Redes de Computadores (RCOMP)

Lecture 09

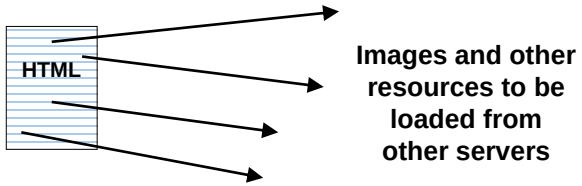
2017/2018

- HTTP application protocol.

Hypertext file transfer

Hypertext refers to documents with live links to other documents, this may mean directly clickable references (hyperlinks) or references to other resources to be included in the document presentation, like for instance images.
In either case, references are links to other documents and resources. Each reference is represented by an URL with a filename location to be accessed through the network by using a specific file transfer application protocol.

To fully load an HTML (Hypertext Mark-up Language) document, beyond the file itself, there may be several references to additional resources to be loaded. For each, an additional file transfer will be required.



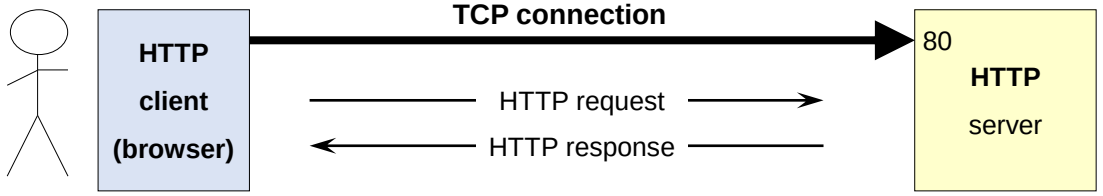
Although FTP (File Transfer Protocol) can be used, it proved to be inappropriate for this type of application. FTP requires one control connection with user authentication (even if it's anonymous) and then another connection for each file transfer from that server. It's not suitable for transferring a big number or relatively small files from different locations.
To workaround FTP issues on hypertext, a content-oriented file transfer protocol was designed, the Hypertext Transfer Protocol (HTTP).

Hypertext Transfer Protocol

Despite earlier versions, the first fully functional version supported nowadays appeared in 1996, named HTTP 1.0. The key idea for HTTP is providing an expedite data transfer, thought it may not be a file, so we just call it a content.
HTTP is also content-aware, this means it will exchange information about content related characteristics with applications using it.

The service model for HTTP is the typical TCP client-server. The client starts by establishing a TCP connection with the server (the standard TCP service port number is 80). Once the connection is established, the client sends an **HTTP request message**, the server must then send back an **HTTP response message**.

HTTP defines several request types, they are known as **methods**.



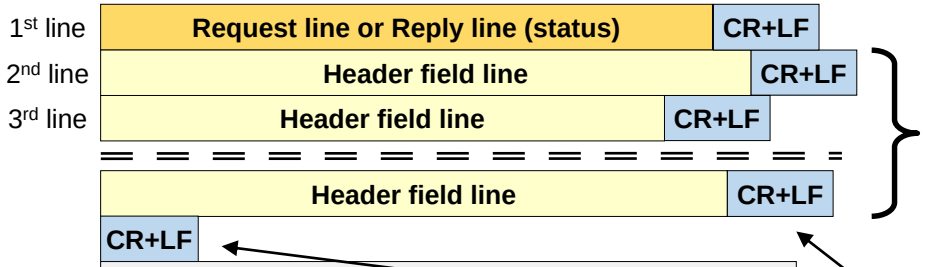
HTTP 1.0 defines GET, POST, and HEAD methods, earlier versions only had GET.

HTTP 1.1 adds to them, OPTIONS, PUT, DELETE, TRACE, and CONNECT methods.

HTTP message format

All HTTP messages (**both requests and responses**) share the same well-defined general format. They always start with a sequence of variable length text lines, terminated by one empty line. Every text line itself is terminated by CR (Carriage Return) byte followed by the LF (Line Feed) byte.

The first line is either the request line (for an HTTP request message), or the reply / status line (for an HTTP response message). Unlike the first one, additional text lines are optional, they are called **header fields**. Header fields transport additional information about the protocol operation and the message content.



A variable number of header field lines, there may be none.

Message **body**, also known as **content** or **entity**.

Can have any format, it may not be text.

It may not exist, not all messages have a body.

Two consecutive CR+LF sequences (an empty line) points out the header's end, the message body (if exists) starts next.

CR	13	0x0D	\r
LF	10	0x0A	\n

HTTP – Request and response messages

The first line in an **HTTP request message** is called the **request line** and has the following format:

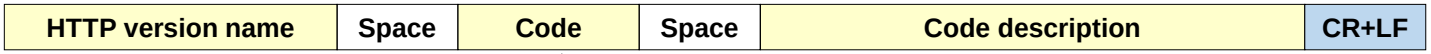
OPTIONS
GET
HEAD
POST
PUT
DELETE
TRACE
CONNECT

Identifies the resource over which the method will be enforced, no spaces neither CR or LF are allowed. It can may have one of three forms:

- An asterisk – not to be applied to any specific resource
- An absolute path (slash started) – a counterpart local resource (URI)
- An URI (may be an URL)

HTTP/1.0
HTTP/1.1
(…)

The first line in an **HTTP response message** is called the **status line** and has the following format:



HTTP/1.0
HTTP/1.1
(…)

The status code is a three digits number.

For instance, 200 means total success on the operation and usually will have the **OK** code description.

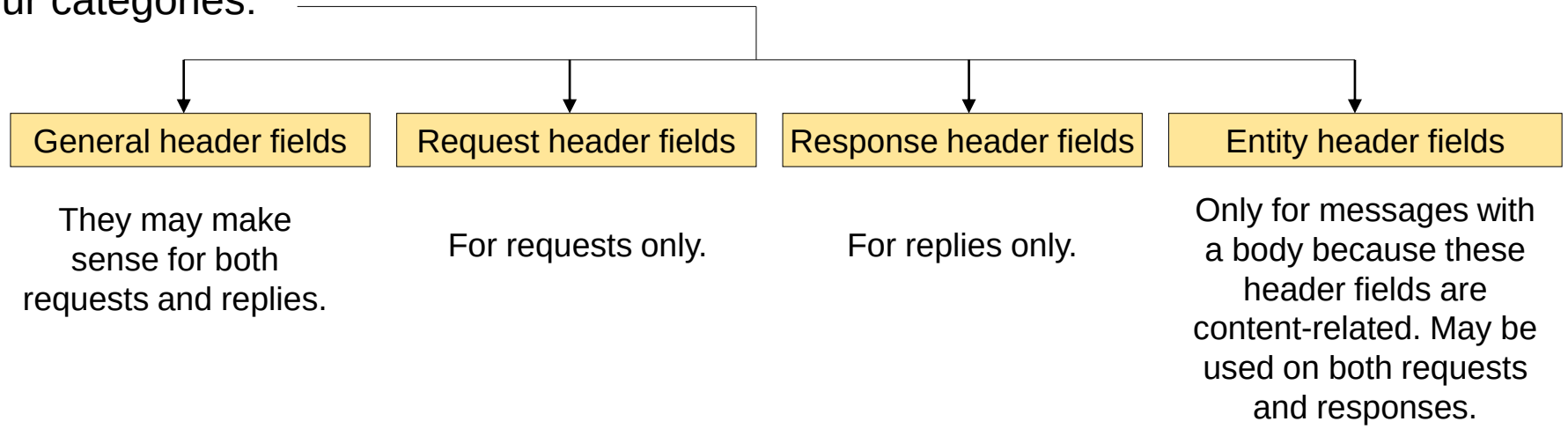
Header fields

Header fields are text lines used to transmit control information, either related to HTTP operations or related to the message's content (body).

The general form is:

Field name	:	Field value	CR+LF

Where **Field name** is a standard case-insensitive identifier with special meaning for HTTP, it's immediately followed by a colon, no whitespaces between.
The **Field value**, on the other hand, may be preceded by white characters, they should be ignored. Depending on the field name, the field value may or not be case-sensitive.
Both requests and replies usually have header fields, but many header fields only make sense for some messages. Traditionally, header lines have been divided into four categories:



HTTP/1.1 general-header fields

They may be used both in requests and responses and do not refer to the content. Some most often used general-header fields are:

Cache-Control	Settles how data may be cached by clients, servers and proxies, some possible values are **no-cache**, **no-store**, **max-age**, **public** and **private**. Not available for HTTP/1.0, Pragma must be used instead.
Connection	Unlike in HTTP/1.0, in HTTP/1.1 the default behavior is keeping connections open to allowing multiple requests and replies. The header field **Connection: close** informs the counterpart the connection is going to be closed after the current transaction.
Date	Hold the date/time of the message creation. For instance: **Date: Tue, 15 Nov 1994 08:12:31 GMT**
Pragma	Settles operational directives, most used value is **no-cache** to indicate no data caching is allowed.
Upgrade	Clients may include this on requests to inform the server about new protocol versions they support, the server may then inform the client it wants to switch to on of them by sending a **101 Switching Protocols** response with the Upgrade header field indicating to which is switching to. For instance: **Upgrade: HTTP/2**
Transfer-Encoding	Informs the counterpart about a transformation applied to the message body. This is similar to the entity header field **Content-Encoding**.

HTTP/1.1 entity-header fields

They are content-related. Even though, they make most sense for messages with a body, they are also used in some other cases. Some common entity-header fields are:

Allow	Informs about supported methods to access a resource. It will be included in a **405 Method Not Allowed** response.
Content-Encoding	Informs the message receiver about some coding was applied to the content, for instance: **Content-Encoding: gzip**
Content-Language	Describes the natural language of the intended audience for the content.
Content-Length	Defines the size in octets of the content. This is supposed to be used by message receivers to know how many bytes they should read from the body starting point.
Content-MD5	Holds the result of applying the Message Digest 5 algorithm to the content, used for integrity checking.
Content-Range	This is used for a partial content message body. It must specify the body position within the original content and the total original content length. Example: **Content-Range: bytes 21010-47021/47022**
Content-Type	Informs the receiver about the content media, thus, how the content should be interpreted and ultimately displayed to the end-user.
Expires	Contains a date/time after which cached copies of the content are no longer valid.
Last-Modified	Contains the date/time the content was last modified. If the content comes from a file may be the file last modification time.

HTTP/1.1 request-header fields

HTTP request messages specific. Some most often used request-header fields are:

From	Contains the personal e-mail address of the human user on the client application side.
Host	Contains the hostname and port number being accessed, either typed by the user at the browser or from the clicked URL in a document. Default port number is 80. Example: **Host: www.dei.isep.ipp.pt.pt:8080**
Referer (misspelled)	Contains the URL of the document from where the present request was followed (referred by). This field should not exist for directly user typed requests. Example: **Referer: http://www.dei.isep.ipp.pt/index.html**
User-Agent	A string identification for the client application, usually a browser. Example: **User-Agent: Mozilla/5.0 (Linux; Android 4.0.4; Galaxy Nexus Build/IMM76B)**
Authorization	User authentication data, usually username/password. Must be included following an **401 Unauthorized** response.
Cookie	Contains a pair name and value provided by the counterpart in a previous response. Example: **Cookie: sessionToken=ts12325**

HTTP/1.1 request-header fields – conditional requests

These HTTP request-header fields introduce client demands regarding contents to be returned in responses.

Accept	Requires the response content to be in one of the specified media types (content types). Example: **Accept: text/*, text/html, text/html;level=1, */***
Accept-Charset	Requires the response content to be in one of the specified charsets. Example: **Accept-Charset: iso-8859-5, unicode-1-1;q=0.8**
Accept-Encoding	Restricts possible content-coding values for the response content. Example: **Accept-Encoding: compress, gzip**
Accept-Language	Restricts possible content languages to a given set. Example: **Accept-Language: da, en-gb;q=0.8, en;q=0.7**
If-Modified-Since **If-Unmodified-Since**	Causes the response to depend on the requested resource last modification time/data.
If-Match **If-None-Match**	Causes the response to depend on the value for the ETag entity-header field. Messages with a body may define a **ETag** entity-header for the content (body) they carry.

HTTP/1.1 response-header fields

HTTP response messages specific. Some most often used response-header fields are:

Age	For cached replies, this is estimated elapsed time in seconds since the original response was obtained.
Location	This is used to redirect the requester to a different document from the one requested. Contains a document URL. Is used for **3xx** responses, for instance **307 Temporary Redirect**.
Public	Inform the client about server supported methods in general, not specifically on the requested URI. Example: **Public: OPTIONS, MGET, MHEAD, GET, HEAD**
Retry-After	Used in **503 Service Unavailable** response to inform about when the service is expected to be available, may be a date/time or a time period is seconds.
Server	A string identification for the server application. Example: **Server: CERN/3.0 libwww/2.17**
WWW-Authenticate	Used with **401 Unauthorized** response informing access to the resource requires user authentication. This field informs about the expected authentication mechanism to be used.
Set-Cookie	Contains a pair name and value for the client to use in the **Cookie** header field on subsequent requests. The purpose is the server being able to identify this particular client in next requests, and thus, maintain with it a stateful session. Example: **Set-Cookie: sessionToken=ts12325**

HTTP/1.1 – OPTIONS and GET methods

OPTIONS	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

The response to this request provides the client with a list of available methods to access the URI, if the URI is an asterisk, then a list of methods supported by the server is provided.
The response will be usually **200 OK** and the response-header field **Allow** will l have a list of supported methods and eventually other header fields defining the server capabilities.

GET	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

Used to obtain (download) the content pointed by URI. Typically, URI refers to a static content stored in a file, however, that may not be the case, it may also be dynamically generated by the server.
The technique known as CGI (Common Gateway Interface), allows the server to execute external programs or scripts and return their output as response message content. In these cases, URI refers to something executable and not a static file.
In most cases, CGI applications require input data to be provided by the client (usually collected in an HTML form). However, GET method requests can´t have a body, this is somewhat overcome by embedding form data in the URI, appending the query string.
The query-string starts by a question mark and it's made of an ampersand separated list of pairs form field name and form field value. For instance:

http://www.server1.net/login?username=teste&password=pppttee&dep=5

A URI is obviously not the best-suited local to place forms data, only plain text data is supported and there are length issues. Beyond that, data will be visible in the URL. The POST method request is more suitable because it can have a body to carry data.

HTTP/1.1 – HEAD, POST, PUT and DELETE methods

HEAD	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

The response to the HEAD request is exactly the same that would be achieved with a GET request for the URI, except that it will have no body, nevertheless, all header fields will be the same.

POST	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

The POST request purpose is sending data to an URI, this will normally be some kind of executable application. Unlike with the GET method, data is placed on the message body, therefore, there are no restrictions whatsoever on data content and length.

PUT	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

The PUT request can be interpreted as the reverse of GET method. It allows the upload of a content to a URI. It is mostly intended to upload a content to a file named by the URI, however, it may also be used with the same purpose of POST if URI refers to an application.

DELETE	Space	Argument (URI)	Space	HTTP/1.1	CR+LF

Used to request the removal of a resource on the counterpart. The URI is supposed to represent the name of the file to be removed.

HTTP/1.1 – Response status-codes (1xx, 2xx, and 3xx)

HTTP responses status-codes can be grouped in five categories depending on the leftmost digit:

HTTP/1.1	Space	1XX	Space	Textual code description	CR+LF

Codes 1XX didn't exist in HTTP/1.0, they indicate some additional messages are expected over the same connection. For instance **100 Continue** indicates the server has accepted the request first part and is expecting something else. The **101 Switching Protocols** is used when the server wants to upgrade to a higher HTTP version (**Upgrade** general-header field).

HTTP/1.1	Space	2XX	Space	Textual code description	CR+LF

Notify about a success on the requested operation. Examples:

200 OK – indicates total success on a GET, HEAD or POST.
201 Created – as result of the request a new resource has been created.
202 Accepted – the request was accepted, but may not have been yet executed, there may be a delay.
206 Partial Content – the content on the response body is only partial.

HTTP/1.1	Space	3XX	Space	Textual code description	CR+LF

Alert about a failure and the need for the client to reformulated the request. Examples:

300 Multiple Choices – there are several option to execute the request. A list is provided.
301 Moved Permanently – the resource was dislocated, the new location is provided by the **Location** field.
303 Moved Temporarily – temporary dislocation, the new location is provided by the **Location** field.
304 Not Modified – response to a conditional GET request when conditions are not meet.

HTTP/1.1 – Response status-codes (4xx and 5xx)

HTTP/1.1	Space	4XX	Space	Textual code description	CR+LF

Codes 4XX alert about what the server thinks it's a client side request error. Examples:

400 Bad Request – the server simply did not understand the request made.
401 Unauthorized – the server demands user authentication for the request made.
403 Forbidden – the resource exists but is not accessible due to the lack of permission.
404 Not Found – the requested resource was not found in the server.
405 Method Not Allowed – the used method is not possible for the requested resource.
406 Not Acceptable – an Accept field restriction on the request could not be satisfied by the server.
411 Length Required – the server refuses to accept the request with no Content-Length specified.
412 Precondition Failed – an If field precondition on the request could not be satisfied by the server.

HTTP/1.1	Space	5XX	Space	Textual code description	CR+LF

These codes are about server side issues, they mean the server is aware there is a problem and was unable to fulfill the request. Examples:

500 Internal Server Error – the server has a severe problem and was unable to process the request.
501 Not Implemented – the request method is not supported by the server.
503 Service Unavailable – the server was unable to process the request due to a temporary overload.
505 HTTP Version Not Supported – the request HTTP version is not supported by the server.

Persistent TCP connections

Under HTTP 1.0, TCP connections between the client and the server are presumed to be non-persistent, this means for each request/response one TCP connection is required and it's closed once the response is received.

HTTP 1.0 may optionally support persistent connections, to force that behavior, clients must include the **Connection: keep-alive** header line. If the server supports it, then it will also include the same header line on the response.

Under HTTP 1.1, TCP connections between the client and the server are presumed to be persistent, this means one TCP connection can be used for several request/response dialogues.
Even so, clients should include the **Connection: keep-alive** header line on their requests if they want to reuse the connection for further requests.

Persistent connections HTTP 1.1 behavior can be reverted to HTTP 1.0 behavior by adding the **Connection: close** header line. Clients using HTTP 1.1, and not supporting persistent connections must include this header line on every request. The server response will also include it, and the connection is then closed.

In principle, persistent connections are maintained until the client sends a request with the **Connection: close** header line. Then, the server response will also include the same header line and once the response is received by the client the connection is closed.

Persistent TCP connections keep alive timeout

In HTTP a persistent TCP connection can be used for several request/response dialogue sequences. If the client wants to close the connection after a request/response sequence it must include the **Connection: close** header line in the request.

> Nevertheless, persistent connections don't persist indefinitely. For the sake of resources saving, both client and server applications define a **keep alive timeout**, if no request/response is send during that time the connection is closed.

Default persistent connections a keep alive timeout for each application differs and may be an application configurable parameter.

Nevertheless, the **Keep-Alive:** header line can be included in requests and responses that contain the **Connection: keep-alive** header line.

This informs the counterpart about its current settings, two parameters are currently supported for the **Keep-Alive:** header line: **max** and **timeout**.

max specifies the maximum number of request/response sequences the connection supports (since it started), once that number is exhausted the connection is closed.

timeout specifies the number of seconds the connection is kept open with no traffic, if no request is sent within this time period, the connection is closed.

Example:

```
Connection: Keep-Alive
Keep-Alive: timeout=10, max=5
```

HTTPS (*Hyper Text Transfer Protocol Secure*) - HTTP over TLS (SSL)

HTTPS is not different from HTTP, it's the same protocol, but instead of running over plain TCP it runs over TLS (Transport Layer Security). TLS is the successor of Secure Sockets Layer (SSL), it provides secure network services for applications.
An HTTP client creates a TCP connection to the server, and may then send the request. An HTTPS client creates a TCP connection to the server, secures it with TLS, and only then, can send the request.

To secure the connection, the client sends the **TLS ClientHello** message to the server. At this stage some, TLS messages are exchanged, the server's authenticity is assured by a **valid public key certificate** and a secret cryptographic key is then generated to encrypt data. Once the TLS handshake is finished, HTTP protocol can then be used, now requests and replies have guaranteed privacy.

Public key certificates have a critical role in HTTPS security, they give clients the guarantee they are talking with the authentic server and not a fake.

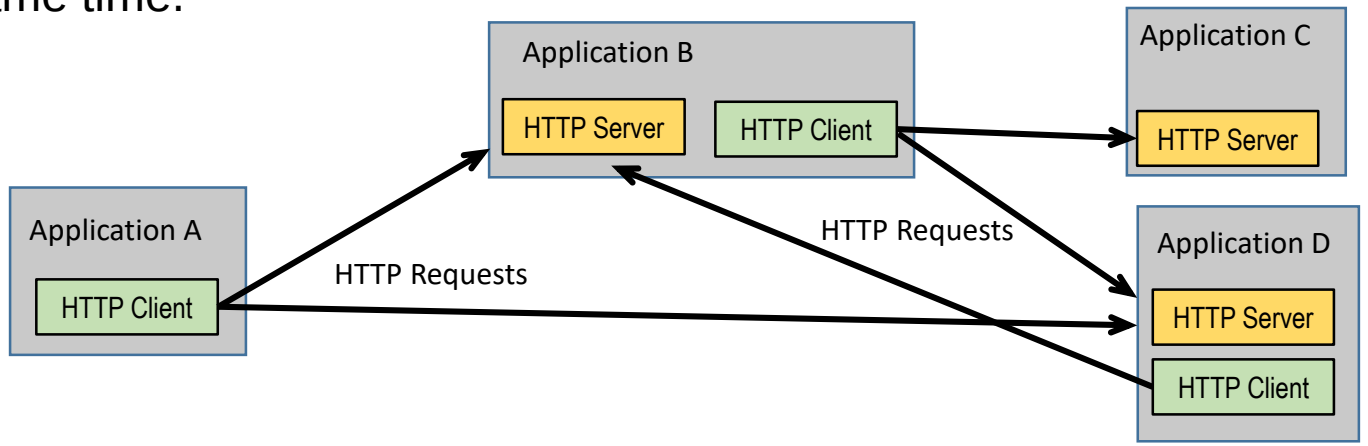
While the standard HTTP service port number is 80, for HTTPS it's port number 443. The browser will assume as default these port numbers by looking at the initial section the URL, correspondingly **http://** or **https://**. Default port numbers may be overridden if explicitly specified, for instance: **http://server.pt:8080**.

HTTP/HTTPS as general purpose application protocol

Designing and implementing a new application layer protocol for some distributed applications architecture is a rather significant effort and investment. This investment can be avoided if an already existing application layer protocol is reused and eventually adapted.

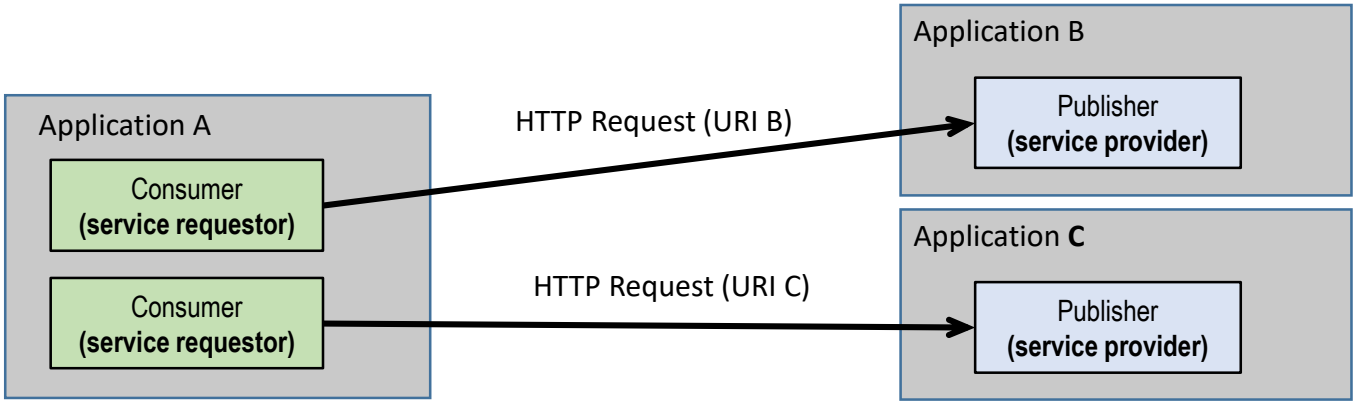
We must bear in mind this may not be the best technical option, however, it may be the best option under investment point of view. Some adaptations to the original protocol usage may be required because it was designed with a different purpose, nevertheless, the protocol specification itself must be kept.

Because it's standard, simple and flexible, HTTP/HTTPS is widely adopted for this purpose. To achieve this, each application contains an HTTP server, an HTTP client, or both. The client-server model is preserved, though one application can be client and server at the same time.



Web Services

The central concept on web services is the use of HTTP for application-to-application communications without direct human involvement.
To make use of a web service, one application (**service requestor or consumer**) assumes the HTTP client's role and the other (**service provider or publisher**) the HTTP server's role. The web service is made available to service requestor applications by the service provider application.



From this central concept, some typical distributed systems issues rise. One issue is about **data representation**, it should be independent of individual local systems so that received data can be understood on any kind of node. Another issue is about **publishers identification** by requestors, that will encompass the publisher's node address or DNS name, and also, the resource itself within that node address.

Web Services – data representation

As it is, the web services concept is very wide. As far as the HTTP protocol is fulfilled and respected, all kind of information exchanges between applications can be implemented as web services.

Concerning data representation, the most widely used solution is extensible markup language (XML), another alternative is JavaScript Object Notation (JSON).

Both represent data in a human readable text format, yet also suitable for automated parsing. In each case the appropriate content-type specification should be used, correspondingly, **application/xml** and **application/json**.

Also, some higher level standards have been established on more details about how applications can communicate through web services, two examples are SOAP (Simple Object Access Protocol) and XML-RPC (Remote Procedure Calls in XML format through HTTP).

Due to the client-server model, implicit by HTTP, requestors must know where to find publishers, and then, what services are provided by that publisher.

Web Services – resources identification

Resources are identified by an URL, an URL identifies a resource, and also, how to access it. So, an URL starts by an access protocol name, for web services **http://** or **https://**, then it identifies the node's address, usually through a DNS host name. Optionally it may also specify a port number preceded by a colon. If the port number is not specified, then the protocol's default port number is implicit.

This is called the **origin** part of the URL. The remaining part of the URL identifies the resource within that origin, it starts by a slash and may reflect an internal hierarchical resources organization with names separated by a slashes.

Regarding the origin part, it shouldn't be hardcoded into applications because it depends on the running environment, they should be provided to applications as runtime configuration data. Each resource's local identification within the origin, on the other hand, may be hardcoded into requestor applications.

Usually requestors known what resources are provided by a publisher, nevertheless, standards have been established on how publishers can inform requestors about that. Web Services Description Language (WSD) and Universal Description, Discovery, and Integration (UDDI) make that information available to requestors in XML format.

Web Services and Web Browsers

From the web services concept, which excludes direct end-users interaction, it could be assumed web browsers are out of scope. Nevertheless, modern web browsers are themselves able to run applications, namely in JavaScript language. This makes them able to take part in web services architecture.

Current web browsers support the **XMLHttpRequest** object, in essence it's an HTTP client and allows a web page to, whenever it desires, make an HTTP request, retrieve data, and typically use that data to update parts of the page being displayed. This may be done without actually reloading the page, by using the HTML DOM (Document Object Model).

Requests with the **XMLHttpRequest** object should be asynchronous, this means, before triggering the request, a response handling function is defined. Then, the request itself will not block the web browser on waiting for the response, if and when the response arrives, then the response handling function is executed.

This technique is called **AJAX** (Asynchronous JavaScript and XML), by using it, the traditional web pages' behavior, requiring a reload or submission for an update with fresh data from the server, is overcome.

RESTful web services design model

REST stands for Representational State Transfer, it's a constrained resource based usage for web services, main principles (constrains) are:

- Clients request operations over server-side resources (identified by URIs), these operations are only: Create, Read, Update and Delete (CRUD), they are mapped to HTTP request methods.
- Resource contents are transferred in XML, HTML or JSON representations.
- Servers are stateless in the sense they do not store information about clients dialogue context. Therefore, on every request clients must provide all required context data.
- If the server has a state, then that state context must be represented by an addressable resource (URI), clients may then refer that state context on requests.

RESTful web services consumer applications can request the following four operations over a URI:

Operation	HTTP methods
Create a resource	POST; PUT
Read/retrieve a resource	GET
Update/Modify a resource	PUT
Delete/remove a resource	DELETE

RESTful – resources and collections

The only **safe method** is GET, meaning it does not change the resource or the server state. Methods PUT, GET, and DELETE are regarded as **idempotent methods**, this means making more than one repeated identical request has no additional effects beyond the effect of the first request.

A URI may refer to a single resource or a collection of resources, **singular names** are to be used for single resources, **plural names** for a collection of resources. Depending on being a single resource or a resources collection, HTTP methods will have different meanings:

HTTP method	Single resource (singular name URI)	Resources collection (plural name URI)
GET	Retrieve the resource.	List the of resources items in the collection. Retrieved data is a list of resources' URIs and optionally other resources' data.
PUT	Replace the resource, if it does not exist, create it.	Replace the whole collection with another collection.
POST	**Not used** because the URI would be regarded as a collection and a new collection item would be created within it.	Create a new resource item within the collection. The new resource URI is automatically assigned.
DELETE	Delete the resource.	Delete the entire collection.

RESTful - URI naming guidelines and best practices

- Singular names for single resources or collection's items/elements.
- Plural names for collections of resources.
- Verbs for controllers and functions.
- Camel casing for resources and lower case for URI.
- Hyphens instead of underscores.
- Avoid CRUD names (Create/Read/Update/Delete) in URI.
- URI path elements should represent resources' hierarchical structure.
- Use URI path components to represent variable values.
- A query component may be added to the URI.

Hypermedia As The Engine Of Application State (HATEOAS)

HATEOAS is a constraint of the REST application architecture. It means by accessing and retrieving a resource, a REST client also retrieves a **list of links** representing alternative actions from that point on. This is very similar to human web usage: when a web page is reached there are a set of alternative links to follow from that point.

This strategy makes the API discoverable by REST clients, though it's state dependent. Only after accessing a URI follow up links are provided, they represent possible state transitions from the initial state and may depend on the resource itself or other factors, like for instance user authentication used. Example using XML:

```
GET /accounts/1111 HTTP/1.1
    Host: example.com
    Accept: application/xml
    ...
HTTP/1.1 200 OK
    Content-Type: application/xml
    Content-Length: ...

    <?xml version="1.0"?>
    <account>
       <account_number>1111</account_number>
       <balance currency="usd">100.00</balance>
       <link rel="deposit" href="/accounts/12345/deposit" />
       <link rel="withdraw" href="/accounts/12345/withdraw" />
       <link rel="transfer" href="/accounts/12345/transfer" />
       <link rel="close" href="/accounts/12345/close" />
     </account>
```

```
GET /accounts/1112 HTTP/1.1
    Host: example.com
    Accept: application/xml
    ...
HTTP/1.1 200 OK
    Content-Type: application/xml
    Content-Length: ...

    <?xml version="1.0"?>
    <account>
       <account_number>1112</account_number>
       <balance currency="usd">0.00</balance>
       <link rel="deposit" href="/accounts/12345/deposit" />
       <link rel="close" href="/accounts/12345/close" />
     </account>
```

Because account 1112 has a zero balance, available actions are only deposit and close.

Same-origin policy

Web browsers implement a security concept called **same-origin policy**. An origin is the URL part representing the protocol, hostname and port number. If a document loading requires the retrieval of resources from other origins different from the base document's origin this is called **cross-origin**.

The **same-origin policy** requires all resources to be retrieved from the same origin as the base document. This is a browser side security feature to assure the user when a URL is typed, all retrieved resources are coming from that origin. **Most important, it guarantees to a web service being accessed, the access is being made from a page downloaded from the web service's origin.**

There's no universal standard **same-origin policy** for browsers, usually this policy is enforced only for **JavaScript and other scripting languages**. Cross-origin for static embedded resources like script sources, images and other media files are allowed. Writing operations are usually allowed, including form submissions. Cross-origin read accesses are not allowed.

However, if within a page, a script accesses a REST API on a different origin, its a clear policy violation and it will be blocked by the browser.

Changing the origin

Within some restrictions, scripts are allowed to change the page's origin of the document. They are allowed to change the hostname part of the document origin as far as it´s changed to an upper level domain name. In JavaScript this is done by setting the **document.domain** property.

Let's take for instance the following scenario:

- We load a page with origin **https://www.ipp.pt**
- This page has a script wanting to call web service **https://dei.isep.ipp.pt/users**. This is a same origin policy violation and is going to be blocked by the browser.
- However, the script is allowed to change it's page origin hostname from **www.ipp.pt** to **ipp.pt**, the web service **https:/dei.isep.ipp.pt/users** is also allowed to change it's origin hostname from **dei.isep.ipp.pt** to **ipp.pt**.
- Now both have the same origin and therefore there's no same origin policy violation anymore.

Notice: some browsers may have issues/bugs around **document.domain** property handling.

Cross-origin resource sharing (CORS protocol)

The **same-origin policy** enforced by browsers can be overridden by using the CORS protocol. When a CORS capable web browser detects a cross-origin request it will ask the requested URL for instructions regarding if access should or not be granted.

The HTTP request header line **Origin:** is used to query the server, it contains the full origin specification for the document making the request. In fact every HTTP request always contains this header line, it will be empty for a user typed URL.

The **Origin:** header line can be included on any request method, the server response is supposed to include a **Access-Control-Allow-Origin:** header line, otherwise the browser is to block the access by default.

If the **Access-Control-Allow-Origin:** header line returned by the server is **"*"**, meaning any origin is allowed, or the origin value specified in the request, then access is granted by the browser, otherwise is blocked.

For methods GET, HEAD and POST the query about access-control can be included in the request itself (Origin: header line). For other methods, a request with the OPTIONS method is triggered by the browser in the first place, this is called CORS preflight.

Access allowed by CORS is method dependent. Without a preflight, the allowed access applies only to the method used by the request.

CORS preflight request

Under CORS, requests with methods GET, HEAD and POST are called simple requests, they require no preflight. Requests with methods PUT, DELETE, CONNECT, OPTIONS, TRACE and PATCH always require a preflight. Though, depending on other factors, even for simple requests, browsers may be required to perform a preflight.

The CORS preflight is a test to anticipate if the real request will be allowed and in what conditions. It´s identical to the real request with the following differences:

- The **OPTIONS** method is used instead.
- The method to be used in the real request is declared on the **Access-Control-Request-Method:** request header line.
- Header lines to be included in the real request are declared at the **Access-Control-Request-Headers:** request header line.
- The **Origin:** header line contains the origin corresponding to the real request.
- Has no content.

The response to the preflight request lets the browser know if the real request should be allowed. Usually the same persistent connection is used for the preflight and then for real request.

CORS preflight response

The CORS preflight response holds a set of Access-Control response headers:

Response header line	
Access-Control-Allow-Origin:	Allowed origin specification, possibly equal to Origin: request header line or “*” (any origin allowed).
Access-Control-Allow-Methods:	A coma separated list of allowed methods, possibly including the requested one (Access-Control-Request-Method).
Access-Control-Allow-Headers:	A coma separated list of allowed header lines from the requested list (Access-Control-Request-Headers).
Access-Control-Max-Age:	For how long can this response be kept in cache.
Access-Control-Allow-Credentials:	Holds the **true** value if credentials can be used, otherwise this header is absent. Credentials can be cookies, authorization headers or TLS client certificates.
Access-Control-Expose-Headers:	A list of additional response headers to be made available to clients. Response headers Cache-Control, Content-Language, Content-Type, Expires, Last-Modified, and Pragma are always exposed.