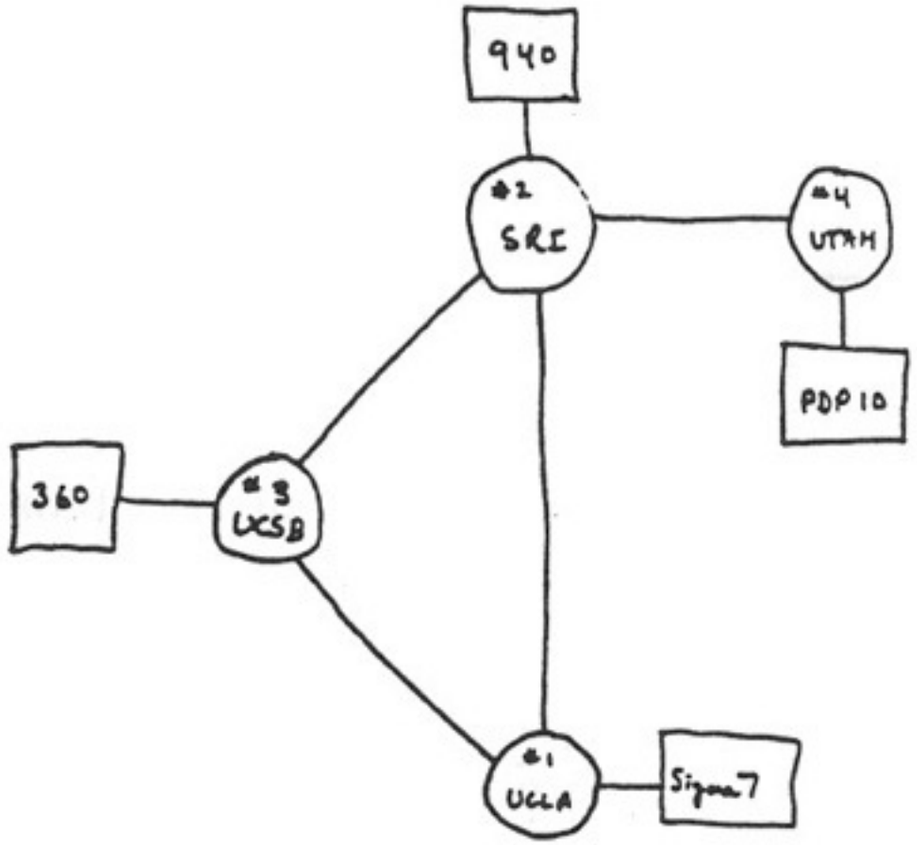
The Internet

Internet Origins

- Started as a project of the USA Department of Defense (DoD) Advanced Research Projects Agency (ARPA) in 1958.

- Developed the idea of “networked computers” which led to the creation of the ARPANET in 1967. The core challenge was how to connect separate physical networks without requiring permanent links between them.

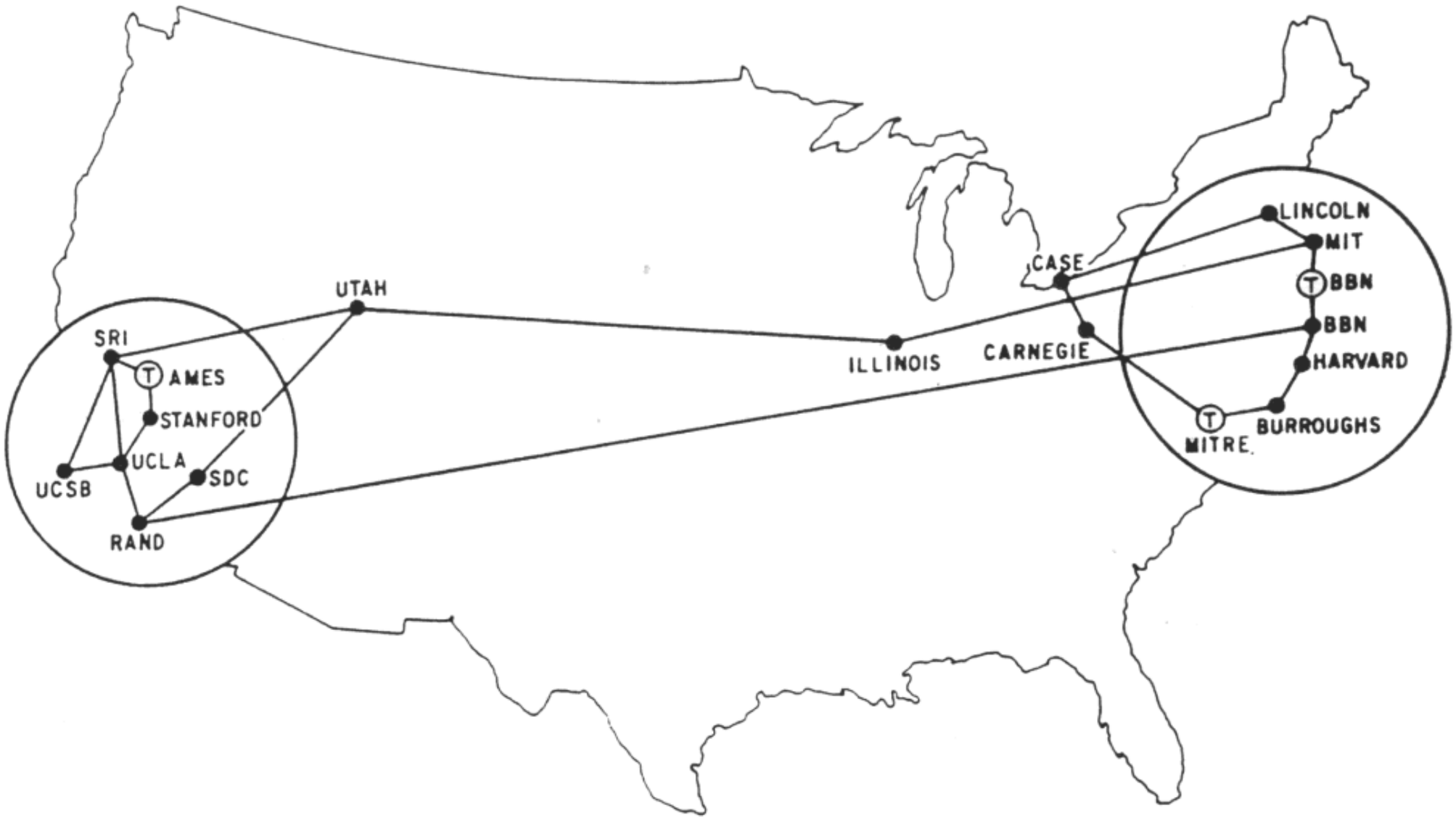
- Other networks appeared worldwide during the same period.
  E.g. JANET, X.25, USENET, CompuServe.



THE ARPA NETWORK

DEC 1969

4 NODES



MAP 4 September 1971

Packet-Switching

- In the late 1960s, computers were expensive and rare. Communication networks were used to make these resources available to wider audiences.

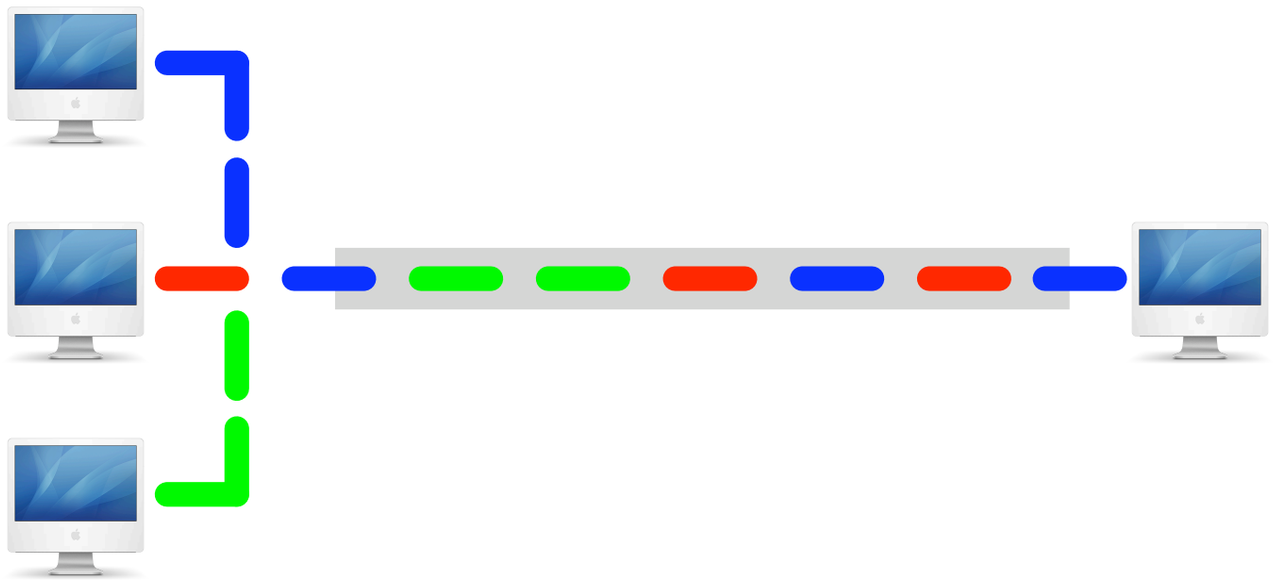
- One of the first challenges faced was how to connect separate physical networks without dedicated links.

- Implementing point-to-point connections does not scale. The only option was to share the available links to optimize resource usage.

- **Packet switching** is a method where data is divided in small chunks and sent out separately.

- With packet switching it is possible to have multiple connections over the same link, i.e. share the communication medium.

Continuous transmission



Packet-based transmission

Internetworking

- The proliferation of different networking technologies and protocols became a problem when trying to connect different networks.

- No network technology is ideal for all scenarios (e.g. Ethernet, Wireless, DSL), thus different technologies will always co-exist. Each network technology was becoming an island, isolated from all others.

- To overcome this problem, and achieve a homogeneous service across heterogeneous networks, both **hardware** and **software** were combined.

- Hardware: routers.

- Software: protocols, specifically TCP/IP.

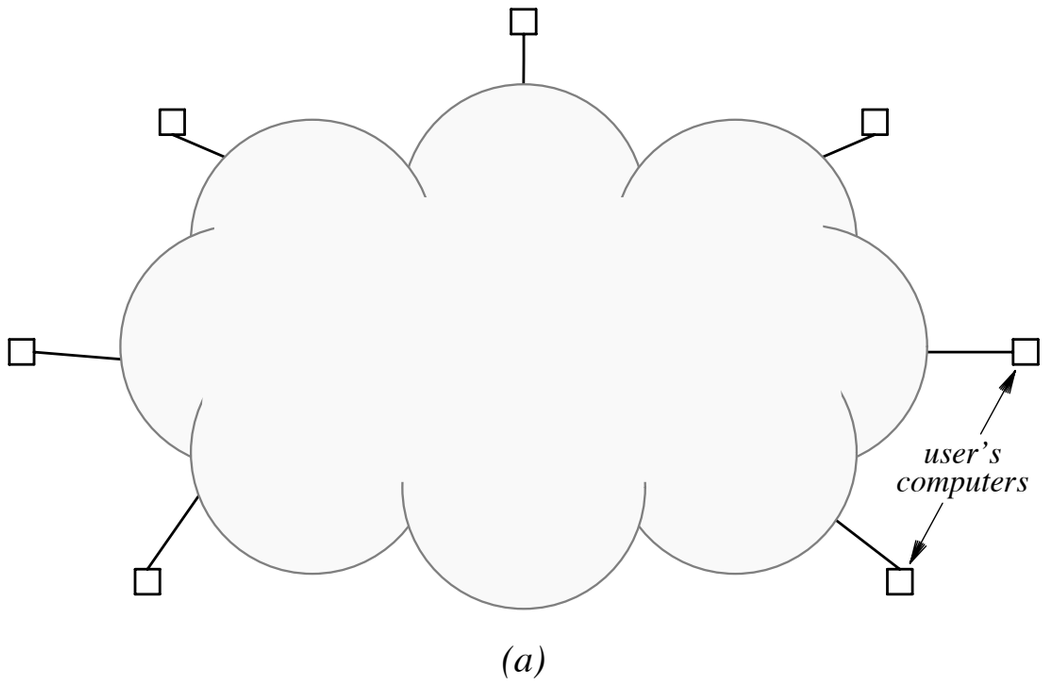
Hardware — Routers

- The router is the core hardware equipment used to connect networks using different physical technologies. There is a vast number of router types.

- An internet (note the lowercase) is a set of networks connected by routers.

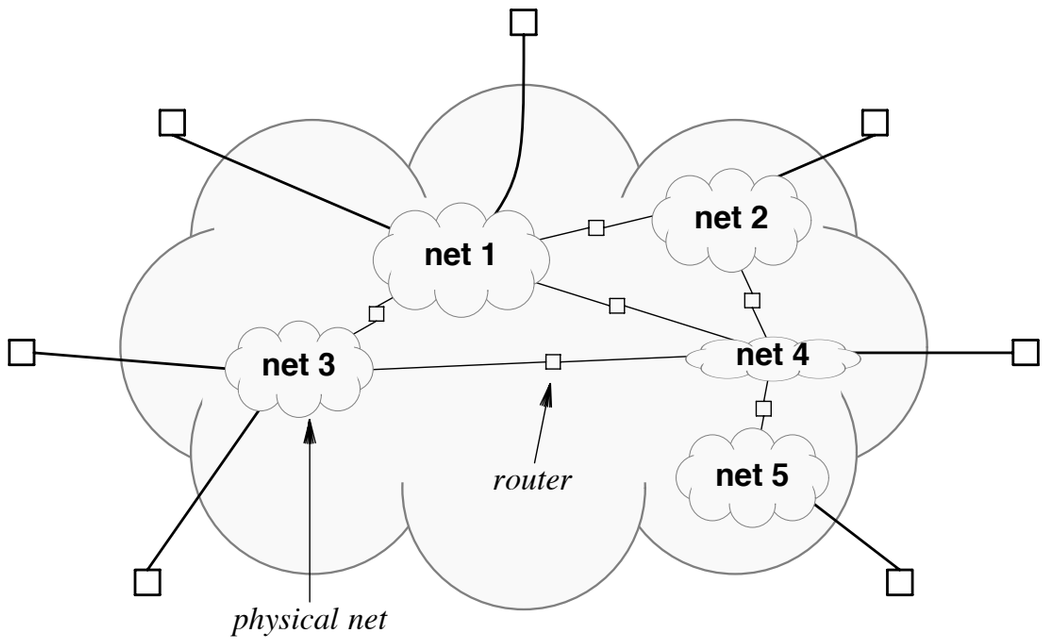
Software — Protocols

- To connect different networks we need communication protocols.
- These protocols establish message formats and message exchanging rules.
- The most important protocols for connecting different networks are called the Internet Protocols or TCP/IP Protocols.
- These protocols were developed in the 1970s and approved as standards in the 1980s.



(a)

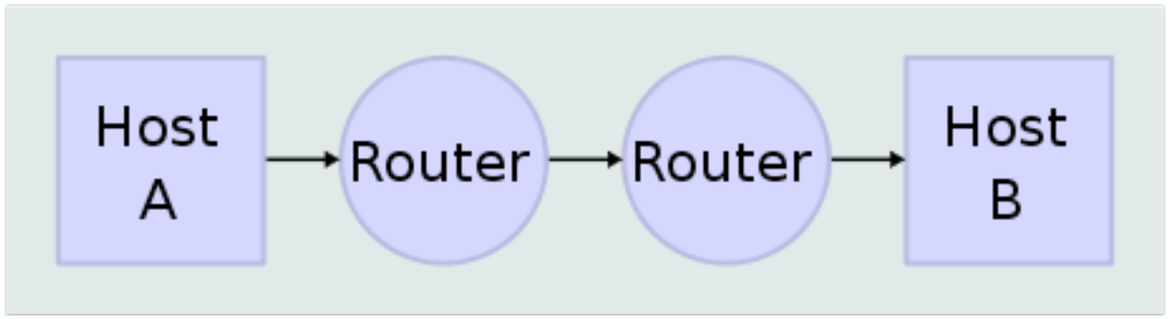
An internet is a virtual network because in reality it is built by combining many physical networks.



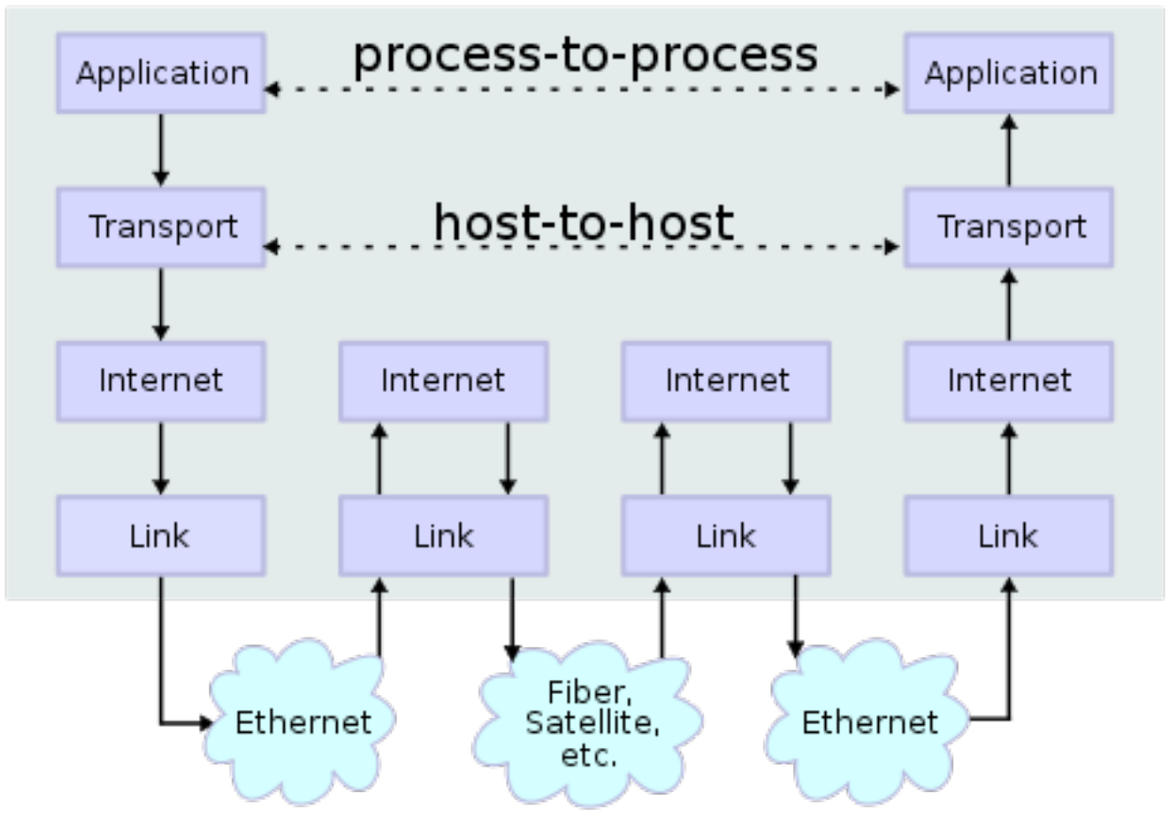
(b)

An internet is a network of networks, not a network of computers.

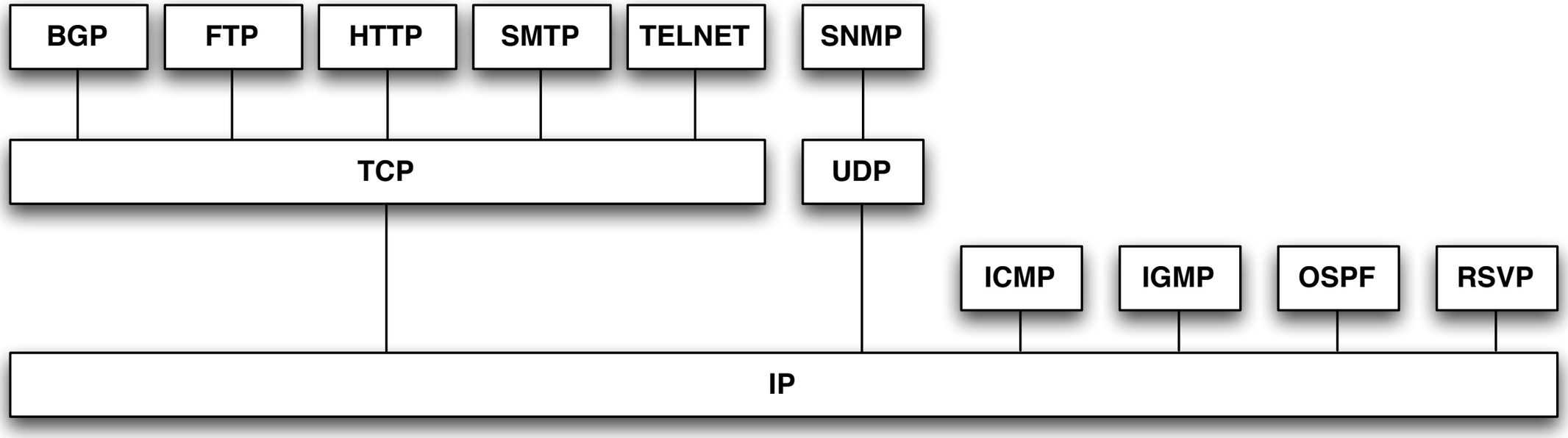
Network Topology



Data Flow



Internet Protocols



BGP = Border Gateway Protocol

FTP = File Transfer Protocol

HTTP = HyperText Transfer Protocol

ICMP = Internet Control Message Protocol

IGMP = Internet Group Management Protocol

IP = Internet Protocol

OSPF = Open Shortest Path First

RSVP = Resource ReSerVation Protocol

SMTP = Simple Mail Transfer Protocol

SNMP = Simple Network Management Protocol

TCP = Transmission Control Protocol

UDP = User Datagram Protocol

Internet Protocol (IP)

- The main function of the Internet Protocol is to offer a virtual network, hiding the underlying physical networks.

- It offers two fundamental services:
  - Addressing system (IP addresses).
  - Datagram structure (packets).

Transmission Control Protocol (TCP)

- The Transmission Control Protocol offers a reliable and ordered delivery of packets between applications in different computers.

- Handles problems not addressed in the lower layers: packet duplication and loss, packer ordering, communication delays, among others.

- Supports important applications such as the WWW, e-mail, FTP, etc.

Internet Services

- DNS — Maps IP addresses to symbolic names.
- SMTP — Handles electronic messages (e-mail).
- SFTP — Offers a mechanism for secure file transfers between computers.
- WWW (HTTP) — A hypertext-based distributed information system.
- …

Domain Name System (DNS)

- The Domain Name System is an application layer service of the Internet.
- Translates human-readable symbolic names to numeric addresses (IP).
- Symbolic names are organized hierarchically.
  The right-most element is the top-level domain (TLD).
- There are different groups of TLDs, namely country TLDs and generic TLDs.
- Country TLDs (ccTLD): .pt, .es, .uk, .usa, .fr, .it, .ao, .fi, .io, .tv ...
- Generic TLDs (gTLD): .com, .net, .org, .name, .biz ...

Generic TLDs

- Generic top-level domains (TLDs) are maintained by the Internet Assigned Numbers Authority (IANA), a department of the Internet Corporation for Assigned Names and Numbers (ICANN), a nonprofit private USA organization.

- Initial list of general purpose domains (1984): com, edu, gov, mil, org and net.

- Recent gTLDs: .biz, .info, .jobs, .mobi, .name, .guru, .today, .xyz … https://www.gandi.net/en/tlds

- In 2012, ICANN decided to open the creation of new gTLDs through a process where organizations can propose new strings.
  There is some debate around this expansion.

- There are currently more than 1,500 TLDs.

.pt Domain

- .pt is the country code top-level domain (ccTLD) for Portugal.

- The .pt ccTLD is currently managed by Associação DNS.PT, which replaced the Fundação para a Computação Científica Nacional (FCCN) as the domain name registry in Portugal. See: http://25anos.pt

- FCCN kept very strict rules during the first years. Multiple adjustments have been made during the years. FCCN also tried to promote the .com.pt subdomain as a more flexible solution.

- In March 2019 there were approximately 350,000 active .pt domain names. More than a one million registered. https://www.dns.pt/estatisticas

WHOIS Protocol

- WHOIS is a query/response protocol used to query databases that contain information about internet resources, such as domain names or IP addresses.

- The protocol presents the information in a human-readable format.

- It is the *de facto* standard for querying domain name information.

Pesquisa Domínio / WHOIS

Pesquise os Domínios disponíveis e obtenha informação sobre os titulares já registados.

Nome do Domínio > .pt

à á â ã ç é ê í ó ô õ ú

Mais Pesquisas

Estou em: Homepage » WHOIS

WHOIS

Domínio	up.pt
Data Submissão	11-10-1991
Data de Expiração	30-05-2016
Estado	ACTIVE
Titular	Universidade do Porto Reitoria - Praça Gomes Teixeira Porto 4099-002 Porto contacto_dnsup@reit.up.pt
Entidade Gestora	Universidade do Porto contacto_dnsup@reit.up.pt
Responsável Técnico	José António Pacheco e Sousa jasousa@reit.up.pt
Informação do Nameserver	up.pt NS dns1.up.pt. up.pt NS dns4.up.pt. up.pt NS dns2.up.pt. dns1.up.pt. A 193.137.55.20 dns4.up.pt. A 193.136.37.10 dns1.up.pt. AAAA 2001:690:2200:a10::20 dns2.up.pt. A 193.137.55.21 dns2.up.pt. AAAA 2001:690:2200:a10::21 dns4.up.pt. AAAA 2001:690:2200:910::10

https://www.dns.pt/pt/ferramentas/whois/detalhes/?site=up&tld=.pt

InterNIC

Home Registrars FAQ **Whois**

Whois Search Results

Search again (.aero, .arpa, .asia, .biz, .cat, .com, .coop, .edu, .info, .int, .jobs, .mobi, .museum, .name, .net, .org, .pro, or .travel) :

facebook.com

- (•) Domain (ex. internic.net)
- ( ) Registrar (ex. ABC Registrar, Inc.)
- ( ) Nameserver (ex. ns.example.com or 192.16.0.192)

Submit

```
Whois Server Version 2.0

Domain names in the .com and .net domains can now be registered
with many different competing registrars. Go to http://www.internic.net
for detailed information.

   Domain Name: FACEBOOK.COM
   Registrar: MARKMONITOR INC.
   Whois Server: whois.markmonitor.com
   Referral URL: http://www.markmonitor.com
   Name Server: A.NS.FACEBOOK.COM
   Name Server: B.NS.FACEBOOK.COM
   Status: clientDeleteProhibited
   Status: clientTransferProhibited
   Status: clientUpdateProhibited
   Status: serverDeleteProhibited
   Status: serverTransferProhibited
   Status: serverUpdateProhibited
   Updated Date: 28-sep-2012
   Creation Date: 29-mar-1997
   Expiration Date: 30-mar-2020

>>> Last update of whois database: Tue, 18 Mar 2014 23:01:39 UTC <<<
```

https://reports.internic.net/cgi/whois?whois_nic=facebook.com&type=domain

who.is Search Domain name or IP address

193.137.55.1 address profile

Overview | Diagnostics

Overview for 193.137.55.1

Updated 40 seconds ago

```
% This is the RIPE Database query service.
% The objects are in RPSL format.
%
% The RIPE Database is subject to Terms and Conditions.
% See http://www.ripe.net/db/support/db-terms-conditions.pdf

% Note: this output has been filtered.
%       To receive output for a database update, use the "-B" flag.

% Information related to '193.137.48.0 - 193.137.55.255'

% Abuse contact for '193.137.48.0 - 193.137.55.255' is 'report@cert.pt'

inetnum:        193.137.48.0 - 193.137.55.255
netname:        PTUNET-UP-6
descr:          Universidade do Porto
descr:          Porto
country:        PT
admin-c:        LMR2-RIPE
tech-c:         FC1899-RIPE
tech-c:         FL514-RIPE
tech-c:         RC14028-RIPE
tech-c:         RR9044-RIPE
status:         ASSIGNED PA
remarks:        SERVIP-UP
remarks:        created 19951220
mnt-by:         AS1930-MNT
mnt-lower:      AS1930-MNT
source:         RIPE # Filtered

person:         Fernando Correia
address:        Universidade do Porto - Reitoria
address:        Praca Gomes Teixeira
address:        4099-002 Porto
address:        PORTUGAL
phone:          +351 220408000
fax-no:         +351 220408186
nic-hdl:        FC1899-RIPE
mnt-by:         AS1930-MNT
source:         RIPE # Filtered
```

The RIPE database contains registration details of IP addresses.

Domain Name Registrars

- Domains are reserved and managed by accredited organizations according to the rules of each specific TLD.

- Domain names are rented for a limited period (e.g. 1 year).
  At the end of the registration period, the owner can decide to renew it or not.

- Different TLDs have different registration prices, some examples:
  .com, .net, .org (~8€/year), .pt (~15€/year), .io (~90€/year), .biz (~15€/year).

The World Wide Web

WWW Origins

- The World Wide Web was invented in 1989 at the European Council for Nuclear Research (CERN), Europe.

- It was a joint work by Tim Berners-Lee and Robert Cailliau to share and link information of various kinds, where the user could browse at will.

- Basically, a distributed information system over the Internet, designed to facilitate content sharing across different computer systems and technologies.

- Initial proposal “WorldWideWeb”, or simply WWW or W3.

- “Information Management: A Proposal”, May 1989
http://www.w3.org/History/1989/proposal.html

- 30 years in 2019. See: https://web30.web.cern.ch/.

Vague but exciting ...

CERN DD/OC

Information Management: A Proposal

Tim Berners-Lee, CERN/DD

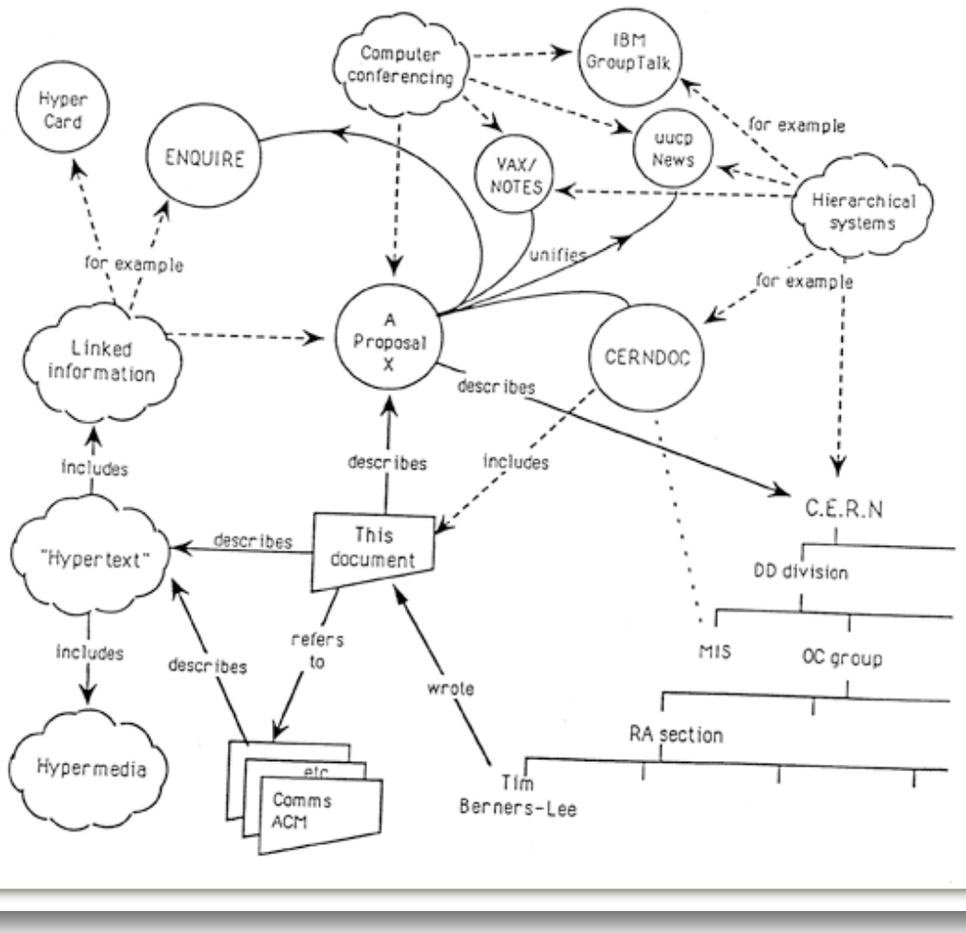
March 1989

Information Management: A Proposal

Abstract

This proposal concerns the management of general information about accelerators and experiments at CERN. It discusses the problems of loss of information about complex evolving systems and derives a solution based on a distributed hypertext sytstem.

Keywords: Hypertext, Computer conferencing, Document retrieval, Information management, Project control



The original proposal: “Vague but exciting…”

Initial Success

- The WorldWideWeb source code was released into the public domain in 1993. The software that was open-sourced included a simple client, a server, and a common library. The protocols were also released royalty-free.

- The royalty-free license was a key factor in the initial success of the WWW when compared to similar alternatives, e.g. WAIS, Gopher, ARCHIE.

- The NCSA released Mosaic, a software program that was a combined WWW browser and Gopher client.

- Mosaic’s popularity was determinant to the growth of the World Wide Web. Mosaic introduced significant innovations at the graphical interface level, namely the integration of text and images in a single page.

930430

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

STATEMENT CONCERNING CERN W3 SOFTWARE RELEASE INTO PUBLIC DOMAIN

TO WHOM IT MAY CONCERN

Introduction

The World Wide Web, hereafter referred to as W3, is a global computer networked information system.

The W3 project provides a collaborative information system independent of hardware and software platform, and physical location. The project spans technical design notes, documentation, news, discussion, educational material, personal notes, publicity, bulletin boards, live status information and numerical data as a uniform continuum, seamlessly intergated with similar information in other disciplines.

The information is presented to the user as a web of interlinked documents .

Acces to information through W3 is:

- via a hypertext model;
- network based, world wide;
- information format independent;
- highly platform/operating system independent;
- scalable from local notes to distributed data bases.

Webs can be independent, subsets or supersets of each other. They can be local, regional or worldwide. The documents available on a web may reside on any computer supported by that web.

...

Declaration

The following CERN software is hereby put into the public domain:

- W 3 basic ("line-mode") client
- W 3 basic server
- W 3 library of common code.

CERN's intention in this is to further compatibility, common practices, and standards in networking and computer supported collaboration. This does not constitute a precedent to be applied to any other CERN copyright software.

CERN relinquishes all intellectual property rights to this code, both source and binary form and permission is granted for anyone to use, duplicate, modify and redistribute it.

CERN provides absolutely NO WARRANTY OF ANY KIND with respect to this software. The entire risk as to the quality and performance of this software is with the user. IN NO EVENT WILL CERN BE LIABLE TO ANYONE FOR ANY DAMAGES ARISING OUT THE USE OF THIS SOFTWARE, INCLUDING, WITHOUT LIMITATION, DAMAGES RESULTING FROM LOST DATA OR LOST PROFITS, OR FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

Geneva, 30 April 1993

W. Hoogland
Director of Research

H. Weber
Director of Administration

opie certifiée conforme

ait à Genève le 03-05-93

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
DIVISION DES FINANCES
- CERN -

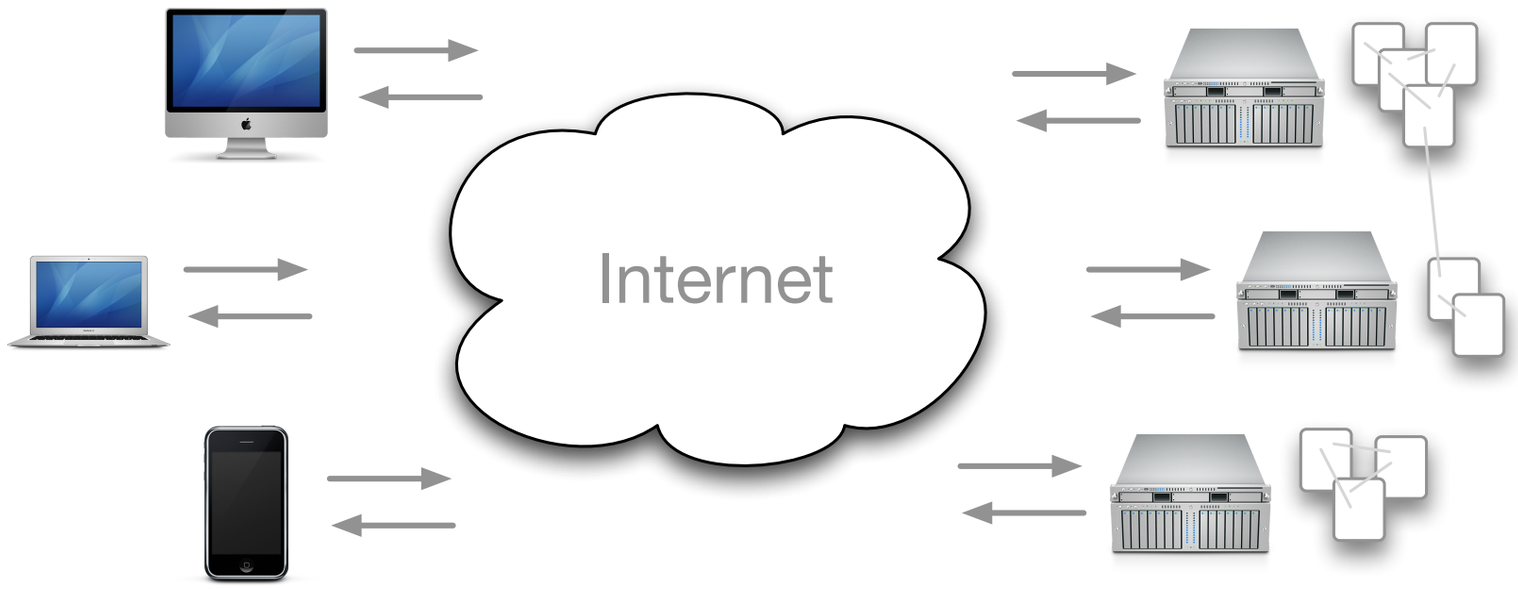
April 1993, CERN puts the WWW in the public domain

WWW Architecture

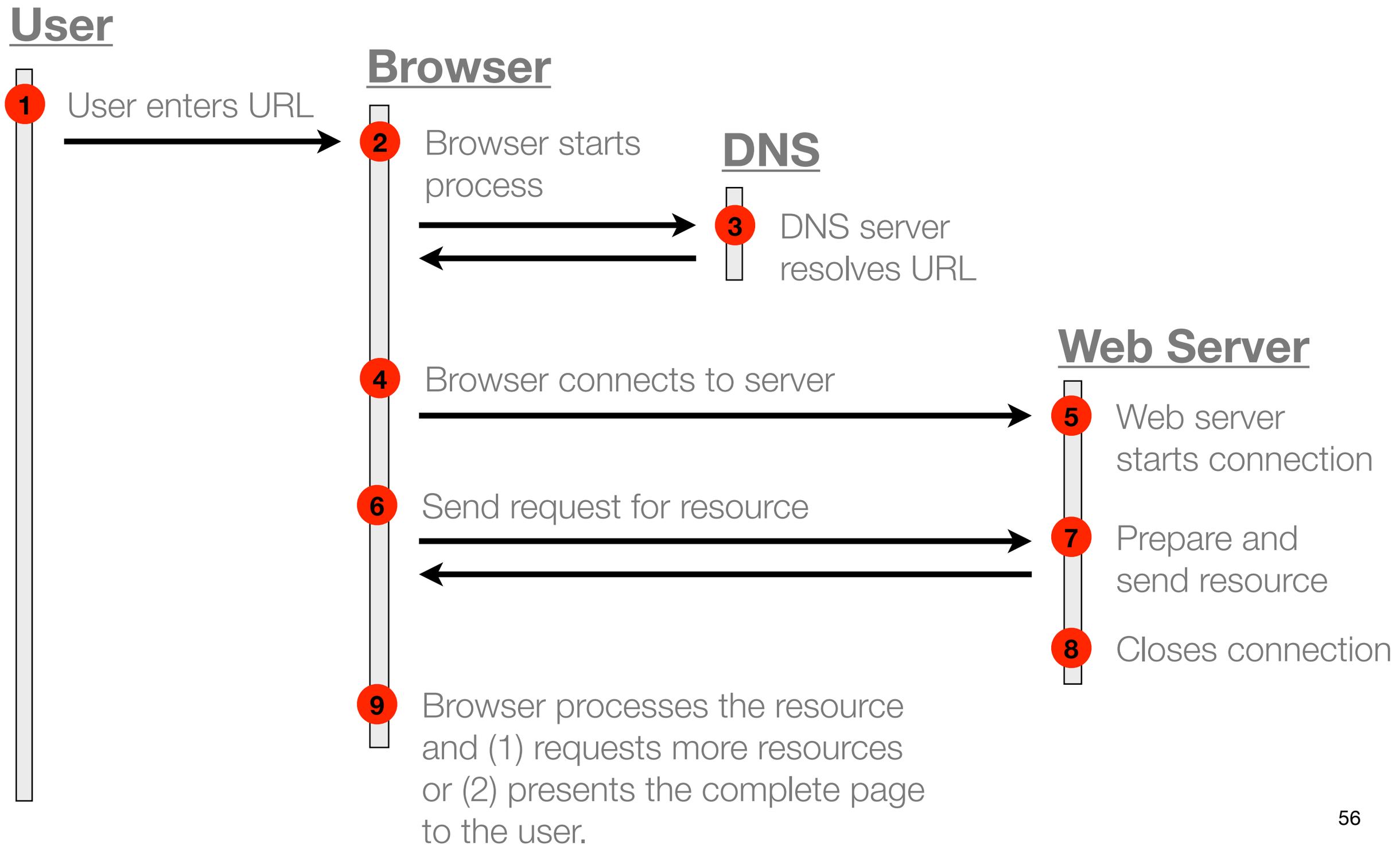
- The Web's architecture follows a standard **client-server model**, where servers provide a function and clients initiate requests for those services.

- **Servers** are machines that are running server applications waiting for requests from clients. Each server can simultaneously serve multiple clients.

- **Clients** are typically web browsers that initiate the communication session with servers. Interactions are simple, one request results in one response.

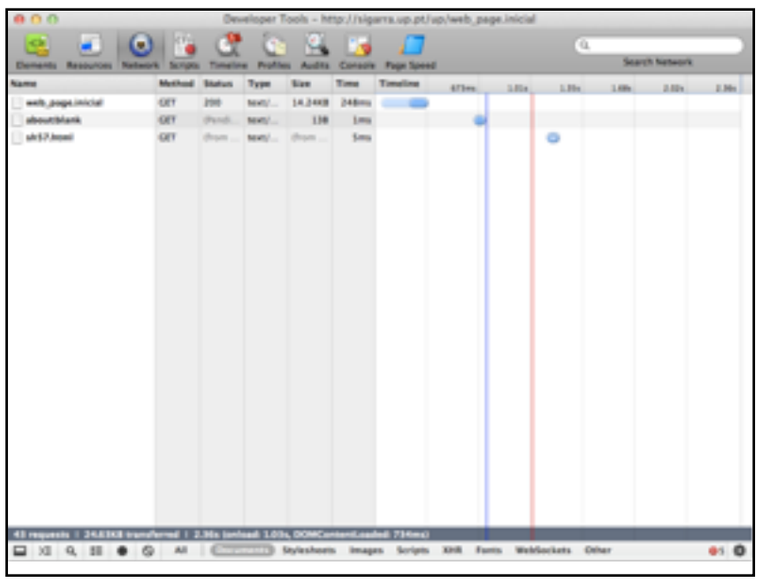


Client Server Interaction

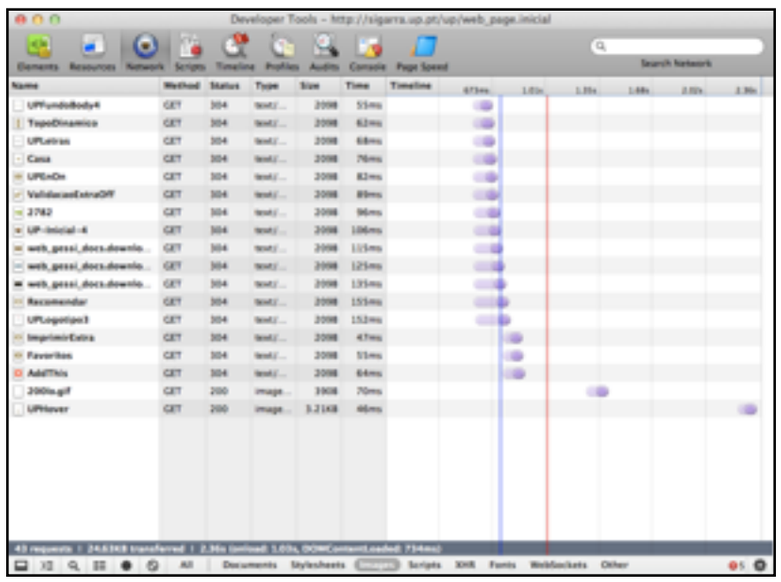


Requesting a Web Page

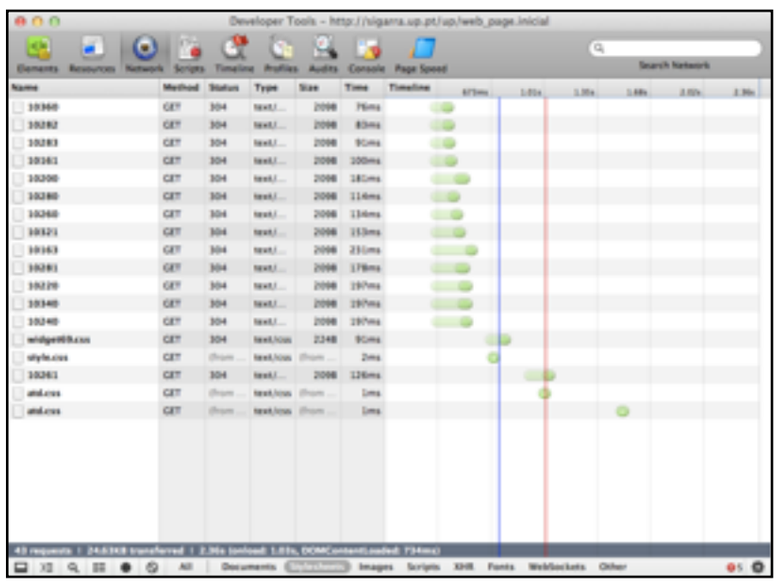
- Web pages combine text, images, and other resources.
- Web browsers issue multiple requests when preparing a single web page, one request for each individual resource (e.g. HTML document, CSS files, images, JavaScript files, etc).



Base documents requested.



Images requested.



CSS files requested.

Web Clients

- World Wide Web client applications, commonly known as web browsers, are software applications capable of retrieving, presenting and transversing information resources available on the World Wide Web.

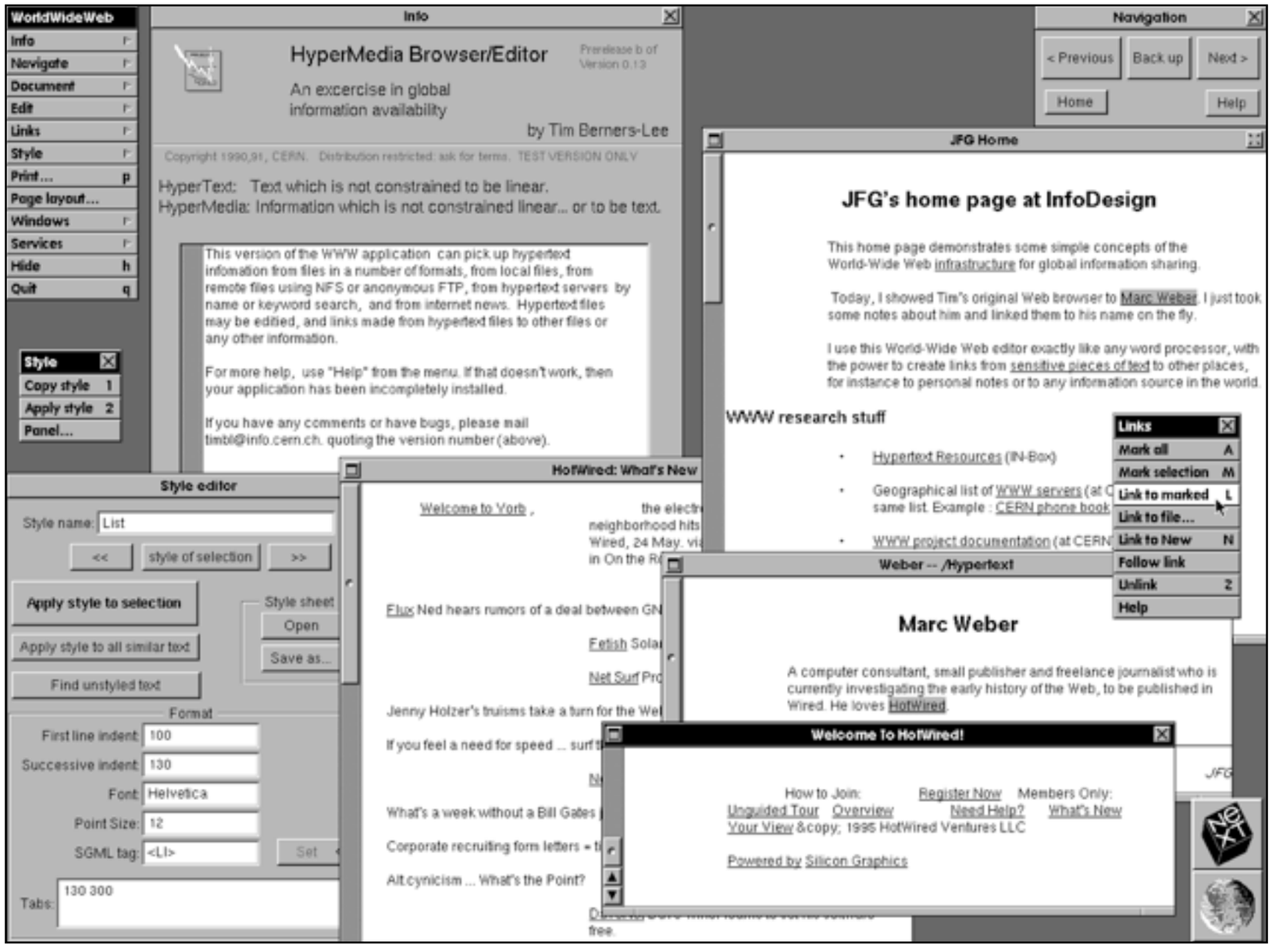
- Web browsers communicate with web servers using the HTTP protocol.

- Web browsers are increasingly sophisticated.

- The first web browser was called WorldWideWeb and was bundled with the releases of the WorldWideWeb system.

- Mosaic, developed at NCSA, was the first popular browser. It was the first to integrate text and images in a single page.

WorldWideWeb (later Nexus) Browser



WorldWideWeb (1990), developed by Tim Berners-Lee, was the first web browser

Mosaic

Mosaic was the first mainstream web browser (1993).

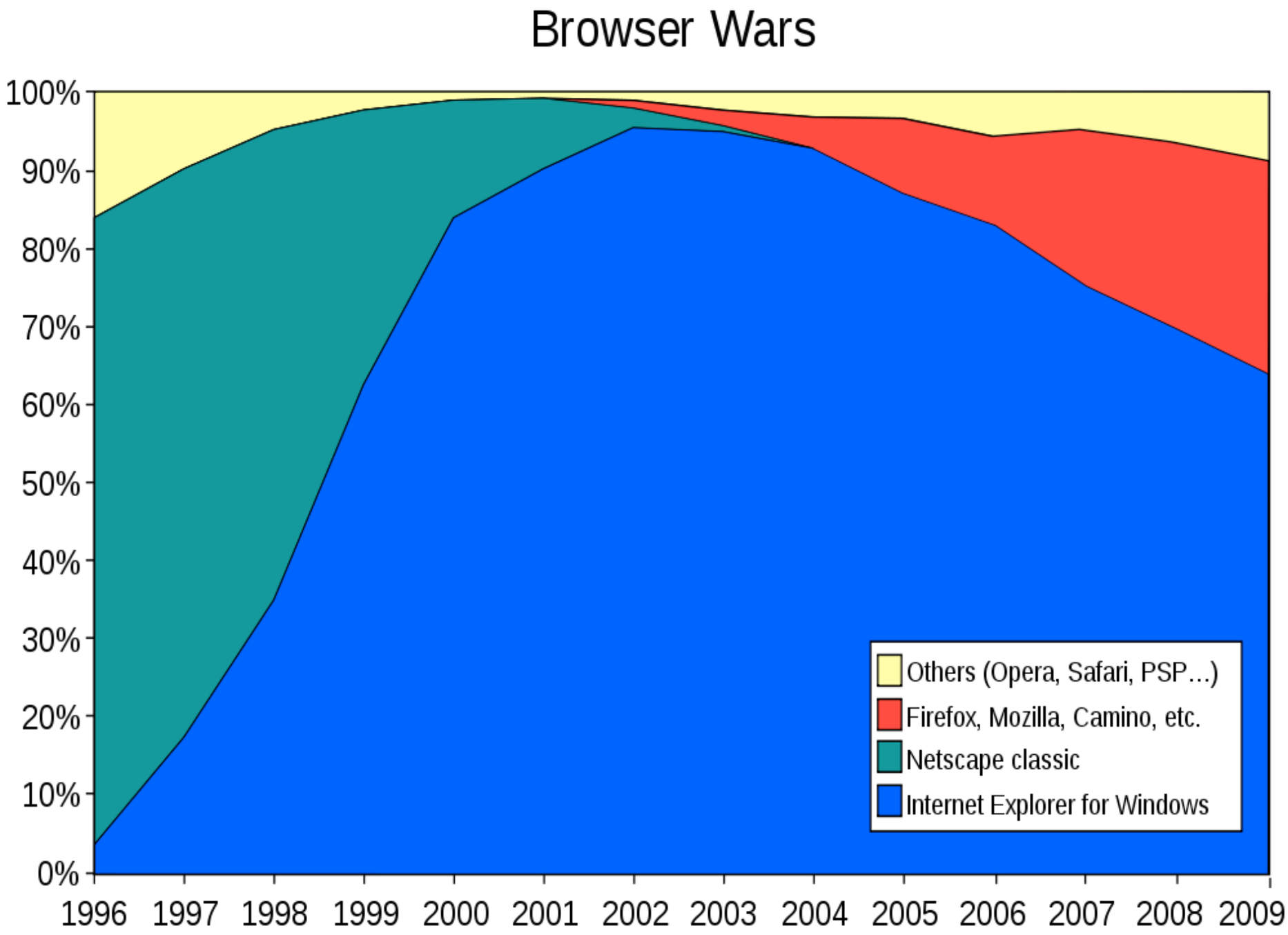
Mosaic

- Marc Andreessen and Jim Clark left NCSA to start Netscape Communications in 1994. Later that year, Netscape version 1 was released.

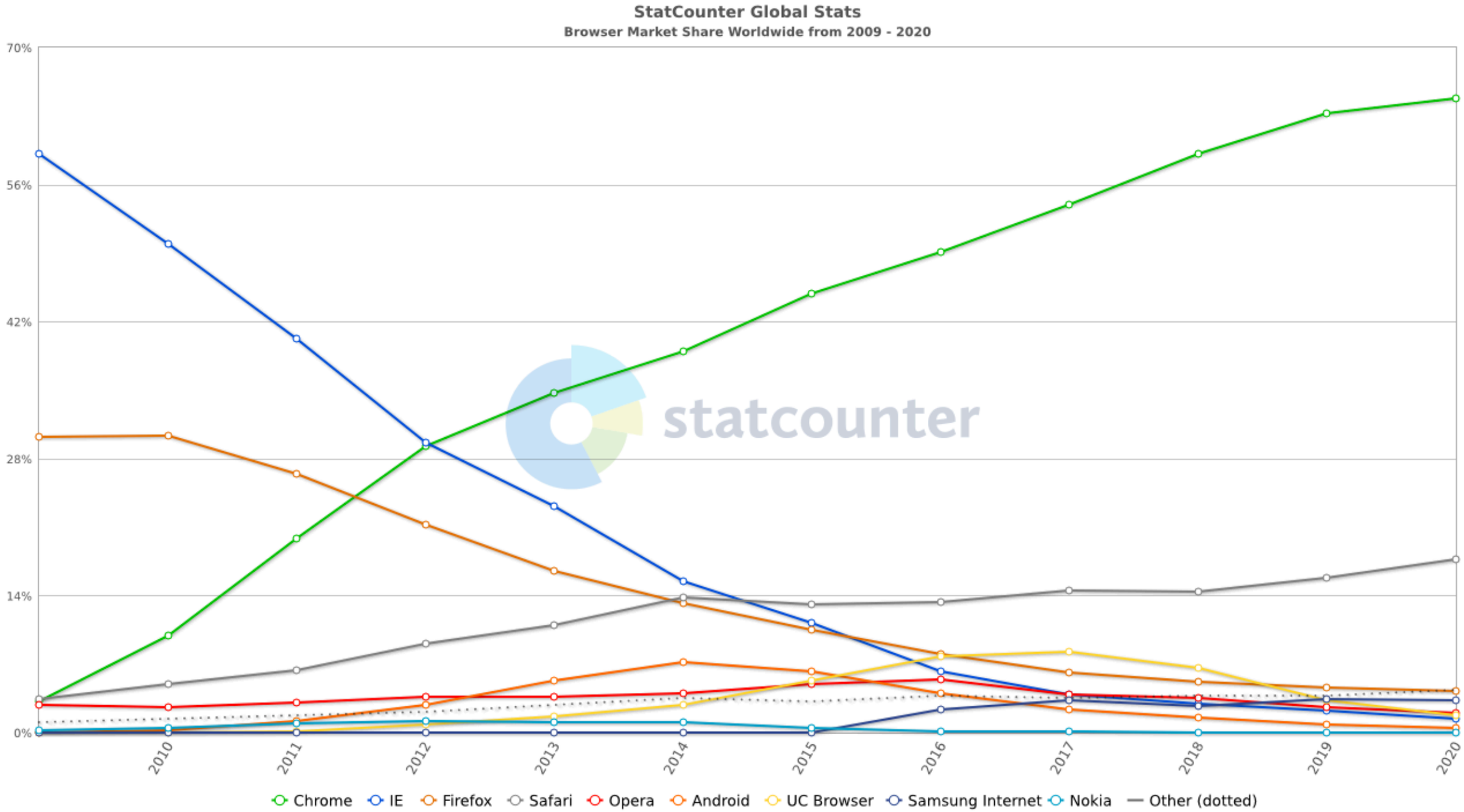
- NCSA licensed Mosaic technology to Microsoft to form the basis of Internet Explorer. Version 1 was released in 1995.

- The “Browser Wars” started for the dominance of the web browser market.

- Internet Explorer had a major advantage — it was bundled with every copy of Windows. This latter led to the USA vs. Microsoft case on monopoly abuse.

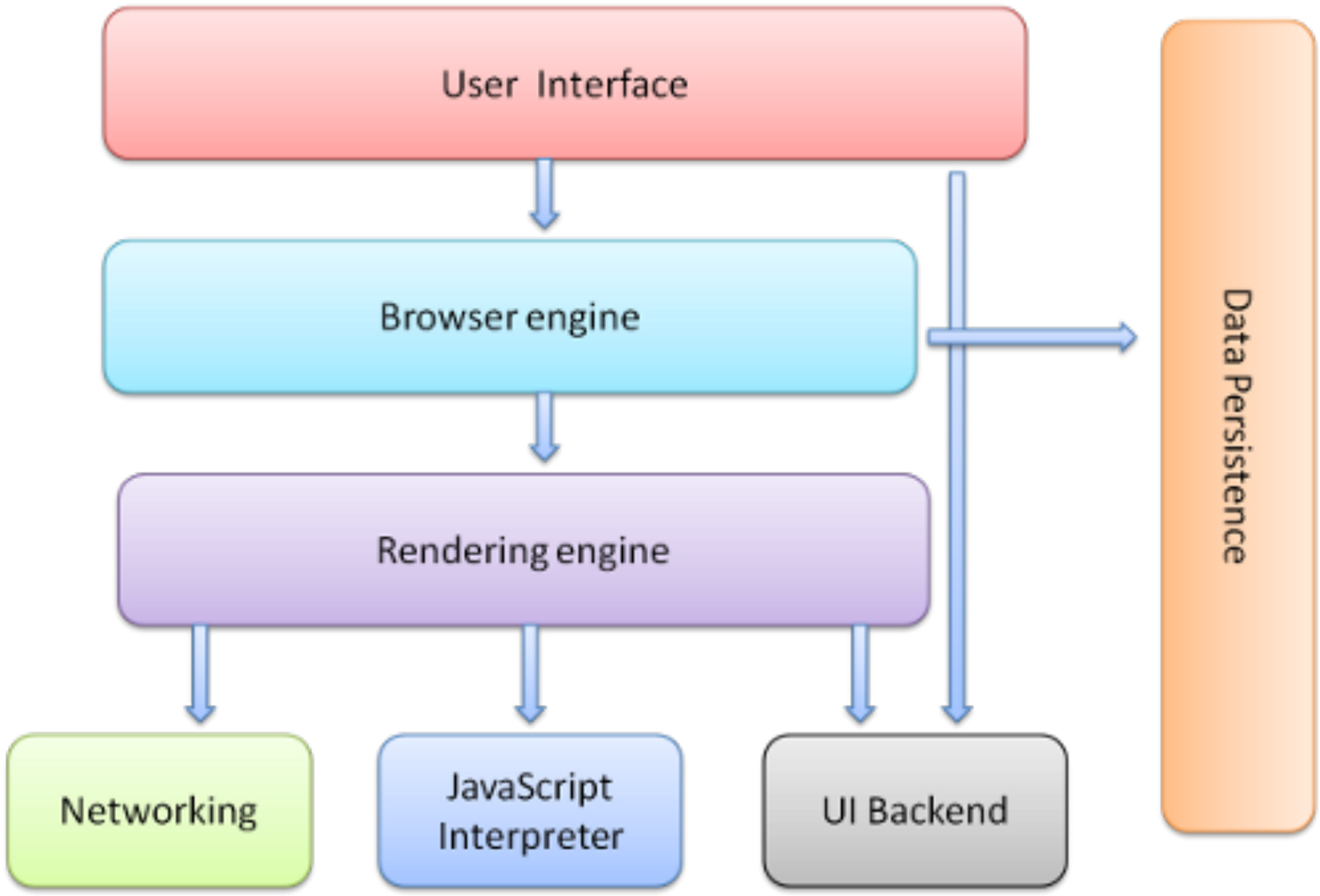


Source: Wikipedia - “Browser Wars”



Source: Wikipedia - “Usage share of web browsers”

Browser's High Level Structure



- User Interface - browser controls
- Browser engine - mapping
- Rendering engine - HTML & CSS
- Networking - network calls
- JS Interpreter - execute javascript
- UI Backend - drawing widgets
- Data Persistence - saves data

How Browsers Work: Behind the scenes of modern web browsers (2011)
http://www.html5rocks.com/en/tutorials/internals/howbrowserswork/

Notable Layout Engines

- **Trident** — Developed by Microsoft for use in Internet Explorer.
- **Gecko** — Developed by the Mozilla Foundation, used in Firefox, Camino.
- **WebKit** — A fork of KHTML developed by Apple, used in Safari.
- **Blink** — A fork of WebKit developed by Google, used in Chrome, Opera and Edge.
- **Presto** — Developed by Opera Software, used in Opera (until 2013).
- **EdgeHTML** — New Microsoft rendering engine launched in 2015. RIP December, 2018.

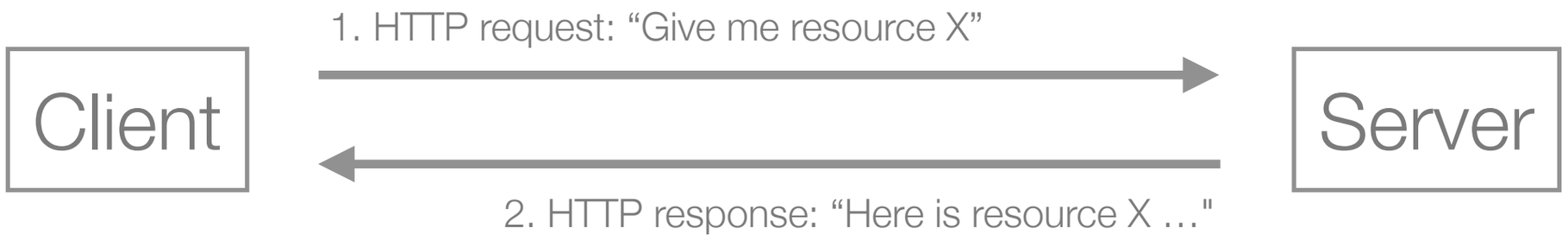
“Comparison of Layout Engines”, Wikipedia
https://en.wikipedia.org/wiki/Comparison_of_layout_engines

“Timeline of web browsers”, Wikipedia
https://en.wikipedia.org/wiki/Timeline_of_web_browsers

Web Servers

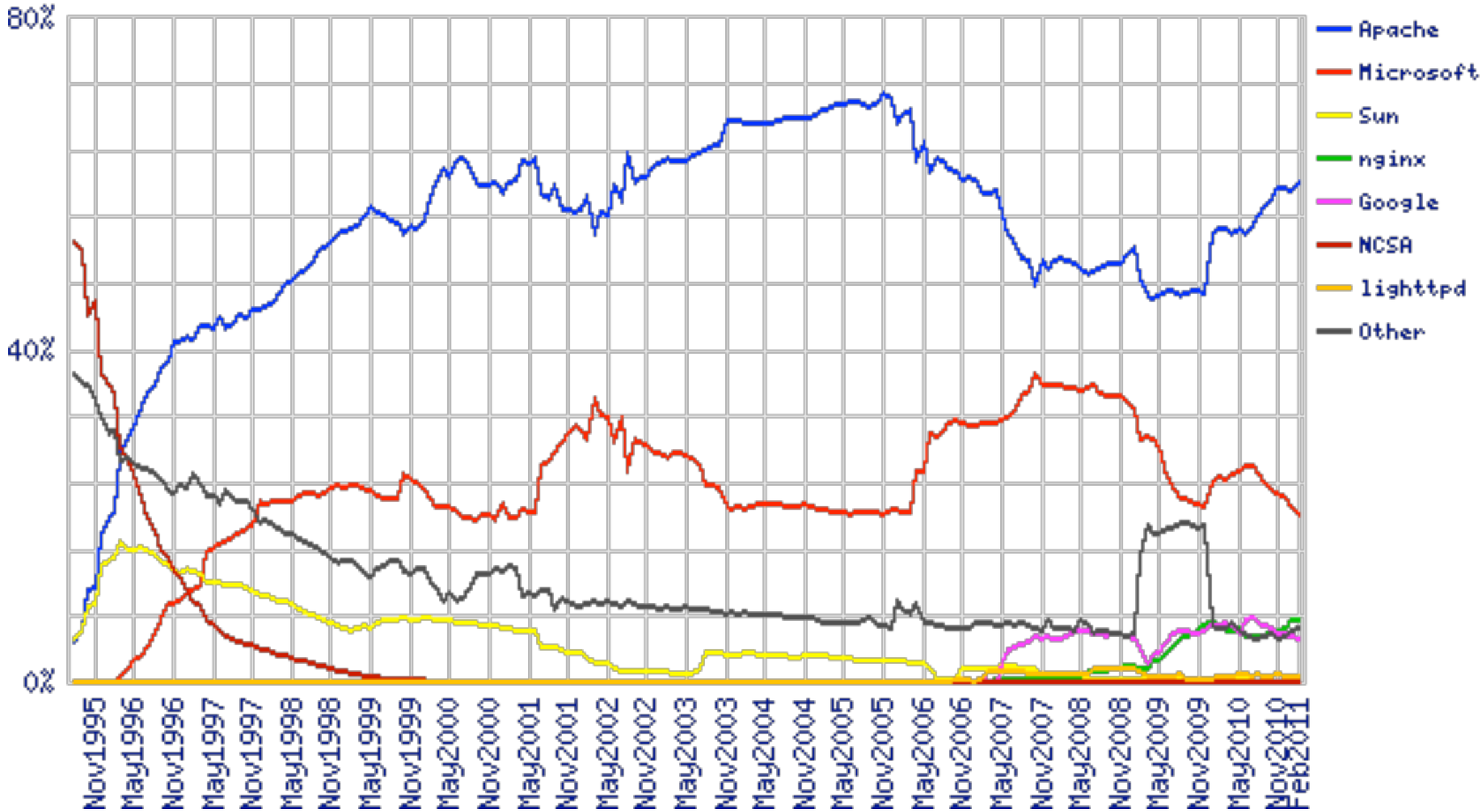
- A web server is a program whose primary function is to deliver resources on clients' requests. Only acts when requests arrive.

- Web servers handle multiple web clients simultaneously.
  Servers and clients communicate using the HTTP protocol.

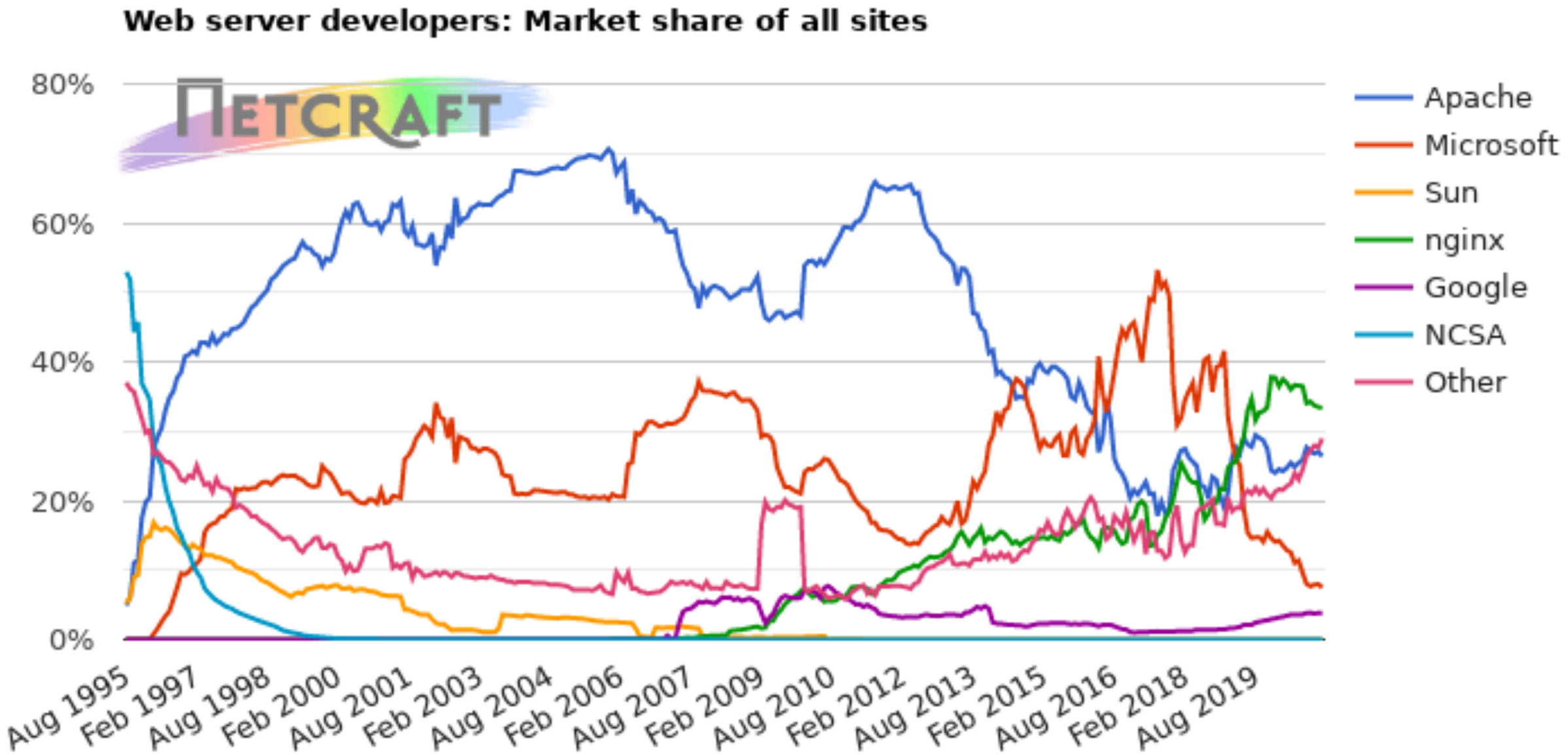


- The most common web servers are the Apache HTTP Server and Microsoft's Internet Information Server (IIS). Lightweight alternatives: nginx, lighttpd.

- Typically, different web servers coexist in a production environment.



Source: Netcraft



Source: Netcraft

WWW's Core Technologies

- The Web is supported by three core technologies:

  - **URL: Uniform Resource Locator**
    Used to identify the resources available on the web.

  - **HTTP: HyperText Transfer Protocol**
    Used to specify how clients communicate with servers.

  - **HTML: HyperText Markup Language**
    Used to represent and interlink documents on the web.

URL: Uniform Resource Locator

- A URL establishes a unique address for a World Wide Web resource, e.g. pages, images, etc. URLs are used to locate web resources.

- Syntax (simplified): protocol://machine:port/directory/file.type

    - Protocol, e.g. http://, ftp://, file://

    - Machine, e.g. www.up.pt or 193.137.55.13

    - Port, e.g. 80 (the default), 1000, 20

    - Resource path, the directory path to the file

- Example: http://www.up.pt:80/sobre/index.html

HTTP: HyperText Transfer Protocol

- The HTTP protocol defines how web client communicate with web servers to access web resources.

- HTTP was developed as a joint work of IETF and W3C.

- It is a request-response protocol, i.e. client issues a request and waits for the server to respond. Timeouts can occur if servers take too long.

- HTTP is a stateless protocol, i.e. each request is treated as an independent transaction. This results in a simpler design, but requires additional information to be send in each request.

HTTP: Request Methods

- HTTP supports several request commands, called HTTP methods. A total of nine methods are defined in the HTTP standard. GET and POST are the most commonly used by web browsers.

    - GET — Requests the resource from the server. Idempotent operation.
    - HEAD — Requests only the headers (without the content).
    - POST — Submits data to be processed to the identified resource.
    - PUT — Uploads data into the specified resource.
    - DELETE — Deletes the specified resource.

HTTP: Status Codes

- All HTTP responses include a numeric status code, indicating if the request succeeded or if other actions are required. Codes are organized in five classes of responses.
    - 1xx — Informational
    - 2xx — Success (e.g. 200 OK, 201 Created)
    - 3xx — Redirection (e.g. 301 Moved Permanently)
    - 4xx — Client Error (e.g. 404 Not Found, 403 Forbidden)
    - 5xx — Server Error (e.g. 500 Internal Server Error)

HTTP is Stateless

- Web servers do not keep any information about clients. Each request is isolated from all others.

- **State must be maintained by web applications.**

- How can we implement a stateful user experience over a stateless protocol (e.g. shopping cart, authenticated access)? Two options:

  - Cookies — client-side pieces of data generated by the server and attached to each HTTP request.

  - Sessions — server-side files with unique identifiers (session IDs), these can be passed in URLs or Cookies.

HyperText Markup Language — HTML

- The HyperText Markup Language (HTML) is used to define the content and structure of hypertext documents.

- First standard was published in 1995 — HTML 2.0.

- HTML 4.01 was published in 1999.

- XHTML was a reformulation of HTML as XML. W3C tried to “force” authors to write well-formed code. Later abandoned due to low adoption by web developers.

- HTML5 is the latest major revision to HTML.

W3C

- The World Wide Web Consortium was founded in 1994 by Tim Berners-Lee to standardize the protocols and technologies used to build the web.

- The W3C is an international standards organization, composed by member organizations and full time staff, that develops technical specifications and guidelines for the web.

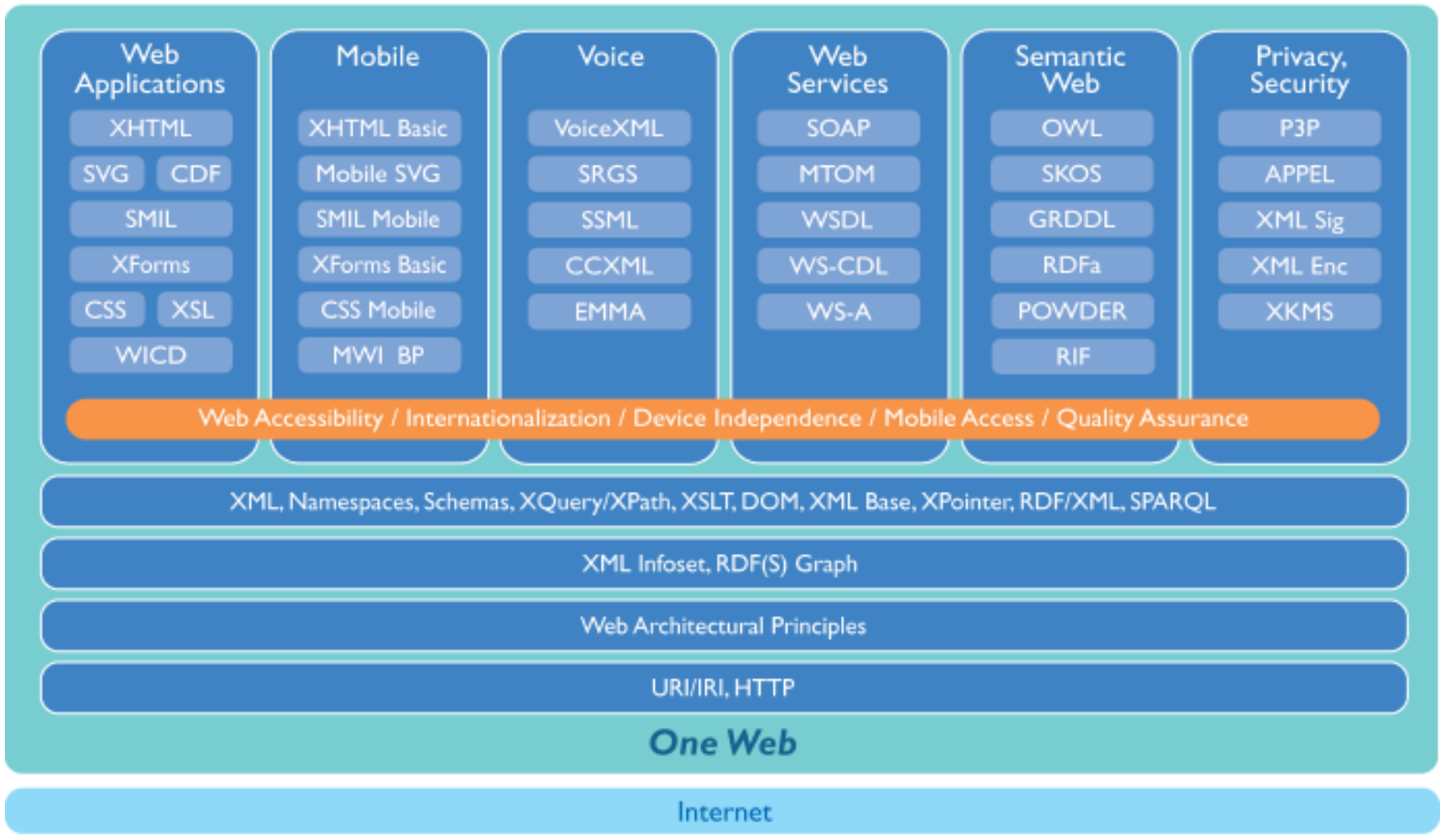
- Mission: “Led the Web to its full potential”.

- W3C Process: (1) members propose new technologies or ideas; (2) working groups are formed; (3) recommendations are developed and approved by consensus.

- The W3C does not enforce their recommendations.

W3C Standards

W3C standards are many and in different areas, from technical specifications to guidelines.



W3C technology stack (circa 2004).
http://www.w3.org/Consortium/techstack-desc.html

W3C Process

- People generate interest in a particular topic (e.g., web services). For instance, Members express interest in the form of Member Submissions, and the Team monitors work inside and outside of W3C for signs of interest.

- When there is enough interest in a topic, the Director announces the development of a proposal for a new Activity or Working Group charter, depending on the breadth of the topic of interest.

- There are three types of Working Group participants: Member representatives, Invited Experts, and Team representatives. Team representatives both contribute to the technical work and help ensure the group's proper integration with the rest of W3C.

- Working Groups generally create specifications and guidelines that undergo cycles of revision and review as they advance to W3C Recommendation status.

Introduction to the W3C Process (2005)
https://www.w3.org/2005/10/Process-20051014/intro

Web Applications

Static Web Pages (early 1990s)

- In the early days of the web, most pages were static files served directly from the filesystem. **Pages are constructed at design time**.

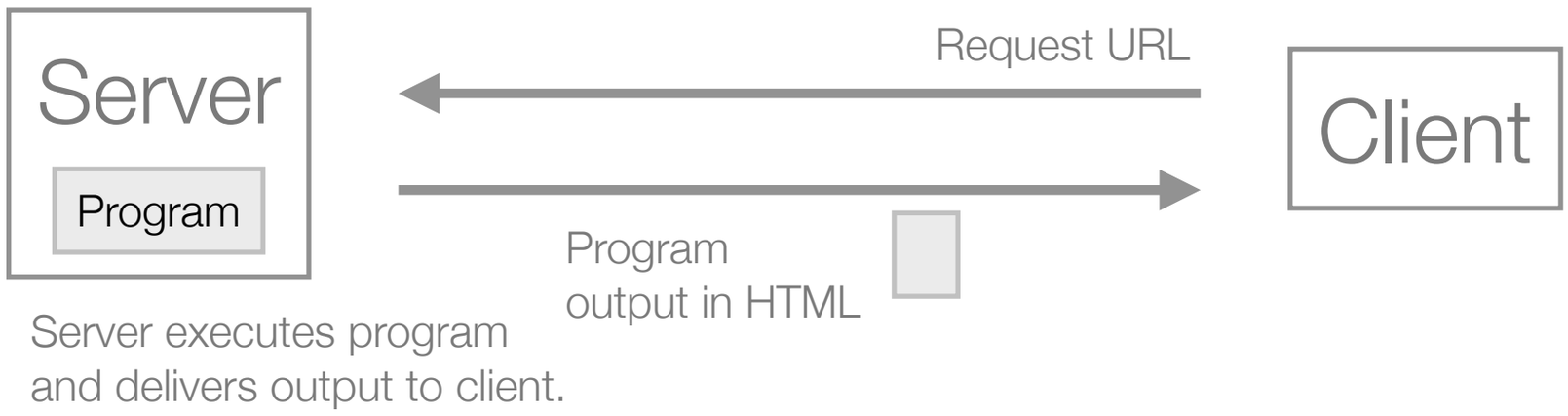
- Developing web pages involved few technologies, mostly just HTML. Learning by example, using the “view source” option, was an important method for knowledge dissemination.

Dynamic Web Pages (mid 1990s)

- Dynamic web pages emerged in the mid 1990s. Instead of serving static files from the filesystem, software applications produce web pages when requested. **Pages are constructed at run time**, when “called” by the browser.

- The Common Gateway Interface (CGI) is a specification that defines how web requests and responses interact with an application program.

- There are several alternatives: Apache modules, IIS plug-ins, FastCGI, WSGI.



Dynamic Web Sites (1990s …)

- Sites emerged as a collection of multiple and coherent web pages. Instead of treating each page independently, multiple web pages were handled by shared functions and libraries.

- Provide a stateful experience to the user (e.g. shopping cart).

- Typically a common data layer was implemented across pages.

- Libraries and frameworks to address repetitive and common tasks.

- Richer user interfaces (e.g. JavaScript).

Web Applications (mid 2000s …)

- Strong developments in client-side technologies and methodologies led to richer and interactive user interfaces.

- AJAX enabled the creation of asynchronous web applications. No need to reload full pages on each user interaction.

- Web documents became applications itself, i.e. code runs on the document.

- Rise of new web frameworks — Ruby on Rails, Django, etc.

- Wide adoption of HTML5.

- A new interaction paradigm with mobile devices.

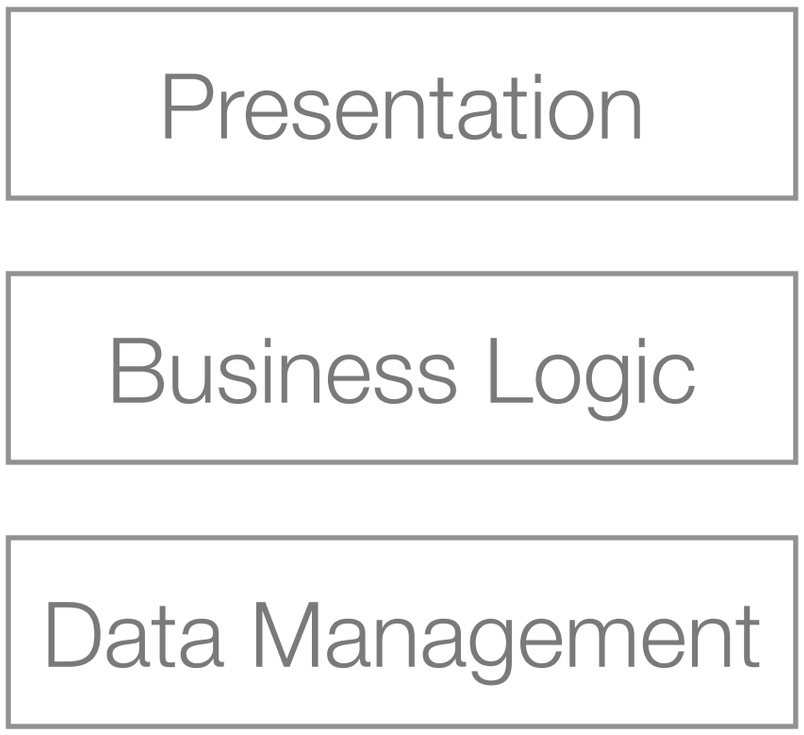
Code Execution

	Server	Client
Static web pages	*No code execution*	
Dynamic web pages	Code Execution	
Web page applications	Code Execution	+ Code Execution

The Three-Tier Architecture

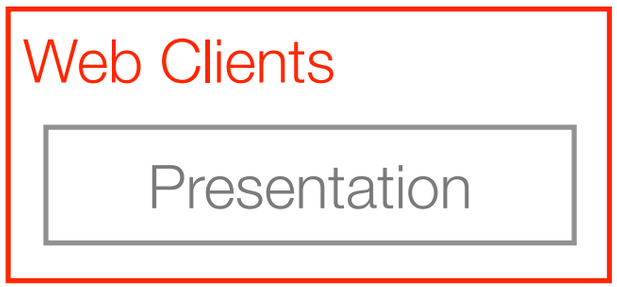
- Web applications are typically structured in three tiers, corresponding to three core aspects of a web system: presentation, business logic and data access.

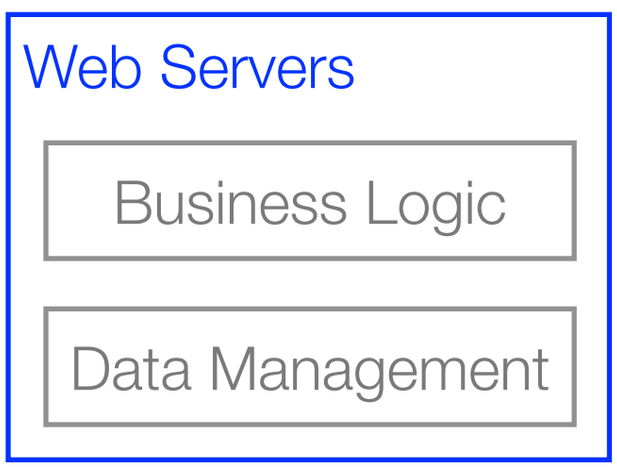
- Main advantages of this approach: separation of concerns, maintainability.



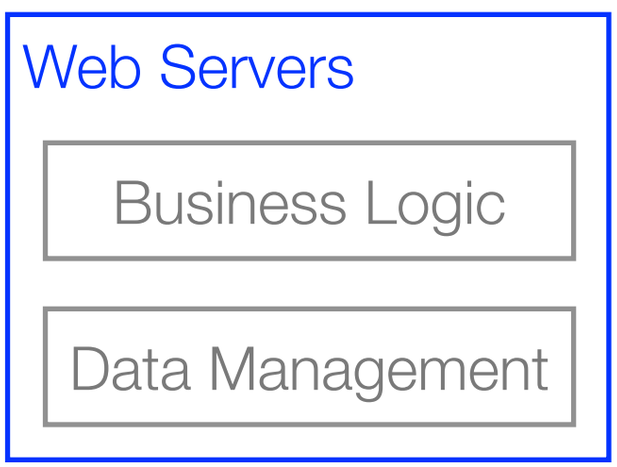
Architecture of Web Applications

- Over time, the architecture of web applications has changed significantly. In the beginning, web clients were only used to present the user interface. Recently, application logic has moved partially to the clients.



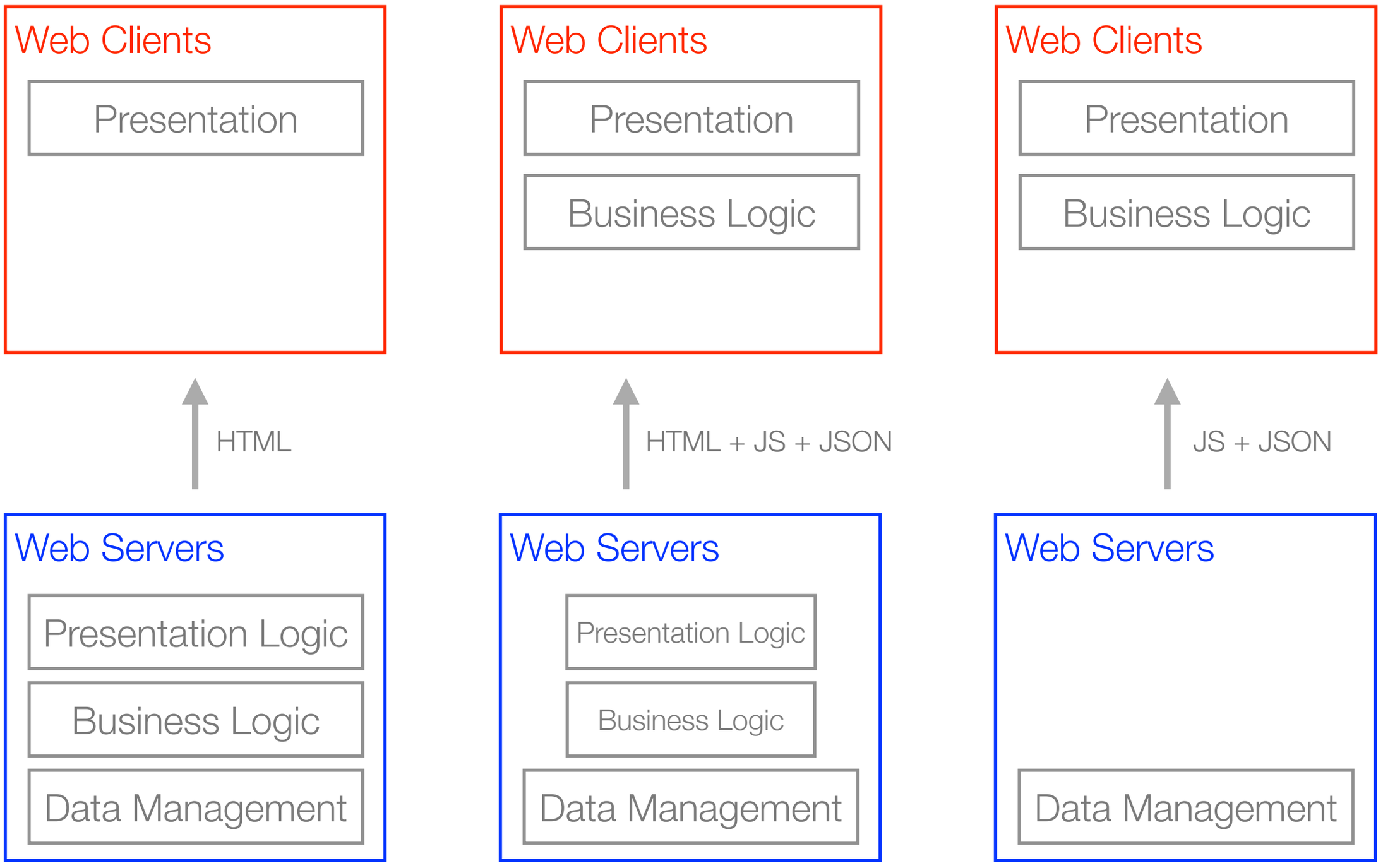


Thin Clients



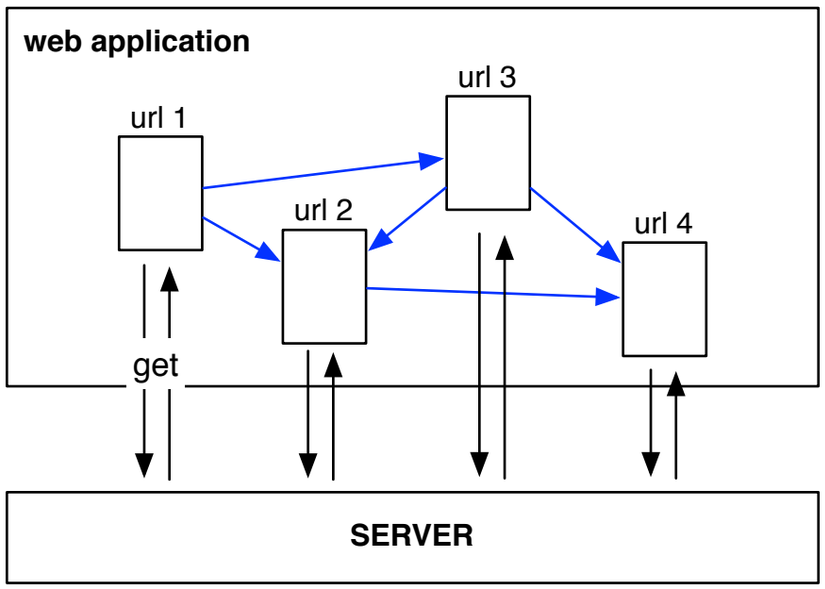
Fat Clients

Different Architectural Options



Multi-Page Web Applications

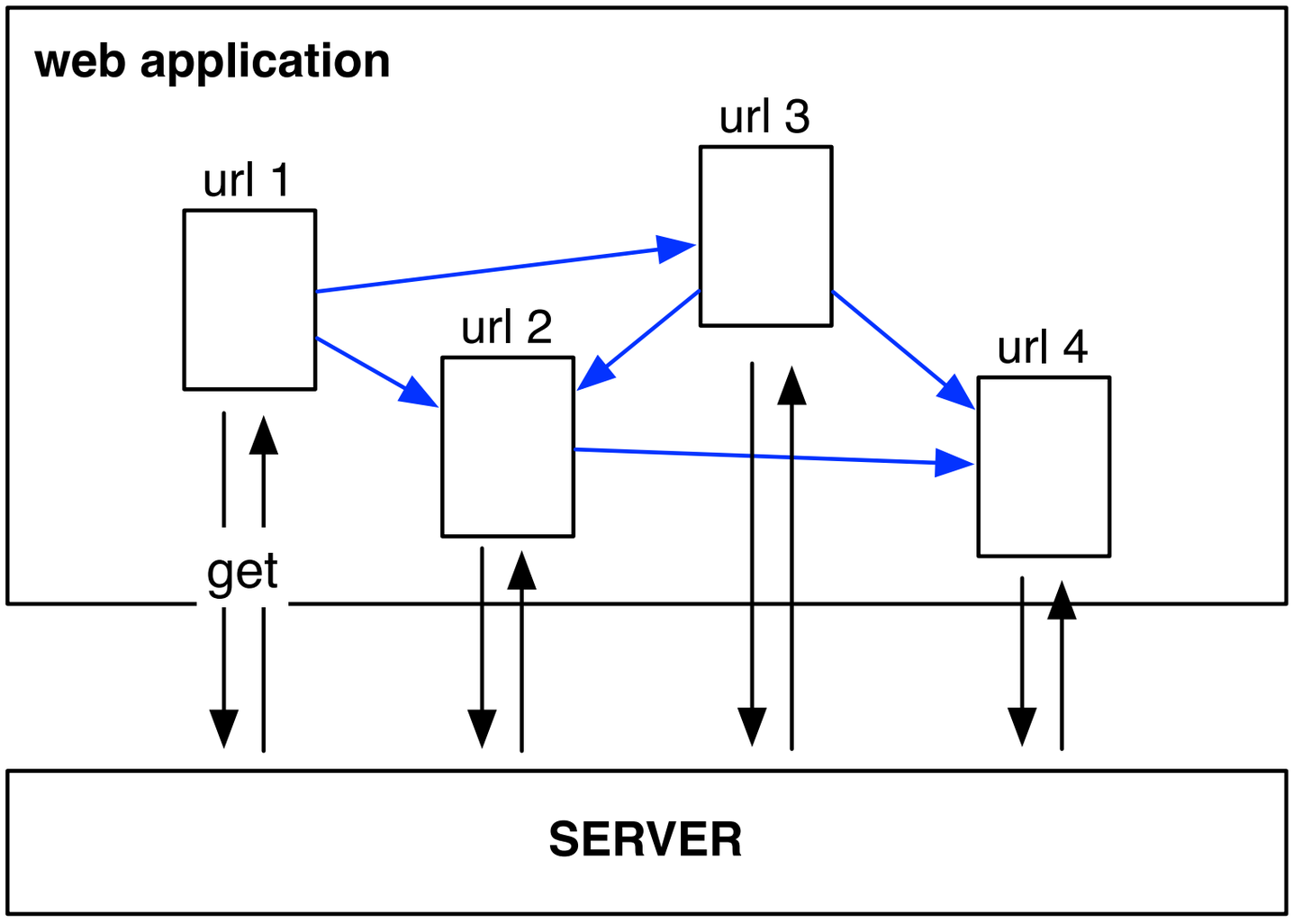
- The web application is implemented as a collection of multiple web pages. The user interacts with the application navigating through these pages. Each page is prepared on the server and only presentation details are sent to the browser.



Each page corresponds to a HTTP GET request. Application logic is all maintained on the server.

E.g. Amazon, SIGARRA

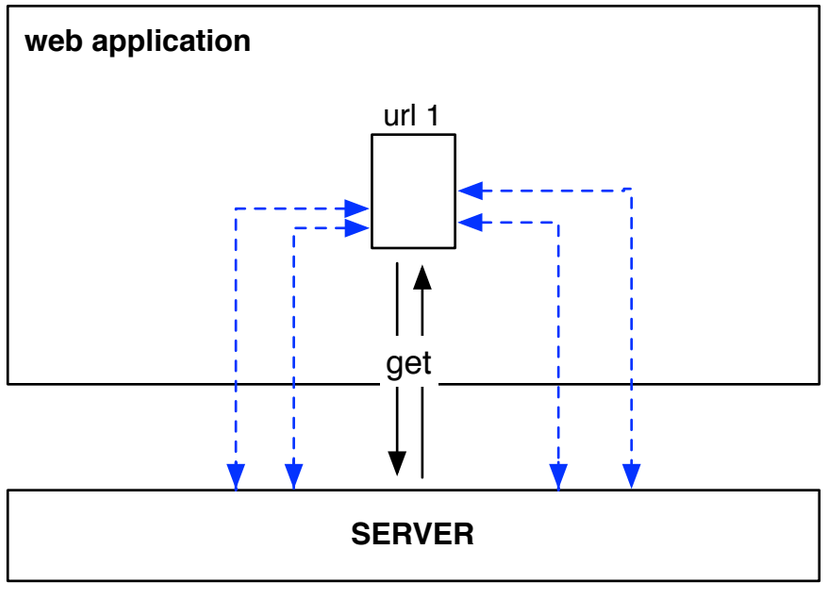
- Advantages: REST style, client independent, consistency across browsers, broad technological ecosystem, application logic is kept on the server.
- Disadvantages: slow performance and responsiveness, fragmented code, no way to deliver updates to an open web page.



Each page corresponds to a HTTP GET request. Application logic is maintained on the server.

Single-Page Web Applications

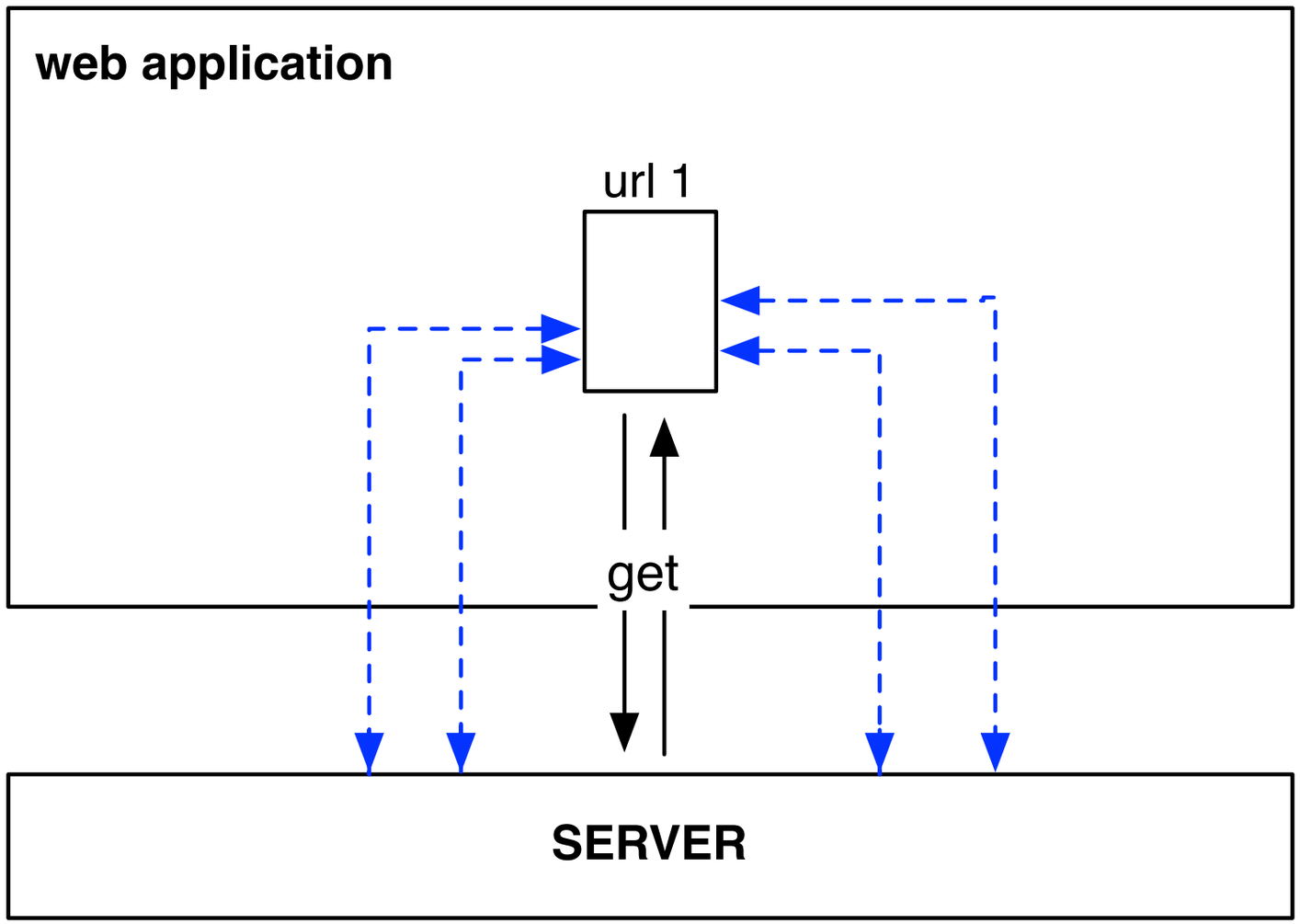
- The web application is implemented as a single web page. All necessary resources are loaded or dynamically added to the page (e.g. using Ajax). Application logic is pushed to the client — fat client architecture.



An initial page is loaded using HTTP GET. All other resources are loaded dynamically following user interactions.

E.g. Slack

- Advantages: improved user experience, reduced bandwidth consumption, decoupled client and server, reusable server interfaces, reusable client code.
- Disadvantages: JavaScript required, breaks browser history, increased browser dependency (versions, features, performance), no REST, difficult to crawl and index.

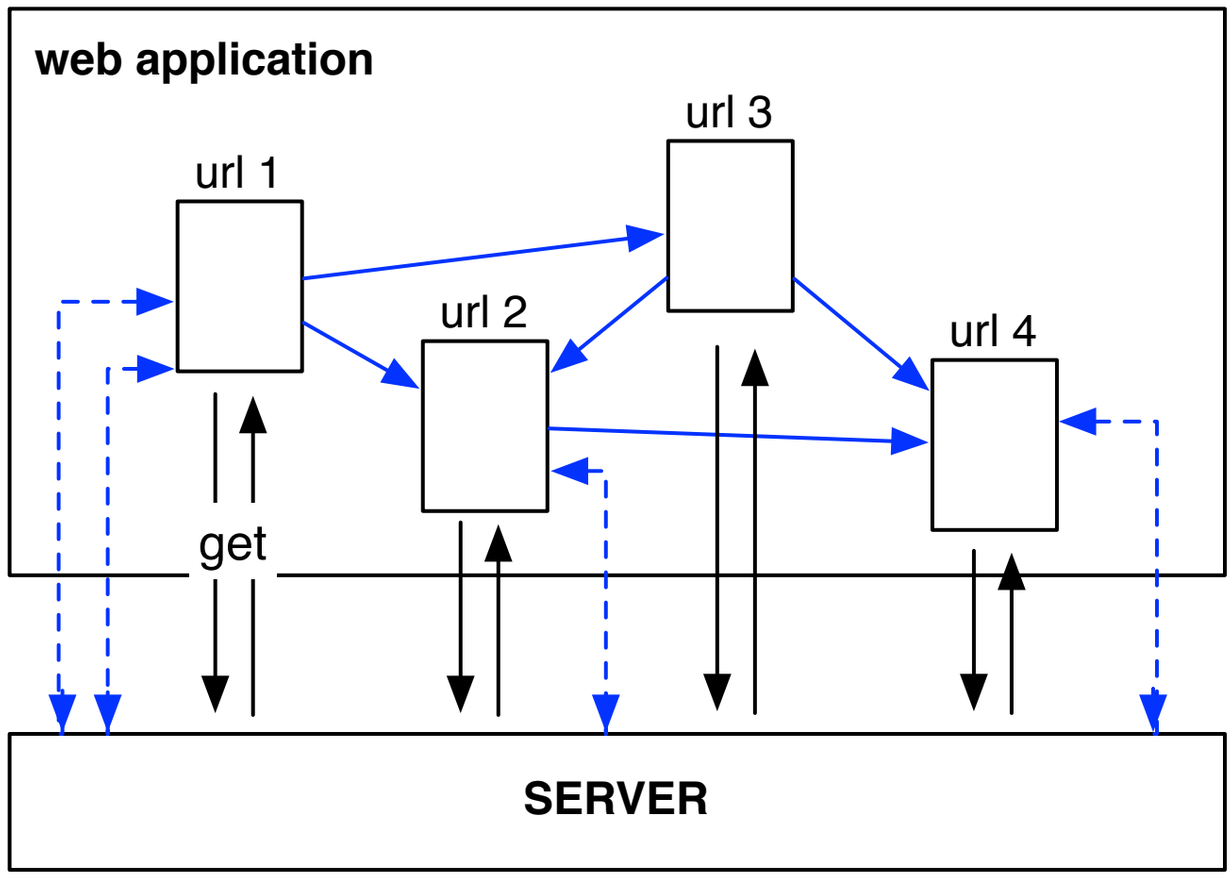


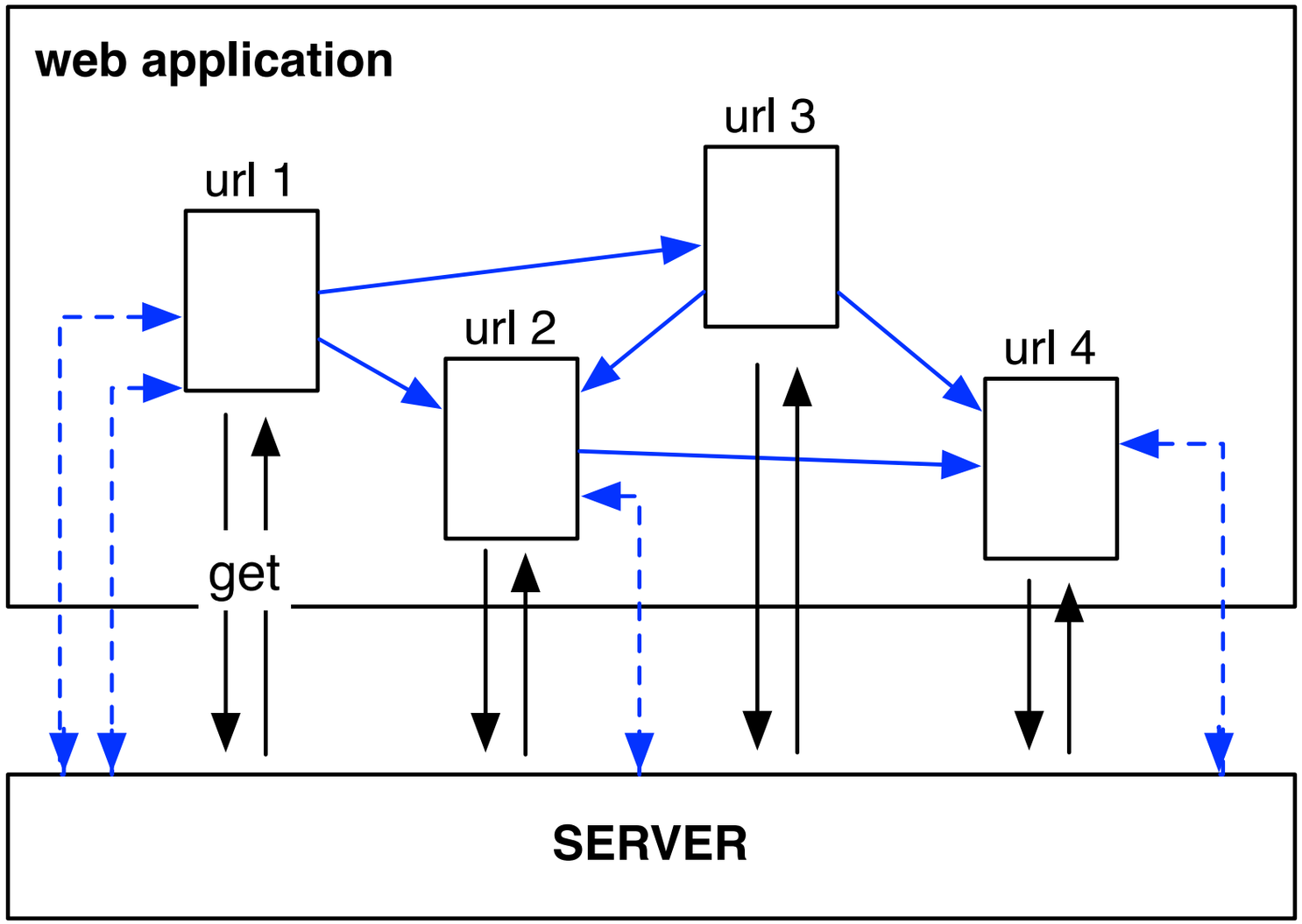
An initial page is loaded using HTTP GET, including the initial HTML document plus JavaScript code.

All other resources are loaded dynamically following user interactions.

Mixed Approach

- The two architectural styles can be mixed to combine the benefits of both.
- Use different web pages to setup the core structure of the application.
- Define data APIs to provide updates to the web pages and support different devices.
- Use asynchronous requests to improve performance and user experience.





Main application resources have a URL.
User interaction is improved by using asynchronous calls to data APIs.

Web Architecture Summary

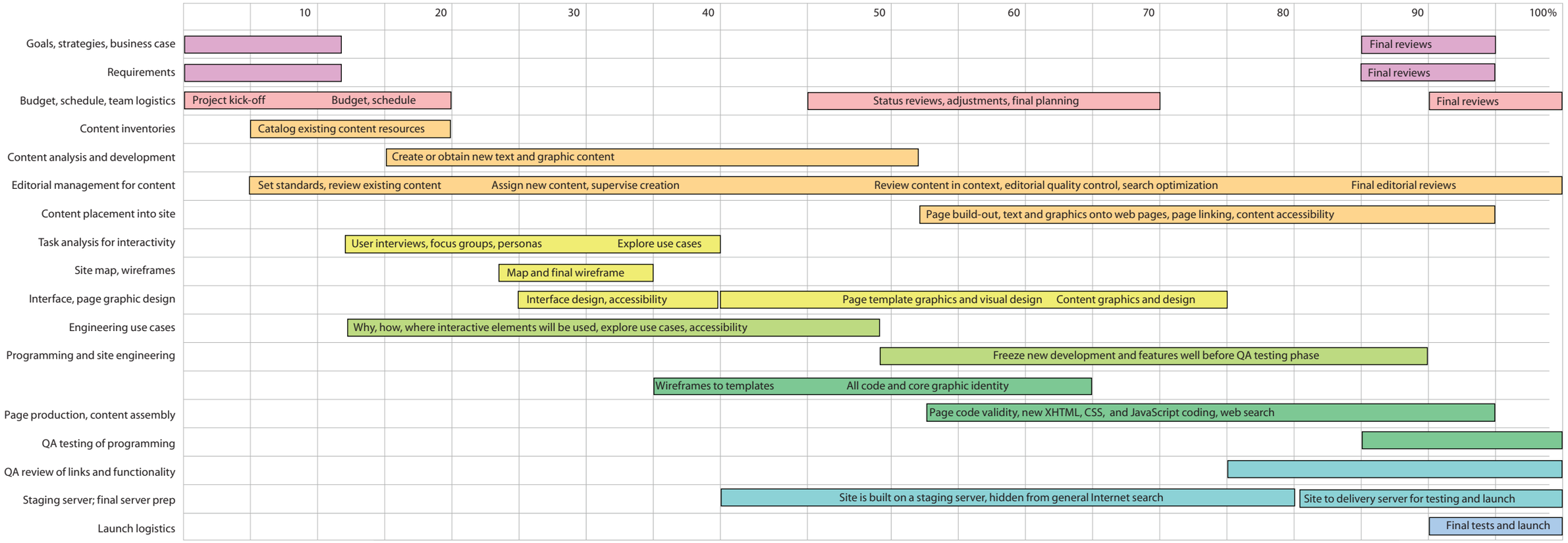
- Criteria to consider in choosing an architecture:
  - **Usability**
    User friendly? Instant updates possible? Browser history?
  - **Search / Share**
    Search engine friendly?
  - **Linking**
    Mapping between URLs and views? 1-to-1?
  - **Performance**
    Consistent across platforms? Optimized content loading? Client effort?
  - **Productivity**
    Developers background? Modularity?
  - **Testing**
    Modularity? What to test? Client dependency?

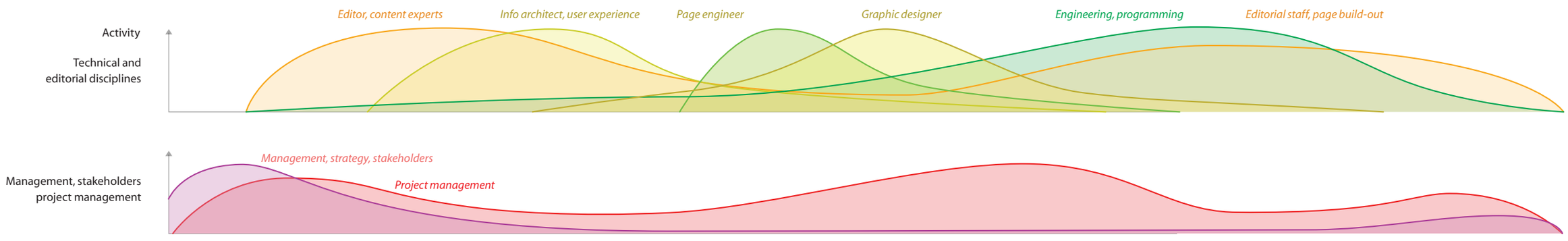
- **Choosing an Architecture == Choosing the Challenges**

Rendering on the Web

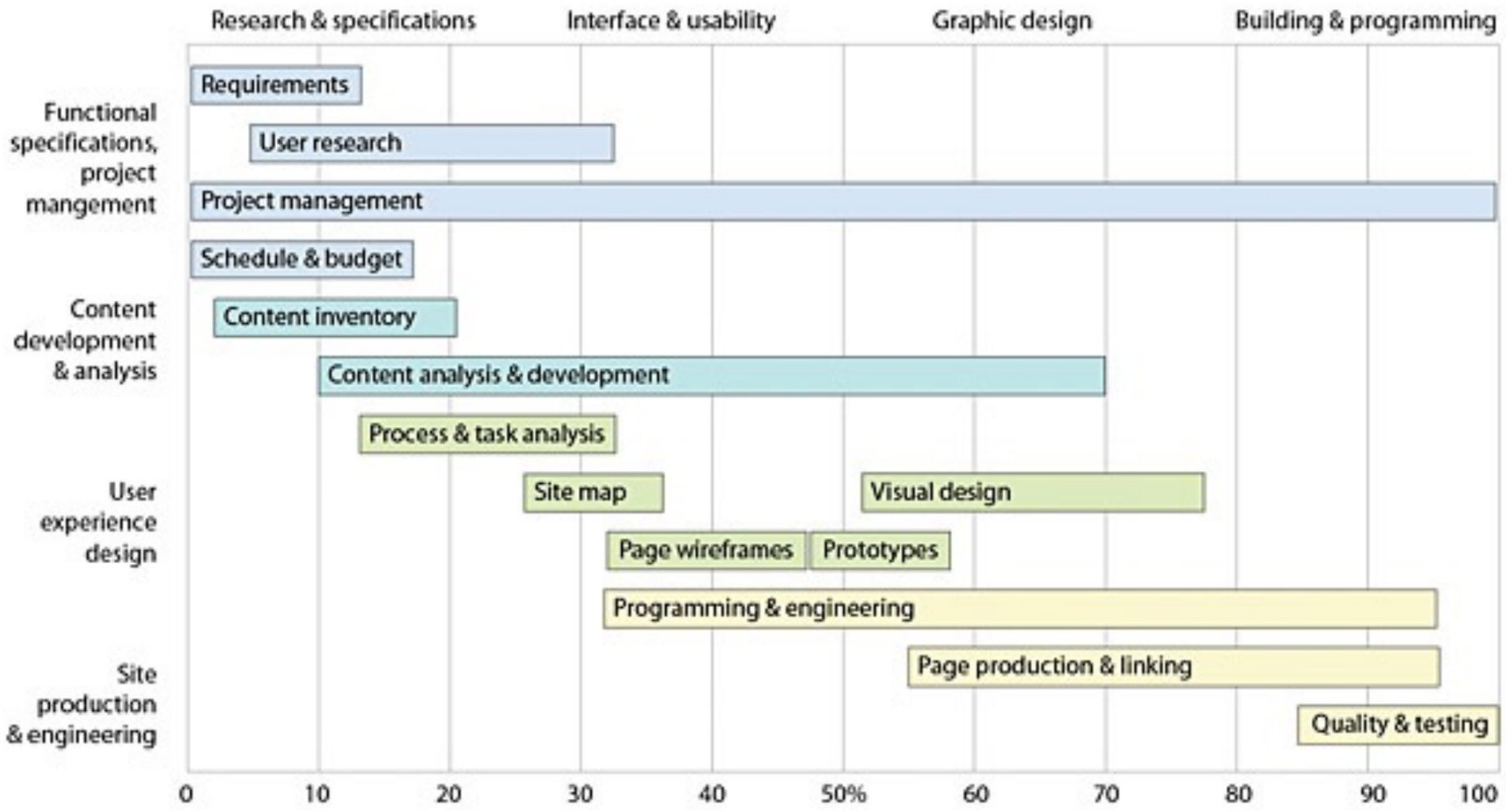
- **Exclusive server-side rendering**
  - Static – HTML corresponds to pre-built files on the server
  - Dynamic – HTML results from applications executed (on request) on the server
- **Server and client-side**
  - Server-side rendering with hydration — HTML is dynamically built on the server with updates on the client (logic mostly on the server)
  - Client-side rendering with server pre-rendering — HTML initial version is prepared on the server but the client then takes over (logic mostly on the client)
- **Exclusive client-side rendering**
  - Full client-side rendering — only a minimal skeleton is served from the server, all the application logic and rendering is done on the client

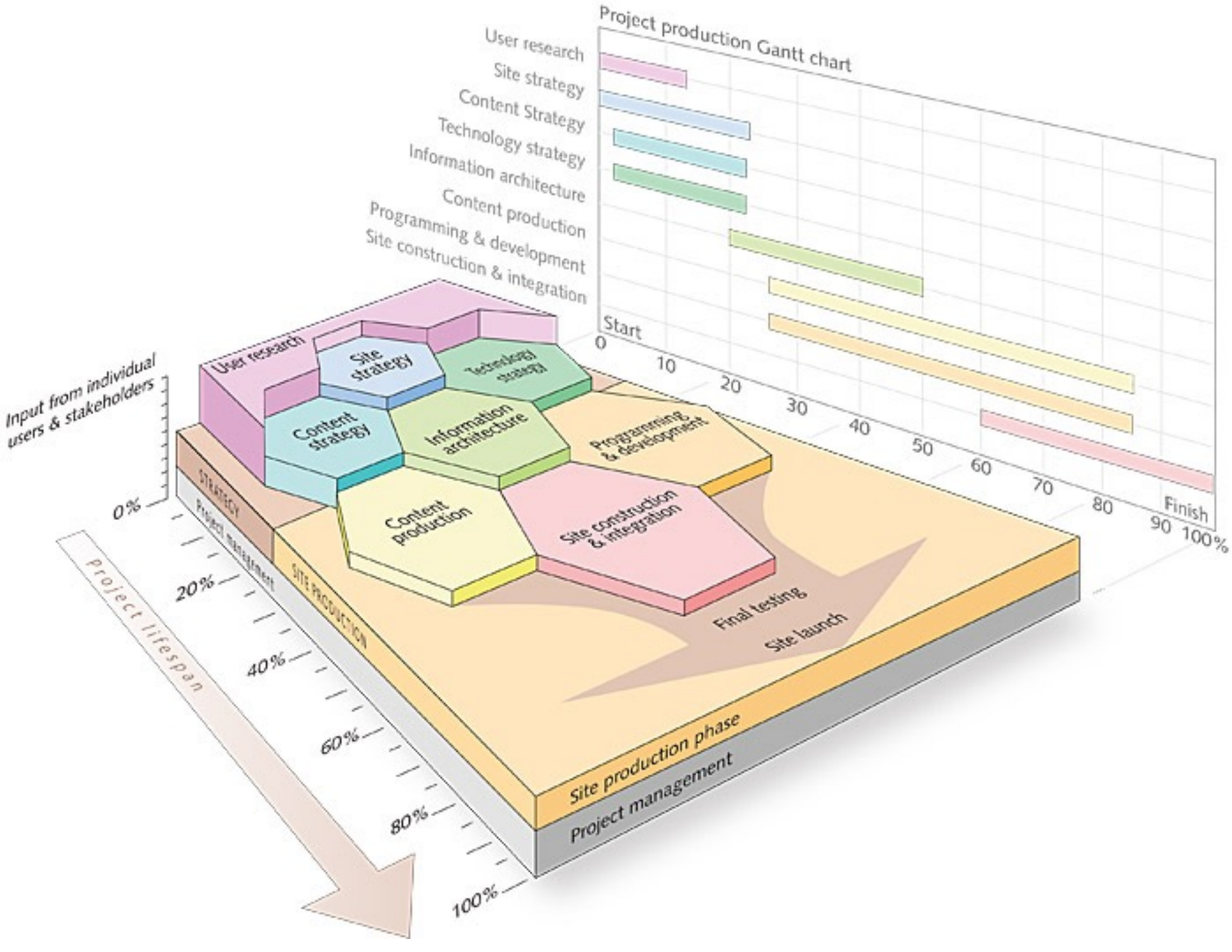
Web Site Development Process

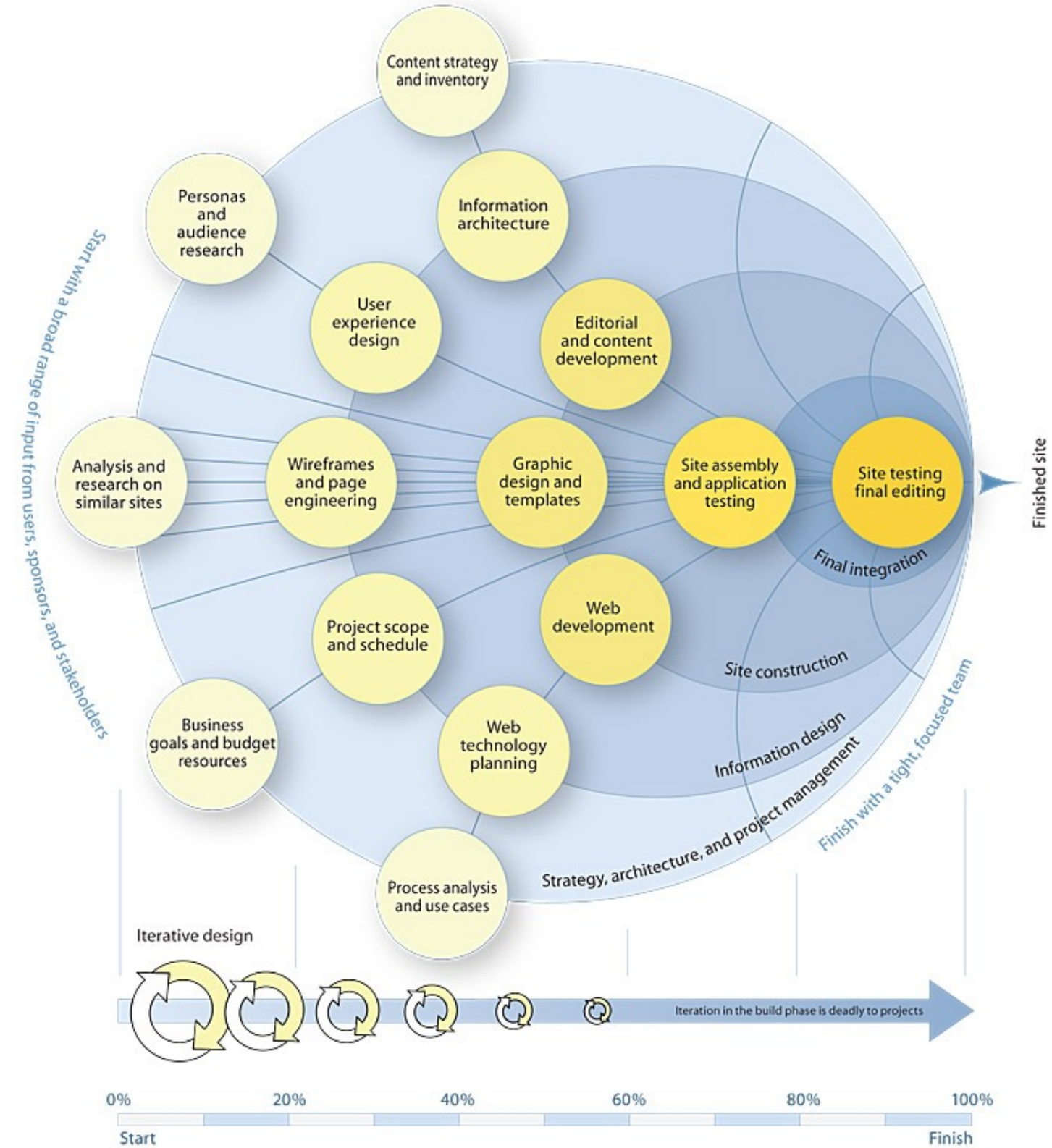




 From the book *Web Style Guide: Basic Design Principles for Creating Web Sites*, 3rd ed. Yale University Press. www.webstyleguide.com


Research & specifications
Interface & usability
Graphic design
Building & programming
Functional specifications, project mangement
Requirements
User research
Project management
Schedule & budget
Content development & analysis
Content inventory
Content analysis & development
Process & task analysis
User experience design
Site map
Visual design
Page wireframes
Prototypes
Programming & engineering
Site production & engineering
Page production & linking
Quality & testing
0
10
20
30
40
50%
60
70
80
90
100


Project production Gantt chart
User research
Site strategy
Content Strategy
Technology strategy
Information architecture
Content production
Programming & development
Site construction & integration
Start
0
10
20
30
40
50
60
70
80
90
100%
Finish
Input from individual users & stakeholders
User research
Site strategy
Technology strategy
Content strategy
Information architecture
Programming & development
Content production
Site construction & integration
Final testing
Site launch
STRATEGY
Project management
Site production
0%
20%
40%
60%
80%
100%
Project lifespan
Site production phase
Project management


Content strategy and inventory
Personas and audience research
Information architecture
User experience design
Editorial and content development
Analysis and research on similar sites
Wireframes and page engineering
Graphic design and templates
Site assembly and application testing
Site testing final editing
Finished site
Final integration
Project scope and schedule
Web development
Site construction
Business goals and budget resources
Web technology planning
Information design
Process analysis and use cases
Strategy, architecture, and project management
Start with a broad range of input from users, sponsors, and stakeholders
Finish with a tight, focused team
Iterative design
Iteration in the build phase is deadly to projects
0%
20%
40%
60%
80%
100%
Start
Finish

The Web Stack of Technologies (1)

- **Networking** – DNS, TCP/IP.
- **Web Protocols** – HTTP, REST.
- **Data Formats** – HTML, JSON, XML.
- **Web Servers** – Apache, IIS, nginx, lighttpd, node.js.
- **Data Storage** – SQL, NOSQL, cache system, file system.
- **Server-side Programming** – Languages, libraries, frameworks.
- **Content Management Systems** – Reusable building blocks (e.g. Wordpress).
- **Library and framework management**
- **Building and packaging** – How to distribute web products: hosting, CDNs.

Based on: http://radar.oreilly.com/2015/03/full-stack-tensions-on-the-web.html

The Web Stack of Technologies (2)

- **Device Capabilities** – Which features are supported.
- **Template Design** – Reusable, modular solutions.
- **Content Presentation** – HTML, CSS.
- **Interface Programming** – Also HTML and CSS but a lot of JavaScript.
- **Performance** – How to improve response speed.
- **Resilience** – How to make reliable systems.
- **Security** – Critical and complex in web systems.
- **Navigation Design** – How to organize content and navigation.
- **Graphics** – Images, SVG, Canvas.

Based on: http://radar.oreilly.com/2015/03/full-stack-tensions-on-the-web.html

Web Technologies

- **The modern web technology stack is huge**.
- There are many different options (at different tiers) for the same task.
- No one is a “web expert”.
- But knowing about the full web stack is important for collaboration.
- Web development is organized in two major areas:
  client-side and **server-side** development.

Server-Side Technologies

- There are many options in server-side technologies. In theory as many as programming languages. Most popular options: PHP, Java, Python, Ruby, Perl, C#, Go. Also JavaScript with node.js.

- Server-side technologies also includes data management solutions, e.g. filesystem, database management systems. Most popular options: MySQL, PostgreSQL, Oracle, SQL Server, SQLite.

- **In LBAW we will use PHP, Laravel framework, and PostgreSQL.**

Client-Side Technologies

- Client-side technologies run on the web client.

- Three main technologies: HTML, CSS and JavaScript. HTML and CSS are declarative languages, while JavaScript is a full-fledged programming language.

- There is an increasing number of libraries and *boilerplates* to support client-side web development.

- **In LBAW we will use HTML, CSS, jQuery and AJAX.**

- Also notes on web performance, security, accessibility and usability.

Further Reading

- "As We May Think"
  Vannevar Bush. Atlantic Monthly, 1945

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- HTTP: The Definitive Guide
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- Opera Web Standards Curriculum
  http://dev.opera.com/articles/wsc/

- The Modern Web: Multi-Device Web Development with HTML5, CSS2 and JavaScript
  Peter Gasston. No Starch Press, 2013
  http://modernwebbook.com/