Web Application Development and Web Services

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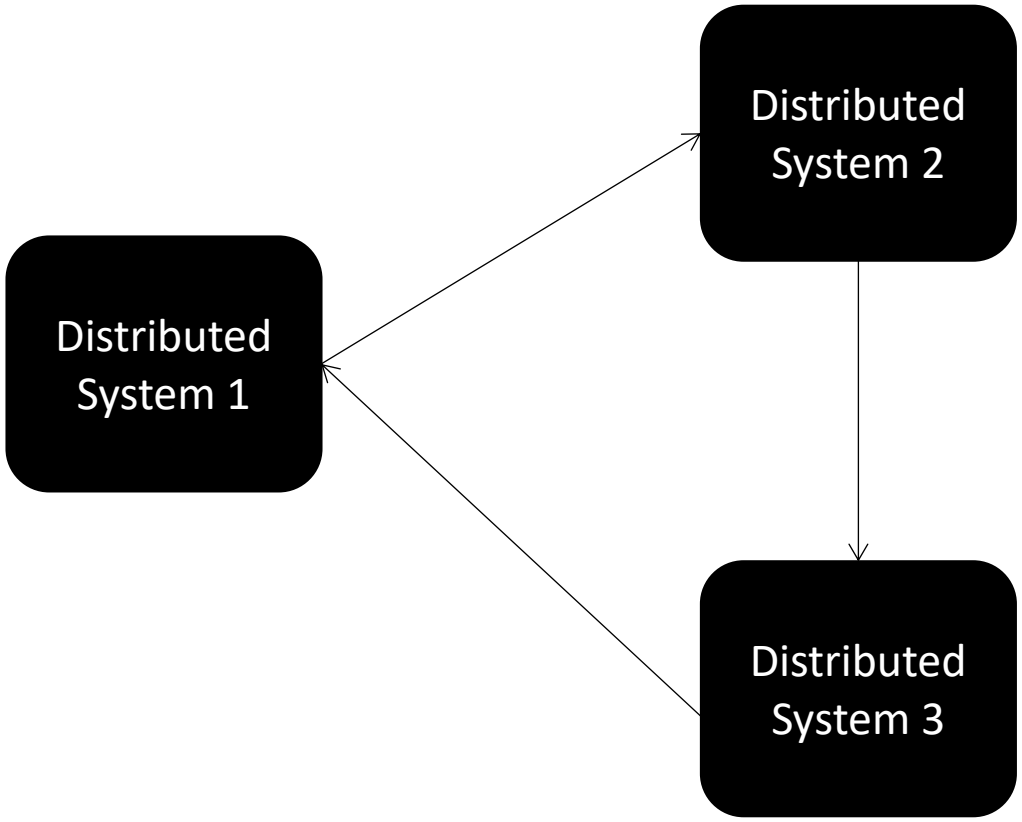
If You Think Math is Hard Try Web Design. **– PixxelzNet.**

How to Achieve Interoperability?

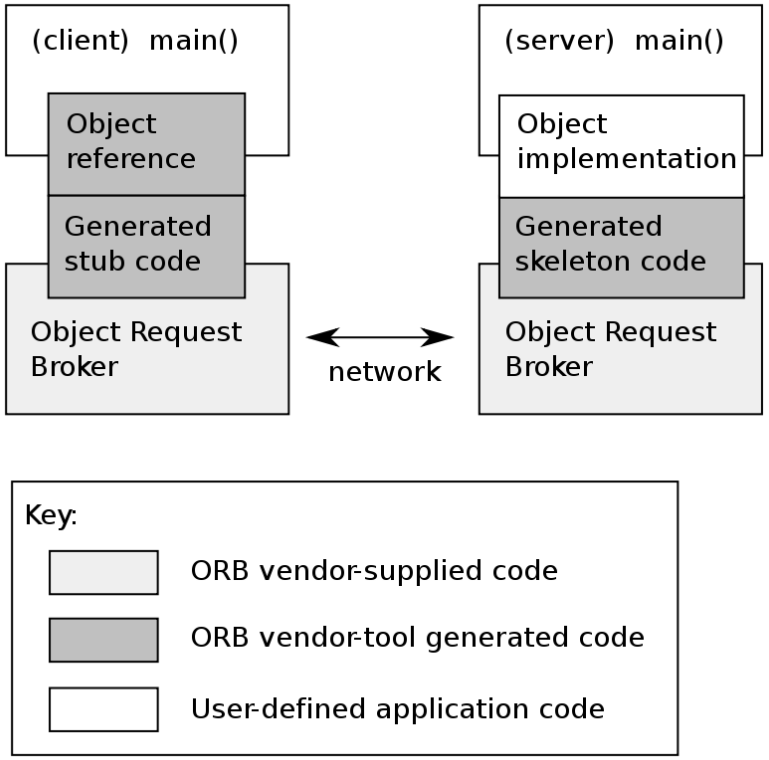


Interoperability Solutions

- Many Solutions
  - File Transfer
  - Shared DB
  - Remote Procedure Calls
  - Message Passing
- Middleware platforms aimed at making it more structured and easier
  - CORBA, DCOM, RMI, …
  - Web Services

Interoperability Solutions

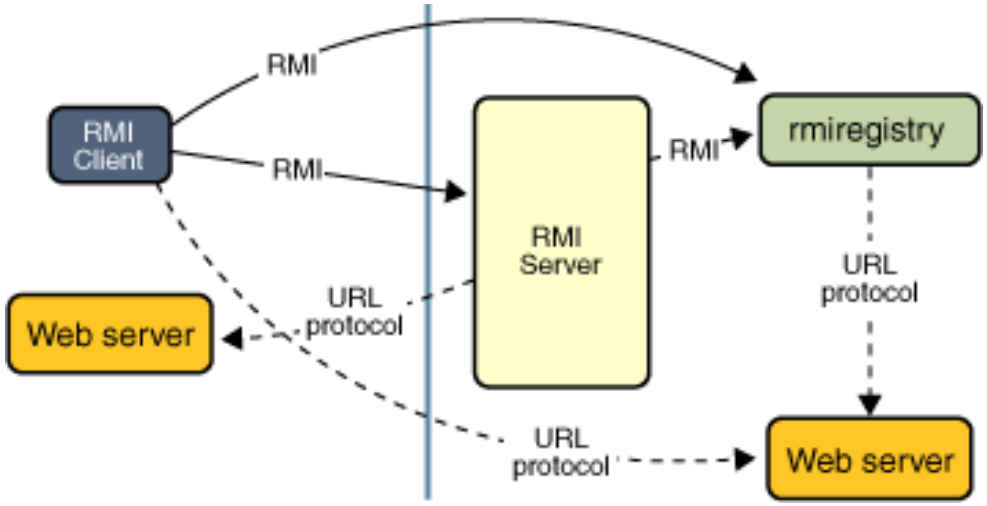
- CORBA (1991)
  - Standards-based, vendor-neutral, and language-agnostic.
  - Communicate by message passing over network
  - Read Corba: Gone But (Hopefully) Not Forgotten, Queue Vol 5, No. 4.



https://www.omg.org/spec/CORBA/
https://en.wikipedia.org/wiki/Common_Object_Request_Broker_Architecture
https://docs.oracle.com/javase/8/docs/technotes/guides/idl/jidlExample.html

More Interoperability Solutions

- Distributed Component Object Model (DCOM) (Microsoft)
- RMI (Sun Microsystems)
  - Invoke method on a remote object.



https://docs.oracle.com/javase/tutorial/rmi/overview.html

Web Services

- A “service” is a software component provided through an (often, network-accessible) endpoint.
- Service consumer and provider use messages to exchange invocation request and response information in the form of self-containing documents.

What do you understand by “**Web**”?

Early Static Web

- Developed in 1990 at CERN
- NCSA Mosaic 1.0 was the first browser, released by the National Center for Supercomputer Applications (NCSA).

The Dynamic Web

- Httpd 1.0 web server allowed Common Gateway Interface (CGI).
- CGI allows a browser client to request data from a program running on a Web server.

CGI Script

```
#! /usr/local/bin/perl
# Display the form data set sent in a GET or POST request.

print "Content-type: text/html\n\n";
print "<html><head><title>Form Data</title></head> \n";
print "<body bgcolor=\"#FFFFFF\"\n>"

if ($ENV{'REQUEST_METHOD'} eq 'POST') {
    read (STDIN, $buffer, $ENV{'CONTENT_LENGTH'});
    @pairs = split(/&/, $buffer);
} elsif ($ENV{'REQUEST_METHOD'} eq 'GET') {
    @pairs = split(/&/, $ENV{'QUERY_STRING'});
} else {
    print "<p>$ENV{'REQUEST_METHOD'} message received</p>";
}
foreach $pair (@pairs) {
    ($name, $value) = split(/=/, $pair);
    $value =~ tr/+/ /;
    $value =~ s/%([a-fA-F0-9][a-fA-F0-9])/pack("C", hex($1))/eg;
    $name =~ tr/+/ /;
    $name =~ s/%([a-fA-F0-9][a-fA-F0-9])/pack("C", hex($1))/eg;
    print "<p>Field $name has the value $value</p> \n";
    $FORM{$name} = $value;
} print "</body></html> \n";
```

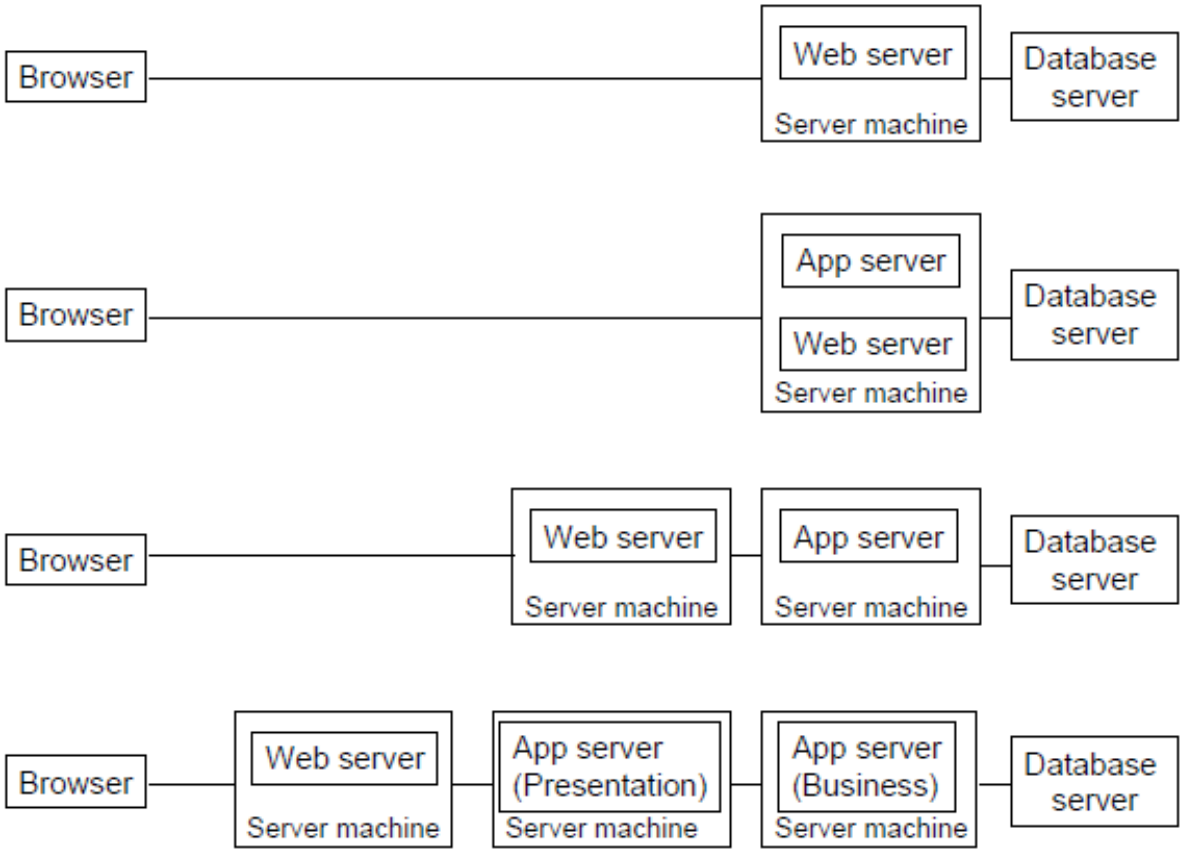
Server-Side (javascript) Scripting

```
<html>
    <head>  <title>Server-Side JavaScript Example Author Listing</title>  </head>
    <body>
        <h1>Author List</h1>
        <server>
            if (!database.connected()){
                database.connect("ODBC","bookdb","admin","","");
            }
            if (database.connected()) {
                qs = "SELECT au_id, au_fname, au_lname FROM authors";
                results =  database.cursor(qs);
                write("<table border=2 cellpadding=2 cellspacing=2>" +
                      "<tr><th>ID</th><th>First Name</th><th>Last Name </th></tr> \n");
                while(results.next()) {
                      write("<tr><td>" + results.au_id + "</td> + "<td>" +
                            results.au_fname + "</td>" +
                            "<td>" + results.au_lname + "</td></tr> \n");
                }
                results.close(); write("</table> \n");
            }
            else {
                write("<p>Database connection failed");
            }
        </server>
    </body>
</html>
```

ASP Page

```
<%
    Dim conn, rs
    Set conn = Server.CreateObject("ADODB.Connection")
    Set rs = Server.CreateObject("ADODB.Recordset")
    conn.Open "bookdb", "sa", "password"
    Set rs = conn.Execute("select au_id, au_fname, au_lname from authors")
%>
<html>
    <head>  <title>ASP Example Author Listing</title></head>
    <body>
        <h1>Author List</h1>
        <table>
            <tr><th>ID</th><th>First Name</th><th>Last Name</th></tr>
            < % Do Until rs.EOF %>
                <tr><td><%=rs("au_id") %></td>
                <td><%=rs("au_fname") %></td>
                <td><%=rs("au_lname") %></td></tr>
                < % rs.movenext
                Loop
            %>
        < /table>
    < /body>
< /html>
```

Evolution of Web and App Servers



Software as a Service (SaaS)

https://od-api.oxforddictionaries.com/api/v2/entries/en-us/ubiquitous

```
7   # TODO: replace with your own app_id and app_key
8   app_id = '<my app_id>'
9   app_key = '<my app_key>'
10  language = 'en'
11  word_id = 'Ace'
12
13  url = 'https://od-api.oxforddictionaries.com:443/api/v2/entries/'  + language + '/'  + word_id.lower()
14  #url Normalized frequency
15  urlFR = 'https://od-api.oxforddictionaries.com:443/api/v2/stats/frequency/word/'  + language + '/?corpus=nmc&lemma='
+ word_id.lower()
16
17  r = requests.get(url, headers = {'app_id' : app_id, 'app_key' : app_key})
18
19  print("code {}\n".format(r.status_code))
20  print("text \n" + r.text)
21  print("json \n" + json.dumps(r.json()))
```

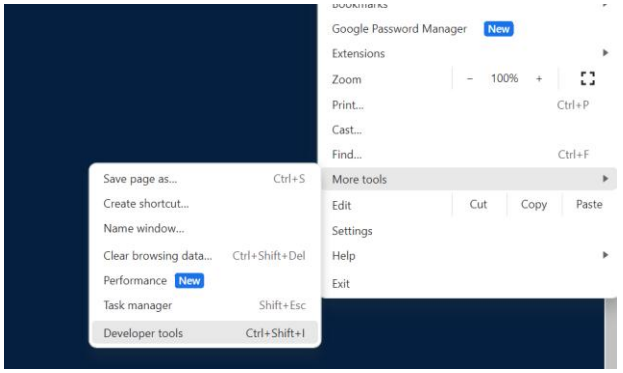
API Service from Oxford Dictionary
https://developer.oxforddictionaries.com/

{
"definitions": [
"present, appearing, or found everywhere"]
}

Response in JSON format

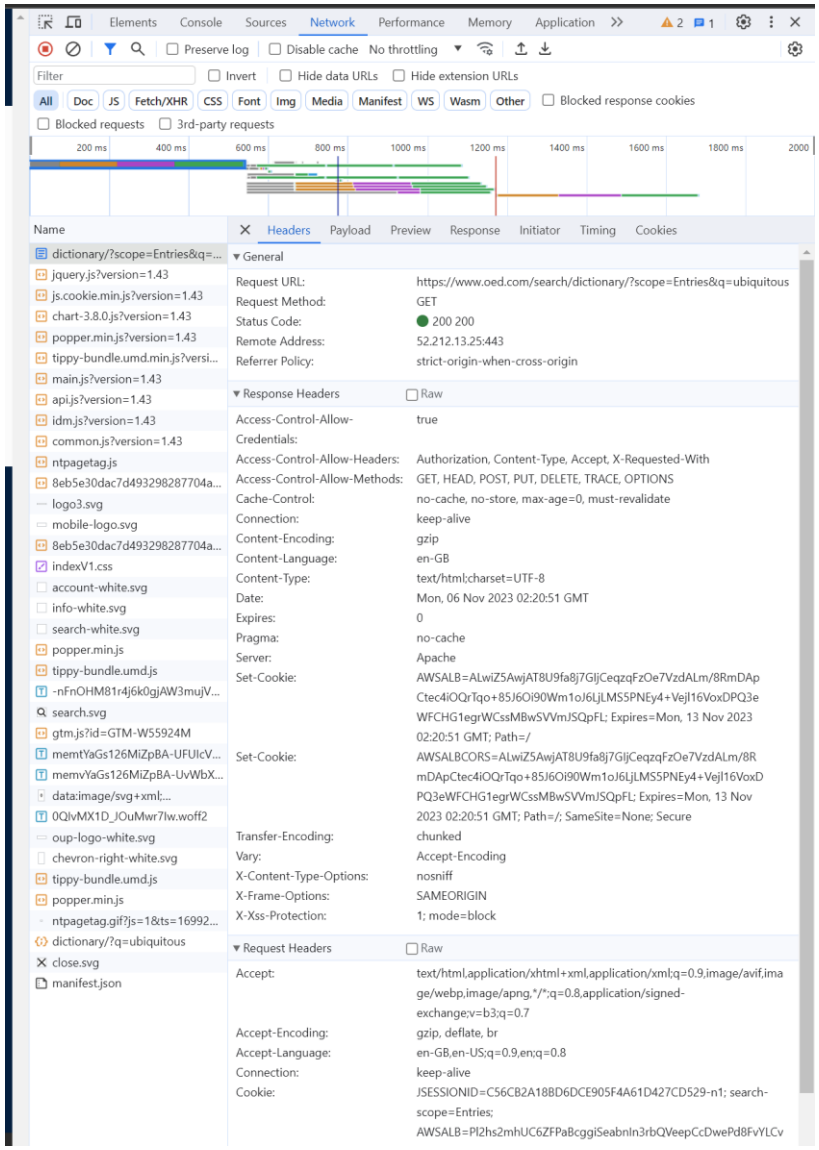
Try this!

- Visit https://www.oed.com/
- Type some word in the dictionary search bar.
- Go to browser settings -> More tools -> Developer tools.
- Open Network tab.
- Hit the search button on the search bar.



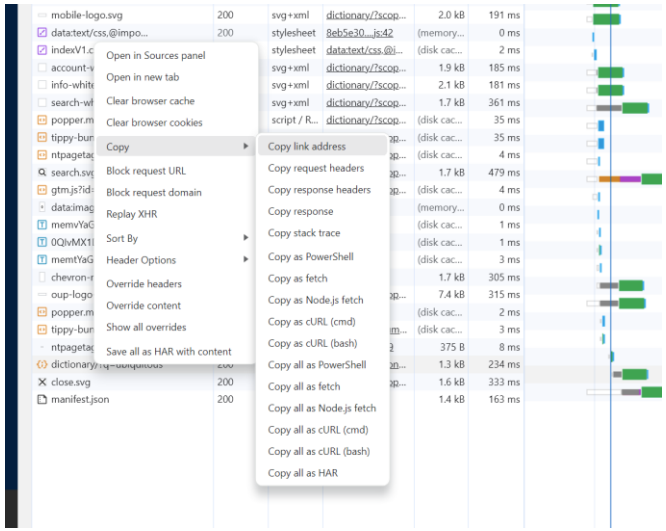
Try this!

- Click on the following entry in the network tab - https://www.oed.com/search/dictionary/?scope=Entries&q=ubiquitous
- You will see the individual requests made by the site and their response details.



Try this!

- Copy this link address and run it in a new browser tab - https://www.oed.com/autocomplete/dictionary/?q=ubiquitous

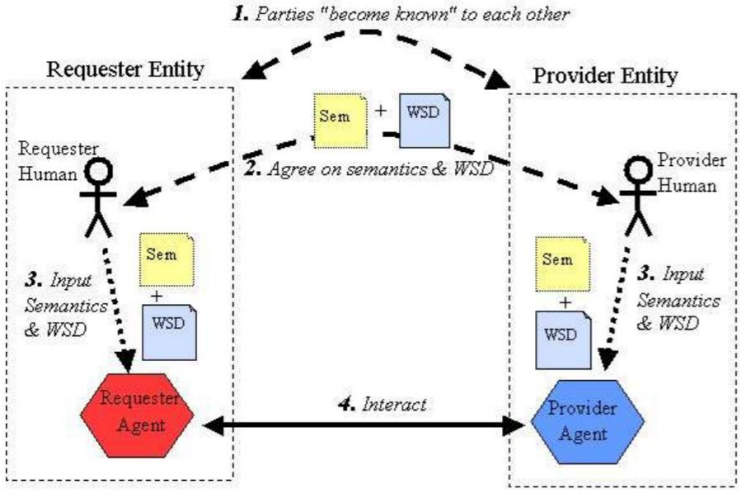


Response

[{"name":"ubiquitous","count":null,"label":"ubiquitous","path":null},{"name":"ubiquitously","count":null,"label":"ubiquitously","path":null},{"name":"ubiquitousness","count":null,"label":"ubiquitousness","path":null},{"name":"ubiquitous computing","count":null,"label":"ubiquitous computing","path":null}]

Web Services

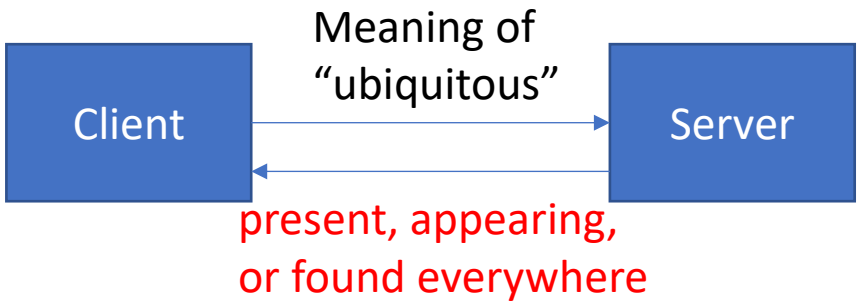
- A Web service is a software system designed to support interoperable machine-to-machine interaction over a network.

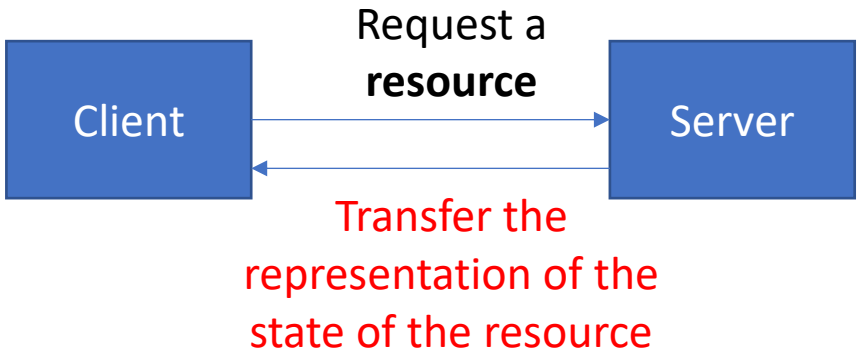


https://www.w3.org/TR/ws-arch/wsa.pdf

REST API

- REST = Representational State Transfer
  - Proposed by Roy Fielding in 2000.





Resource

- Any information that can be named is a resource
  - Document, image, or any other object.
- Description of the state of the resource at any timestamp is known as resource representation
  - Representation consists of data describing the resource.
- Resource methods are used to transfer the resource state representations.
  - Need not be always HTTP (GET/POST/…).

RESTful Web Services API

- Let us retrieve an existing configuration:
  - http://example.com/network-app/configurations/678678
  - HTTP GET /configurations/{id}

- Similarly, we can POST, PUT, and DELETE.
  - HTTP POST /devices
  - HTTP POST /configurations
  - HTTP PUT /devices/{id}/configurations
  - HTTP DELETE /devices/{id}/configurations/{id}

https://restfulapi.net/rest-api-design-tutorial-with-example/

HTTP

- HTTP Methods

HTTP Method	Purpose
POST	Create
GET	Retrieve
PUT	Update
DELETE	Delete

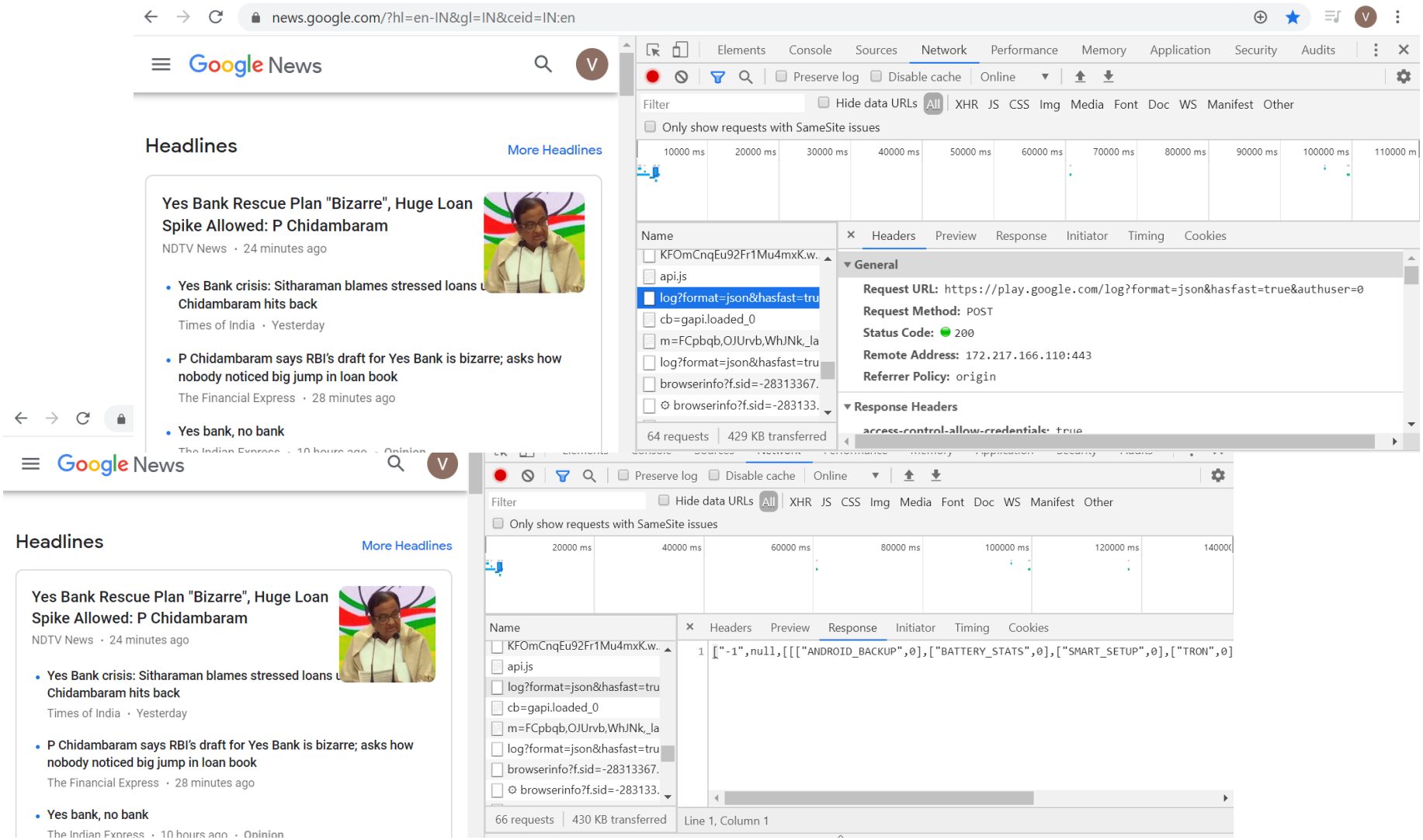
- *"An idempotent HTTP method is an HTTP method that can be called many times without different outcomes."*
  - POST is NOT idempotent.
  - GET, PUT, DELETE are idempotent.

HTTP Response Codes

- 2xx
  - Success
  - Example: 200 = OK, 201 = Created (POST created a resource), 202 = Accepted (if it is a long-running task)
- 4xx
  - Client Error
  - Example: 400 = Bad Request, 404 = Not Found.
- 5xx
  - Server Error
  - Example: 500 = Internal Server Error

https://restfulapi.net/http-status-codes/

REST in Real World



Designing REST API

- Identify the object model
- Create Model URIs
- Determine Representations
- Assign HTTP Methods

```
<device id="12345">
    <link rel="self" href="/devices/12345"/>
    <deviceFamily>apple-es</deviceFamily>
    <OSVersion>10.3R2.11</OSVersion>
    <platform>SRX100B</platform>
    <serialNumber>32423457</serialNumber>
    <connectionStatus>up</connectionStatus>
    <ipAddr>192.168.21.9</ipAddr>
    <name>apple-srx_200</name>
    <status>active</status>
</device>
```

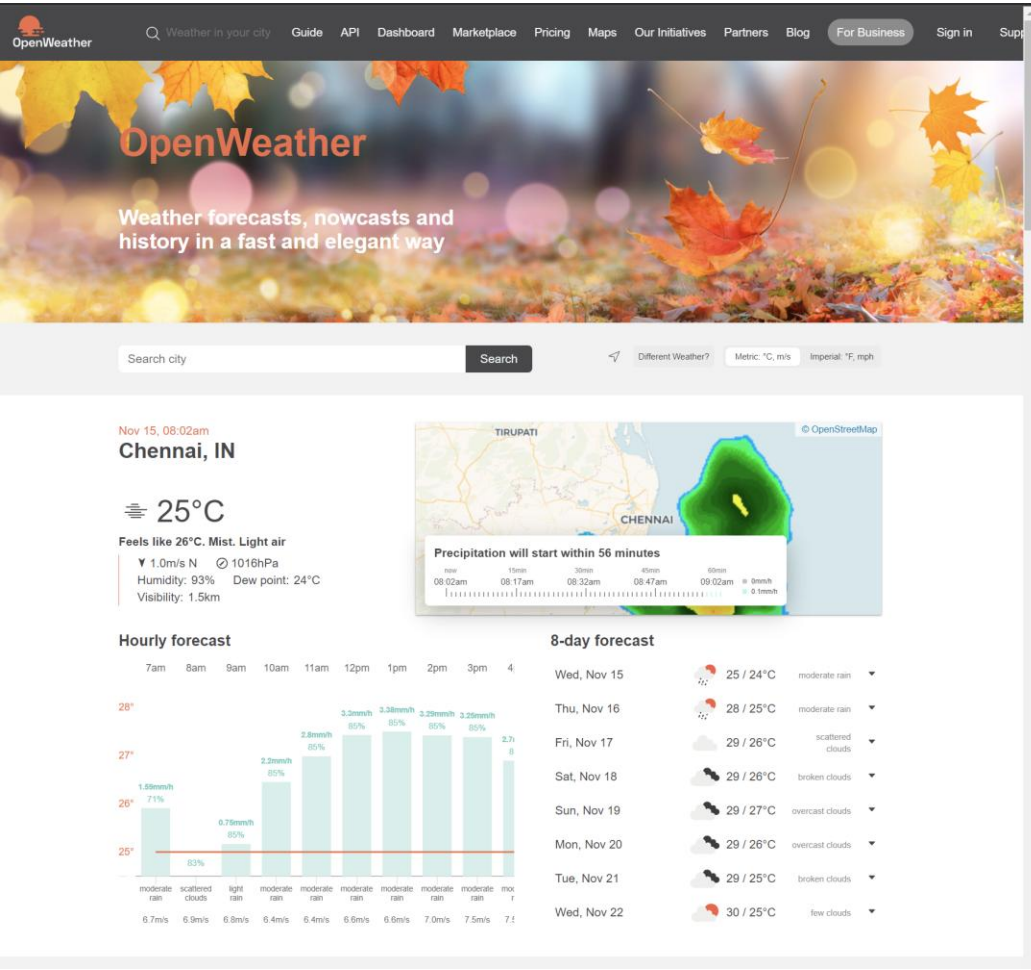
Web Services for a Banking Application

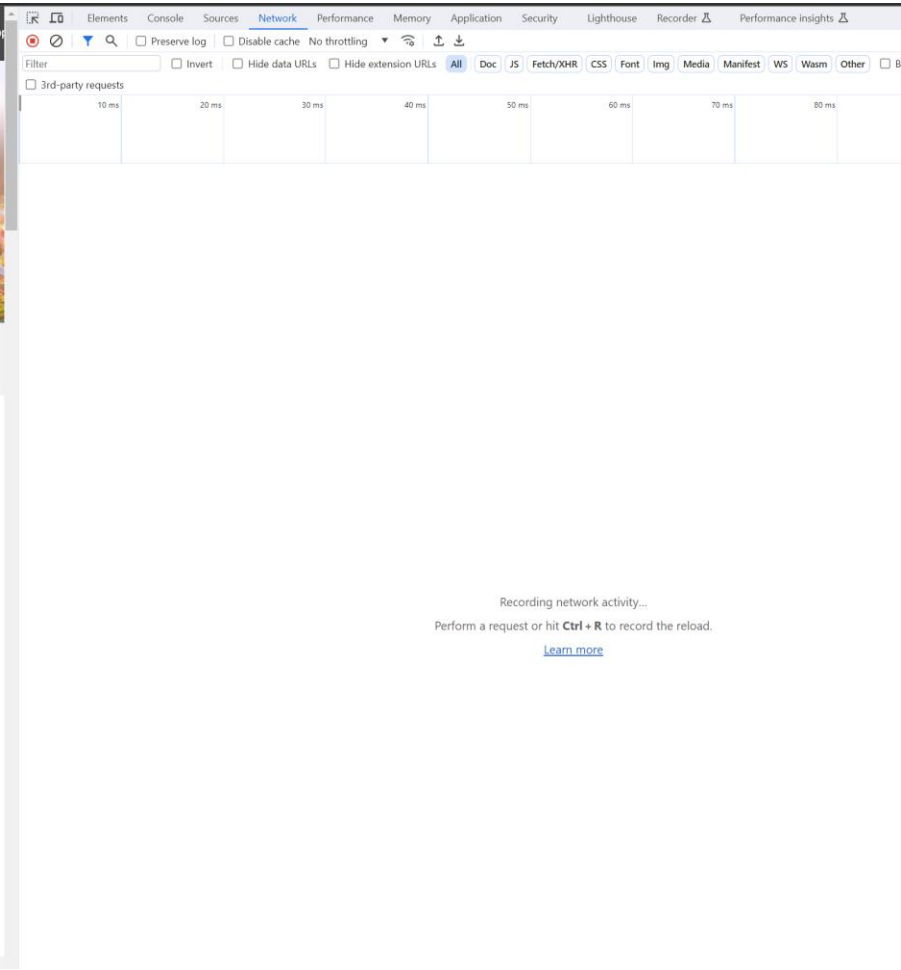
- Designing the REST API
  - Object Model
    - Customer, Account
  - Create Model URIs
    - /customers/{customerId}
    - /customers/{customerId}/accounts
    - /customers/{customerId}/accounts/{accountId}
  - Determine Representations
    - Represent all Account information as an XML/JSON
    - Represent all Customer information as XML/JSON
  - Assign HTTP Methods
    - Open Account = Create an Account Resource ➔ HTTP POST
    - Close Account = Delete the Account ➔ HTTP DELETE

Weather Example

- See https://openweathermap.org

https://api.openweathermap.org/data/2.5/weather?lat={lat}&lon={lon}&appid={API key}


OpenWeather
Weather in your city
Guide
API
Dashboard
Marketplace
Pricing
Maps
Our Initiatives
Partners
Blog
For Business
Sign in
OpenWeather
Weather forecasts, nowcasts and history in a fast and elegant way
Search city
Search
Different Weather?
Metric: °C, m/s
Imperial: °F, mph
Nov 15, 08:02am
Chennai, IN
25°C
Feels like 26°C. Mist. Light air
1.0m/s N
1016hPa
Humidity: 93%
Dew point: 24°C
Visibility: 1.5km
TIRUPATI
CHENNAI
© OpenStreetMap
Precipitation will start within 56 minutes
now
15min
30min
45min
60min
08:02am
08:17am
08:32am
08:47am
09:02am
0mm/h
0.1mm/h
Hourly forecast
7am
8am
9am
10am
11am
12pm
1pm
2pm
3pm
28°
27°
26°
25°
1.69mm/h
71%
0.75mm/h
85%
2.2mm/h
85%
2.8mm/h
85%
3.3mm/h
85%
3.38mm/h
85%
3.29mm/h
85%
3.25mm/h
85%
83%
moderate rain
scattered clouds
light rain
moderate rain
moderate rain
moderate rain
moderate rain
moderate rain
moderate rain
6.7m/s
6.9m/s
6.8m/s
6.4m/s
6.4m/s
6.6m/s
6.6m/s
7.0m/s
7.5m/s
8-day forecast
Wed, Nov 15
25 / 24°C
moderate rain
Thu, Nov 16
28 / 25°C
moderate rain
Fri, Nov 17
29 / 26°C
scattered clouds
Sat, Nov 18
29 / 26°C
broken clouds
Sun, Nov 19
29 / 27°C
overcast clouds
Mon, Nov 20
29 / 26°C
overcast clouds
Tue, Nov 21
29 / 25°C
broken clouds
Wed, Nov 22
30 / 25°C
few clouds


Elements
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Lighthouse
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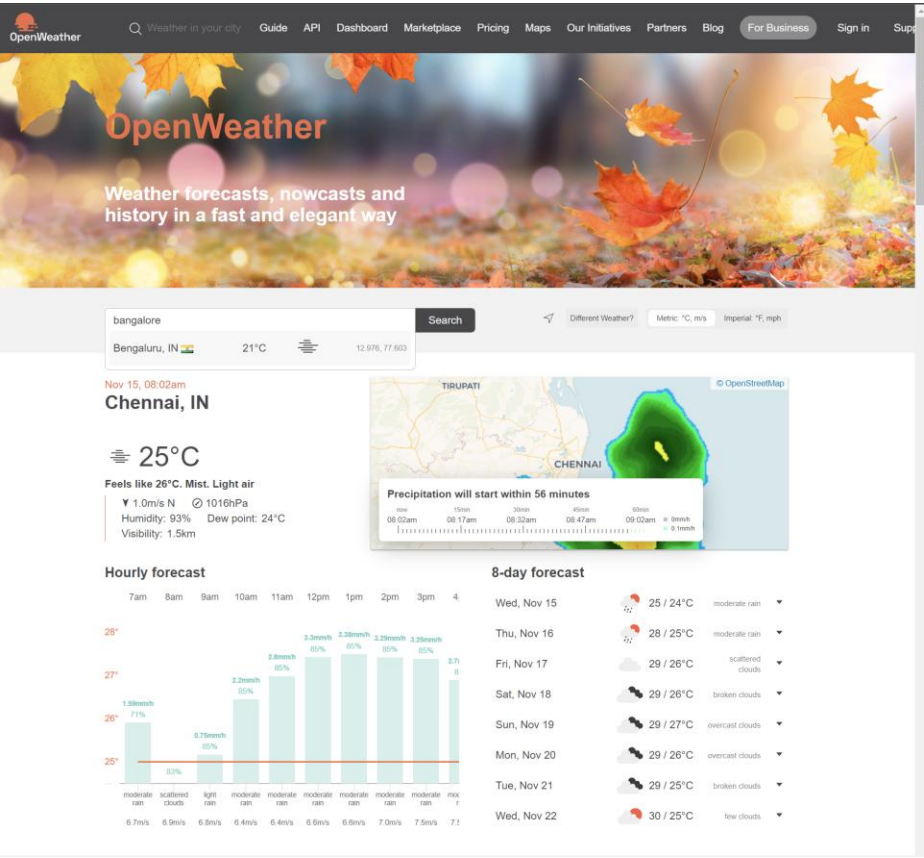
Performance insights
Preserve log
Disable cache
No throttling
Filter
Invert
Hide data URLs
Hide extension URLs
All
Doc
JS
Fetch/XHR
CSS
Font
Img
Media
Manifest
WS
Wasm
Other
3rd-party requests
10 ms
20 ms
30 ms
40 ms
50 ms
60 ms
70 ms
80 ms
Recording network activity...
Perform a request or hit Ctrl + R to record the reload.
Learn more


OpenWeather
Weather in your city
Guide
API
Dashboard
Marketplace
Pricing
Maps
Our Initiatives
Partners
Blog
For Business
Sign in
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Weather forecasts, nowcasts and history in a fast and elegant way
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Bengaluru, IN
21°C
Different Weather?
Metric: °C, m/s
Imperial: °F, mph
Nov 15, 08:02am
Chennai, IN
25°C
Feels like 26°C. Mist. Light air
1.0m/s N
1016hPa
Humidity: 93%
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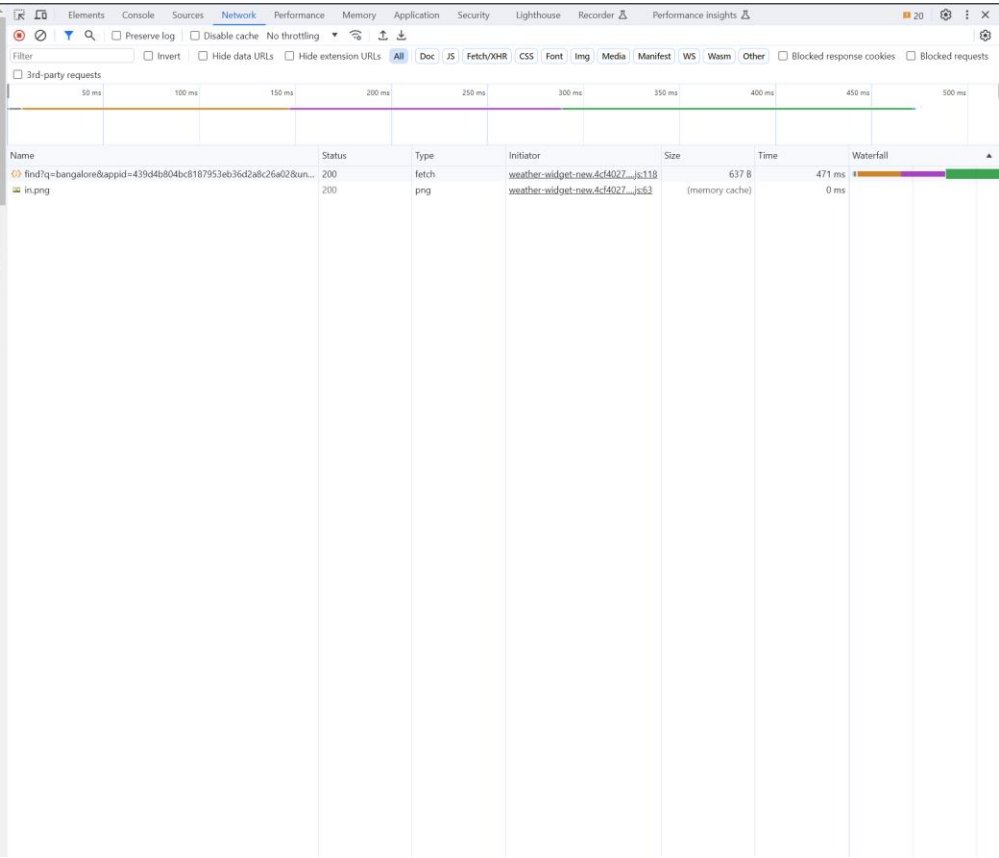
Visibility: 1.5km
TIRUPATI
CHENNAI
© OpenStreetMap
Precipitation will start within 56 minutes
Hourly forecast
8-day forecast
Wed, Nov 15 25 / 24°C moderate rain
Thu, Nov 16 28 / 25°C moderate rain
Fri, Nov 17 29 / 26°C scattered clouds
Sat, Nov 18 29 / 26°C broken clouds
Sun, Nov 19 29 / 27°C overcast clouds
Mon, Nov 20 29 / 26°C overcast clouds
Tue, Nov 21 29 / 25°C broken clouds
Wed, Nov 22 30 / 25°C few clouds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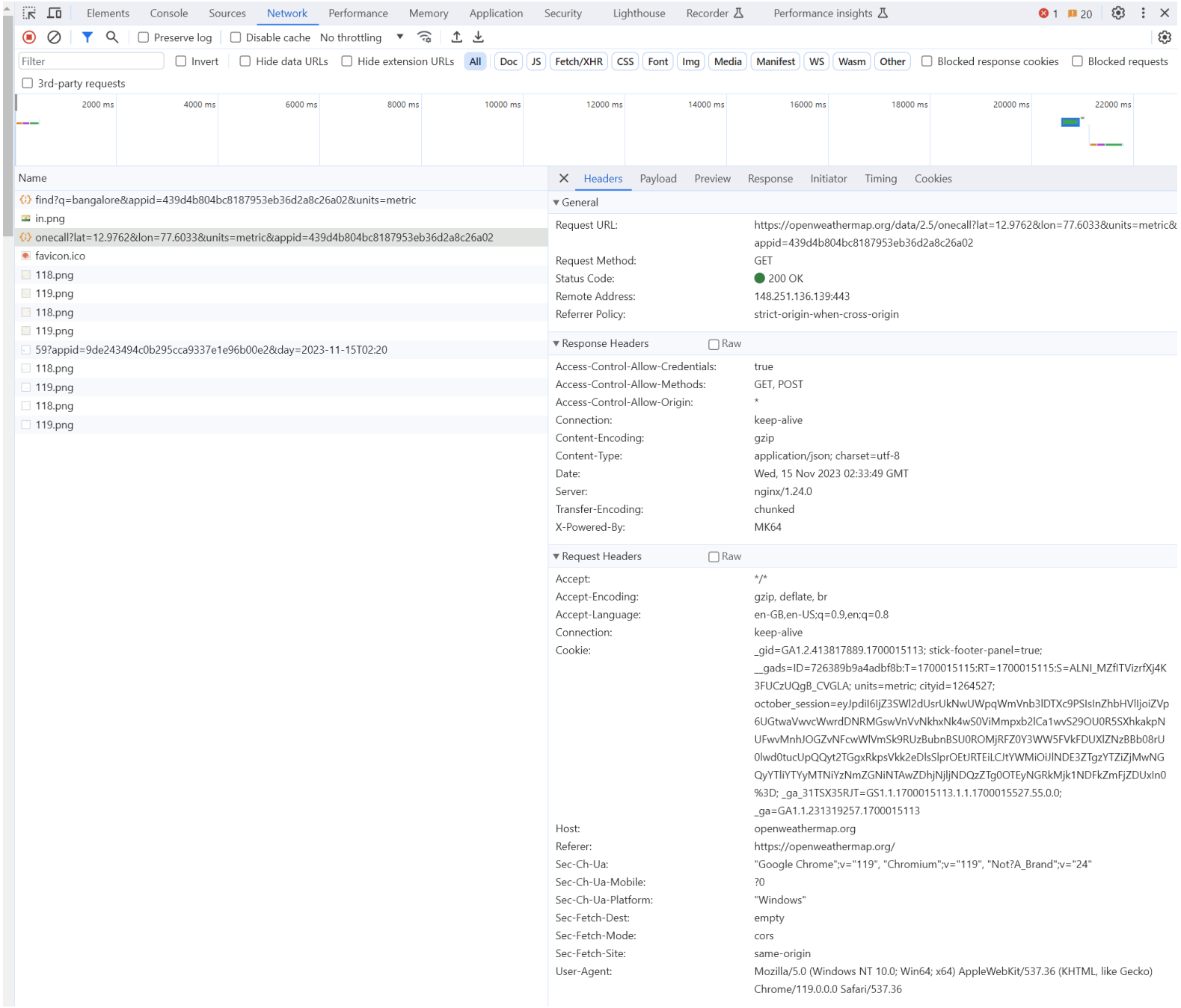
Font
Img
Media
Manifest
WS
Wasm
Other
Blocked response cookies
Blocked requests
3rd-party requests
Name
Status
Type
Initiator
Size
Time
Waterfall
find?q=bangalore&appid=439d4b804bc8187953eb36d2a8c26a02&un... 200 fetch weather-widget-new.4cf4027...js:118 637 B 471 ms
in.png 200 png weather-widget-new.4cf4027...js:63 (memory cache) 0 ms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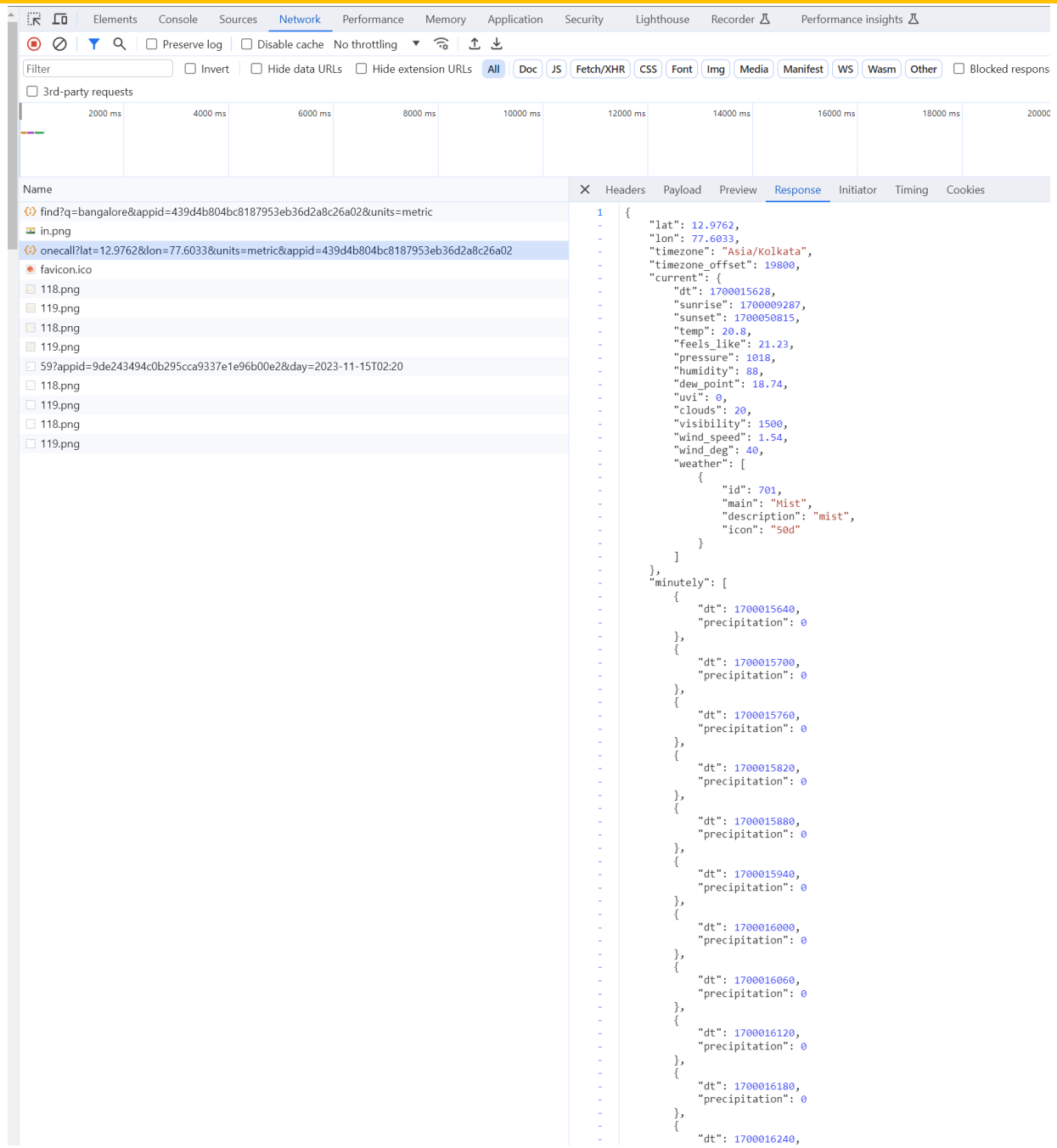
Img
Media
Manifest
WS
Wasm
Other
Blocked response cookies
Blocked requests
3rd-party requests
2000 ms
4000 ms
6000 ms
8000 ms
10000 ms
12000 ms
14000 ms
16000 ms
18000 ms
20000 ms
22000 ms
Name
find?q=bangalore&appid=439d4b804bc8187953eb36d2a8c26a02&units=metric
in.png
onecall?lat=12.9762&lon=77.6033&units=metric&appid=439d4b804bc8187953eb36d2a8c26a02
favicon.ico
118.png
119.png
118.png
119.png
59?appid=9de243494c0b295cca9337e1e96b00e2&day=2023-11-15T02:20
118.png
119.png
118.png
119.png
Headers
Payload
Preview
Response
Initiator
Timing
Cookies
General
Request URL:
https://openweathermap.org/data/2.5/onecall?lat=12.9762&lon=77.6033&units=metric&appid=439d4b804bc8187953eb36d2a8c26a02
Request Method:
GET
Status Code:
200 OK
Remote Address:
148.251.136.139:443
Referrer Policy:
strict-origin-when-cross-origin
Response Headers
Raw
Access-Control-Allow-Credentials:
true
Access-Control-Allow-Methods:
GET, POST
Access-Control-Allow-Origin:
*
Connection:
keep-alive
Content-Encoding:
gzip
Content-Type:
application/json; charset=utf-8
Date:
Wed, 15 Nov 2023 02:33:49 GMT
Server:
nginx/1.24.0
Transfer-Encoding:
chunked
X-Powered-By:
MK64
Request Headers
Raw
Accept:
/
Accept-Encoding:
gzip, deflate, br
Accept-Language:
en-GB,en-US;q=0.9,en;q=0.8
Connection:
keep-alive
Cookie:
_gid=GA1.2.413817889.1700015113; stick-footer-panel=true;
__gads=ID=726389b9a4adbf8b:T=1700015115:RT=1700015115:S=ALNI_MZfITVizrfXj4K3FUCzUQgB_CVGLA; units=metric; cityid=1264527;
october_session=eyJpdiI6IjZ3SWl2dUsrUkNwUWpqWmVnb3lDTXc9PSIsInZhbHVlIjoiZVp6UGtwaVwvcWwrdDNRMGswVnVvNkhxNk4wS0ViMmpxb2lCa1wvS29OU0R5SXhkakpNUFwvMnhJOGZvNFcwWlVmSk9RUzBubnBSU0ROMjRFZ0Y3WW5FVkFDUXlZNzBBb08rU0lwd0tucUpQQyt2TGgxRkpsVkk2eDlsSlprOEtJRTEiLCJtYWMiOiJlNDE3ZTgzYTZiZjMwNGQyYTliYTYyMTNiYzNmZGNiNTAwZDhjNjljNDQzZTg0OTEyNGRkMjk1NDFkZmFjZDUxIn0%3D; _ga_31TSX35RJT=GS1.1.1700015113.1.1.1700015527.55.0.0;
_ga=GA1.1.231319257.1700015113
Host:
openweathermap.org
Referer:
https://openweathermap.org/
Sec-Ch-Ua:
"Google Chrome";v="119", "Chromium";v="119", "Not?A_Brand";v="24"
Sec-Ch-Ua-Mobile:
?0
Sec-Ch-Ua-Platform:
"Windows"
Sec-Fetch-Dest:
empty
Sec-Fetch-Mode:
cors
Sec-Fetch-Site:
same-origin
User-Agent:
Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/119.0.0.0 Safari/537.36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Manifest
WS
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Blocked respons
3rd-party requests
2000 ms
4000 ms
6000 ms
8000 ms
10000 ms
12000 ms
14000 ms
16000 ms
18000 ms
20000
Name
find?q=bangalore&appid=439d4b804bc8187953eb36d2a8c26a02&units=metric
in.png
onecall?lat=12.9762&lon=77.6033&units=metric&appid=439d4b804bc8187953eb36d2a8c26a02
favicon.ico
118.png
119.png
118.png
119.png
59?appid=9de243494c0b295cca9337e1e96b00e2&day=2023-11-15T02:20
118.png
119.png
118.png
119.png
Headers
Payload
Preview
Response
Initiator
Timing
Cookies
{
"lat": 12.9762,
"lon": 77.6033,
"timezone": "Asia/Kolkata",
"timezone_offset": 19800,
"current": {
"dt": 1700015628,
"sunrise": 1700009287,
"sunset": 1700050815,
"temp": 20.8,
"feels_like": 21.23,
"pressure": 1018,
"humidity": 88,
"dew_point": 18.74,
"uvi": 0,
"clouds": 20,
"visibility": 1500,
"wind_speed": 1.54,
"wind_deg": 40,
"weather": [
{
"id": 701,
"main": "Mist",
"description": "mist",
"icon": "50d"
}
]
},
"minutely": [
{
"dt": 1700015640,
"precipitation": 0
},
{
"dt": 1700015700,
"precipitation": 0
},
{
"dt": 1700015760,
"precipitation": 0
},
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"dt": 1700015820,
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},
{
"dt": 1700015880,
"precipitation": 0
},
{
"dt": 1700015940,
"precipitation": 0
},
{
"dt": 1700016000,
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{
"dt": 1700016060,
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},
{
"dt": 1700016120,
"precipitation": 0
},
{
"dt": 1700016180,
"precipitation": 0
},
{
"dt": 1700016240,

Implementing RESTful web services

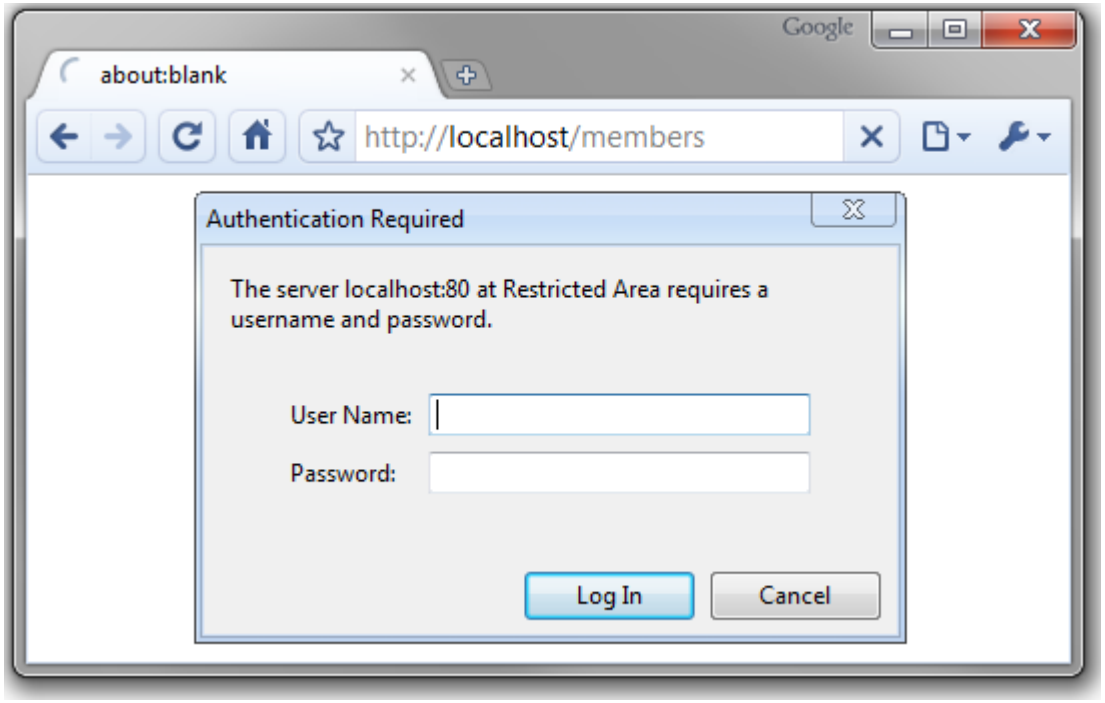
- Java API for RESTful web services (JAX-RS) [JSR 311] is specification.
- Jersey is a popular JAX-RS implementation.
- JAX-RS Annotations helps in building web services

```
@Path("/configurations")
public class ConfigurationResource
{
    @Path("/{id}")
    @GET
    public Response getConfigurationById(@PathParam("id") Integer id){
        ...
    }
}
```

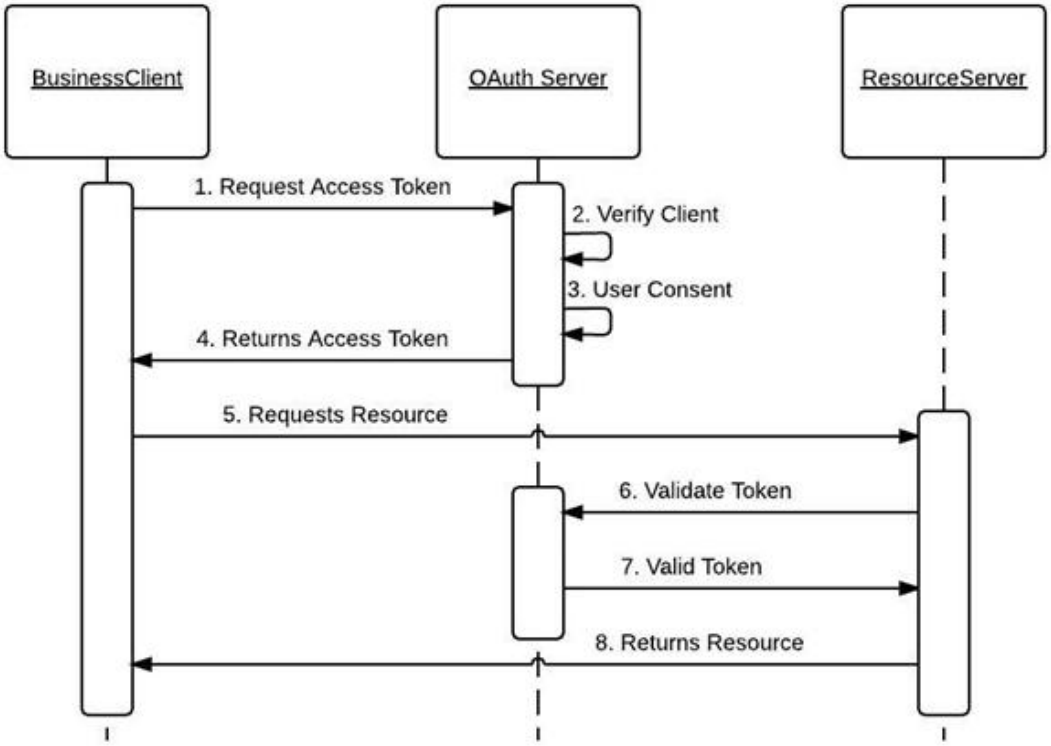
Authentication

- Basic HTTP Authentication
  - User enters the credentials
- Query String Authentication
  - URL has the credentials
- API Keys
  - Sever generated keys are used to identify the user.
- Token-based Authentication
  - oAuth method
  - Most secure form of authentication out of these four.

Basic HTTP Authentication



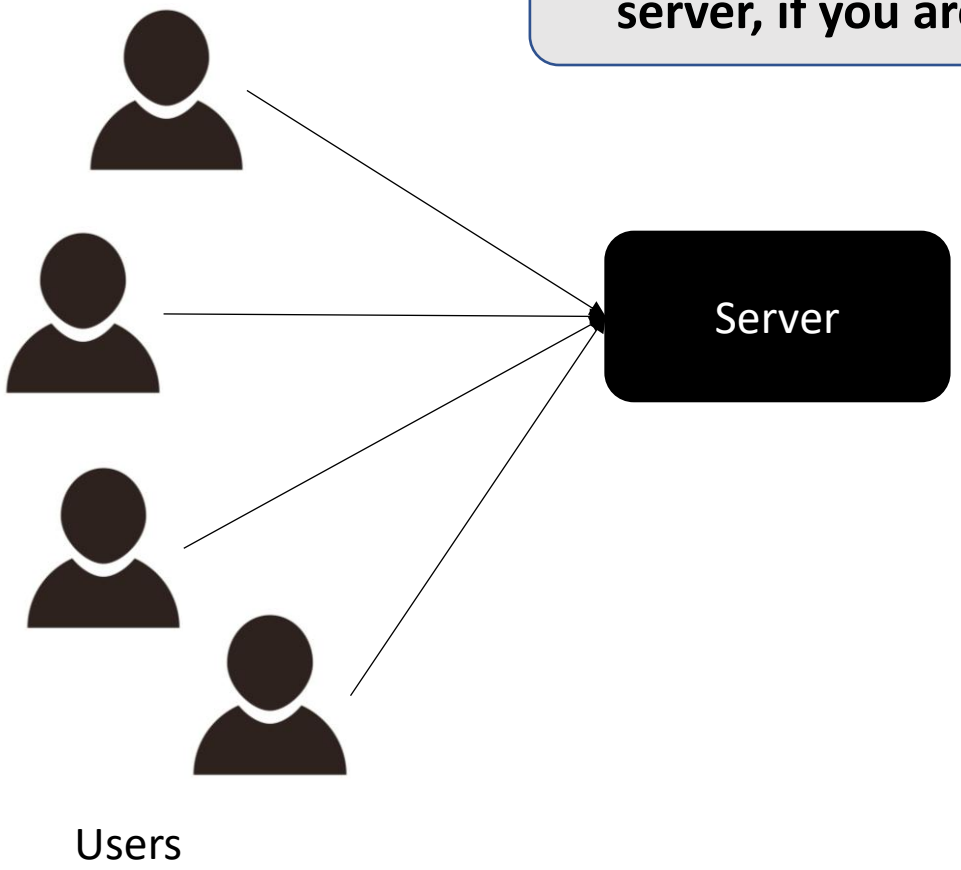
oAuth 2.0 Architecture



https://docs.oracle.com/cd/E82085_01/160027/JOS%20Implementation%20Guide/Output/oauth.htm

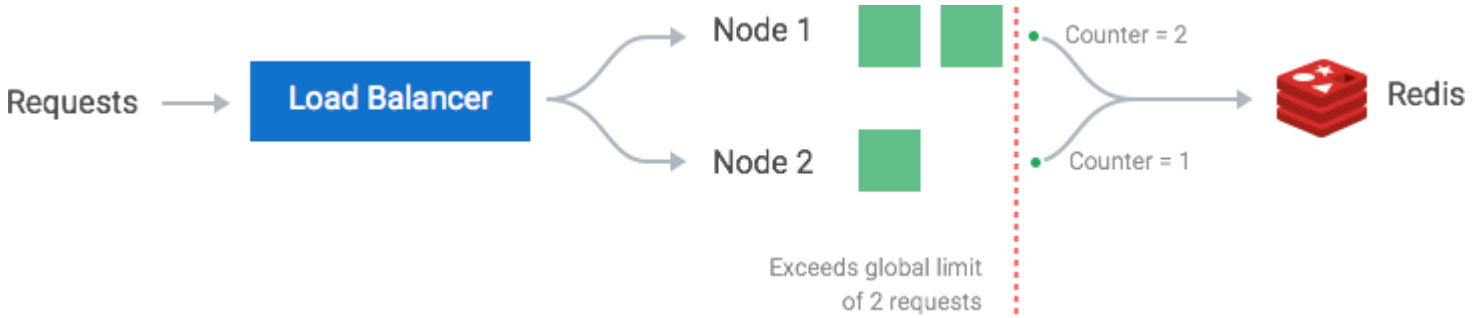
Web Services – Rate Limiting

Can you think of a way to bring down a server, if you are one of the users?



Rate Limiting

- A Leaky Bucket Solution
  - Queue up and service at a specific rate.
- Fixed Window Approach
  - Every request is served in a fixed time slot.
  - If the counter exceeds a threshold, the request is discarded.



https://konghq.com/blog/how-to-design-a-scalable-rate-limiting-algorithm/

Scaling

- Need for scaling
  - Traffic volume is different at different times
  - Keeping lesser number of server instances saves cost
  - Increase the server instances only when traffic is high
- Manual Scaling
  - May not work in situations where we cannot predict traffic patterns

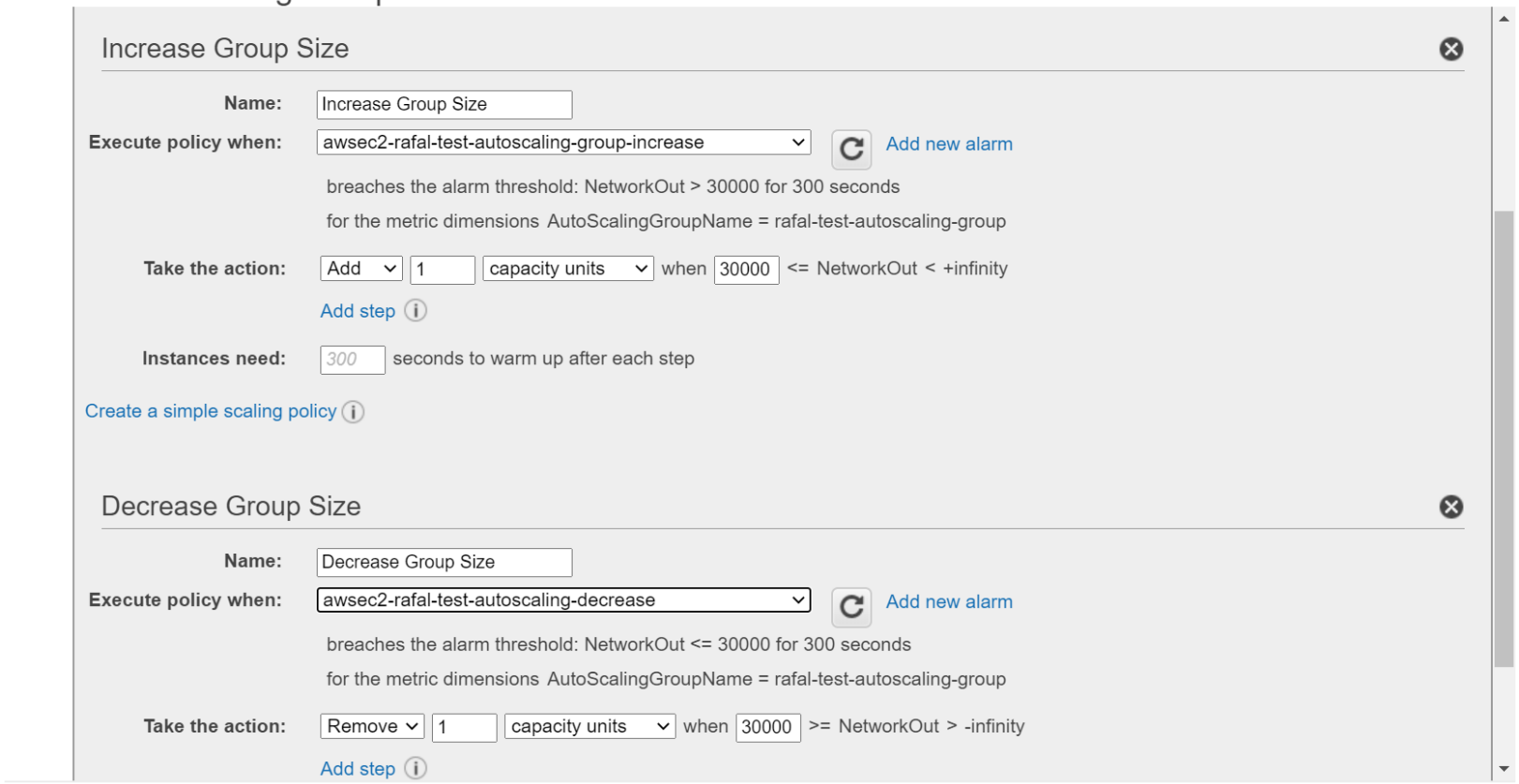
Server Auto-Scaling

- Simple Scaling
  - Increase/Decrease the server instances
    - at specific times, or based on number of concurrent users, etc.
    - by a specific count (say, 10% or 10 instances)
  - Apply a cooldown time period to let the new servers come into action
- Target Tracking
  - Attempts to keep a specific metric
    - For e.g., Keep Average CPU utilization at 50%
    - Increase server instances above threshold
    - Decrease the server instances below threshold
- Step Scaling
  - Improvement over simple scaling
  - Increase in steps – Say 2 instance at a time

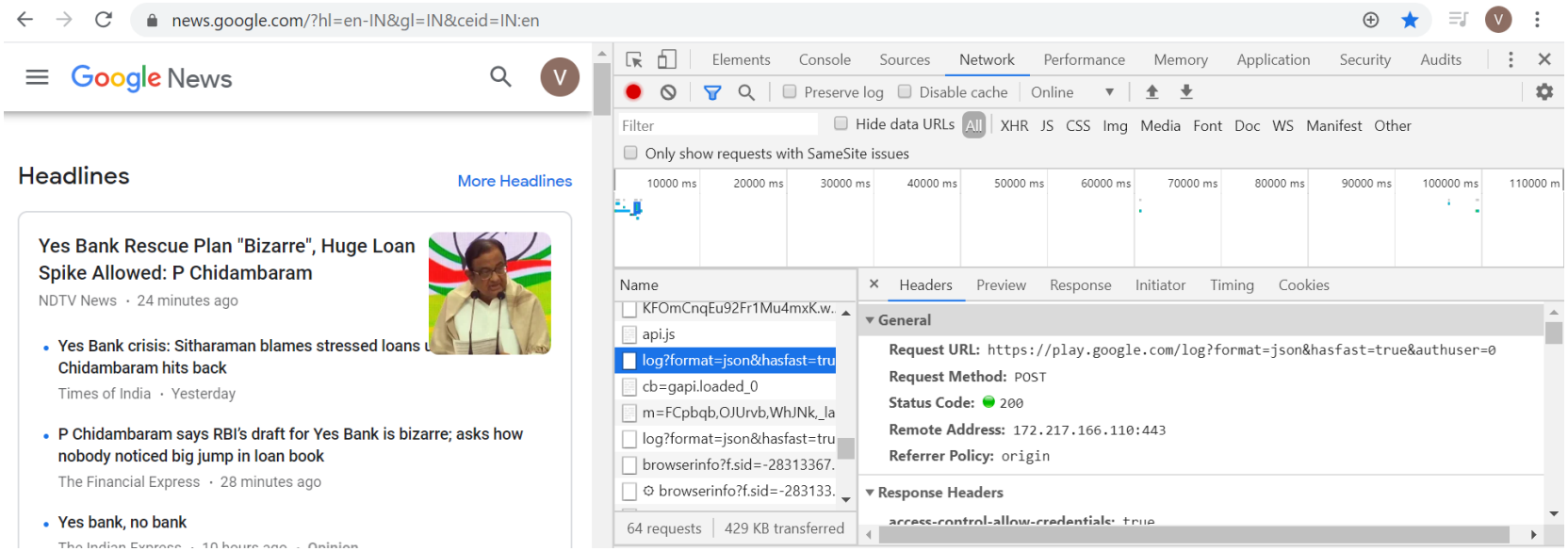
AWS Dynamic Scaling Policies: https://docs.aws.amazon.com/autoscaling/ec2/userguide/scale-your-group.html

Scaling in AWS

Create Auto Scaling Group



Putting it all Together!



Private Cloud

- Many companies build and use their own private cloud.
  - Each private cloud is a single-tenant server or cluster of servers
  - Total control over the resources of the physical hardware layer.
  - No risk of resource or capacity contention.
  - Best suited for privacy and compliance.
  - Expensive!
- Smaller companies that cannot afford a private cloud buy infrastructure (from IaaS) on a public cloud.
- There are also corporates that believe in hybrid cloud.
  - For economies of scale.

Public Cloud

- Storage and Computing services offered by third-party providers over the public Internet, making them available to anyone who wants to use or purchase them.
- Often pay-as-you-go service.
- Sold on-demand.
- No management and maintenance overhead.
- May have restrictions due to security concerns (say, can’t open certain ports).

Hybrid Cloud

- Combines a public cloud and a private cloud by allowing data and applications to be shared between them.
- As demand fluctuates, hybrid cloud computing gives businesses the ability to seamlessly scale their on-premises infrastructure up to the public cloud.
  - No need to make massive capital expenditures to handle short-term spikes.
  - Companies will pay only for resources they temporarily use.

Future of Big Data Technologies

- Research Trends
  - Big Data Analysis
    - Knowledge Discovery, Data Mining, …
  - Big Data Storage
    - Knowledge Management, Principles of Database Systems, …
  - Big Data Applications
    - Web Search, Ecommerce, Recommendation systems, …
- Trending among Practitioners
  - Business Intelligence and Visualization
  - Technology Stacks (Cloudera, Azure, AWS, GCP, …)

Summary

What Comes Next?

byte

kilobyte

megabyte

gigabyte

??

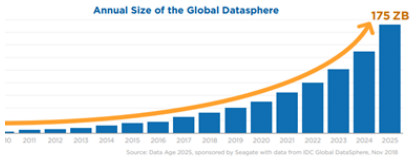
???

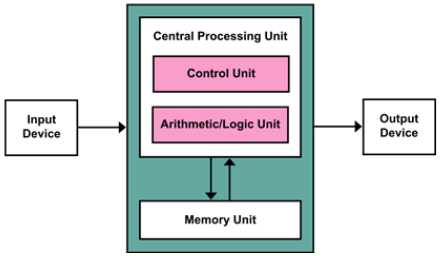
????

?????

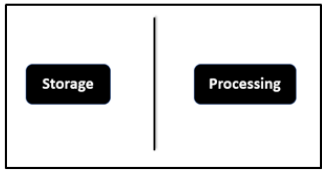
Data Storage, Processing & File Systems

Name	Size
Byte	8 bits
Kilobyte	1024 bytes
Megabyte	1024 kilobytes
Gigabyte	1024 megabytes
Terabyte	1024 gigabytes
Petabyte	1024 terabytes
Exabyte	1024 petabytes
Zettabyte	1024 exabytes
Yottabyte	1024 zettabytes

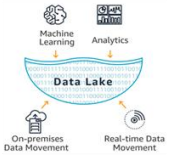




Challenges

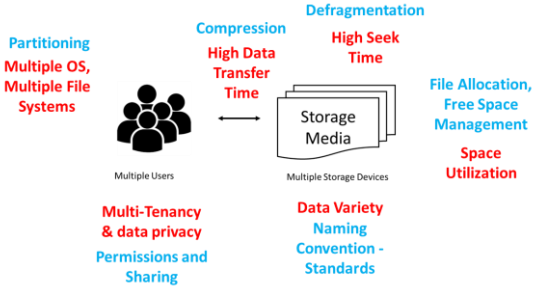


Data Storage

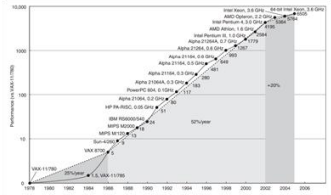


Amazon S3

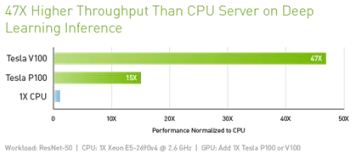
STaaS



Data Processing

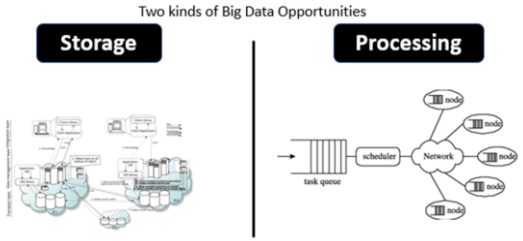


CPU Performance



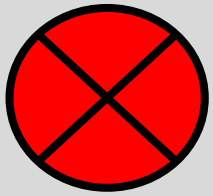
GPU Performance

SuperComputers



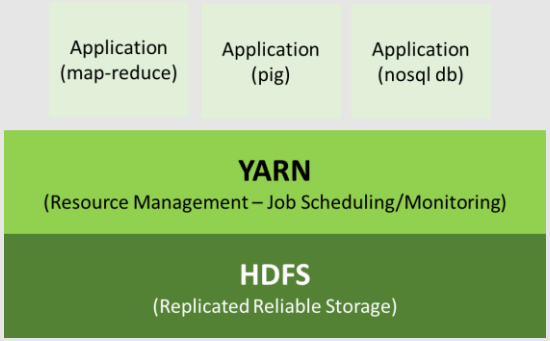
Hadoop, HDFS and Map-Reduce

When not to use Hadoop?

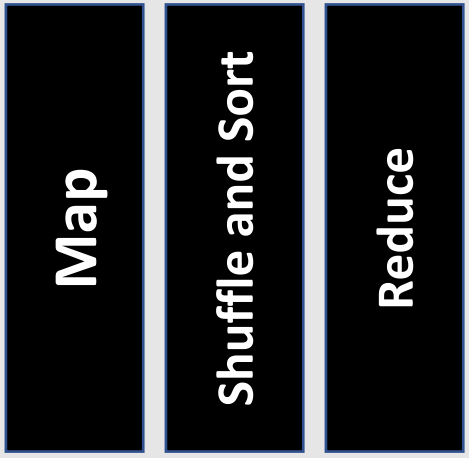


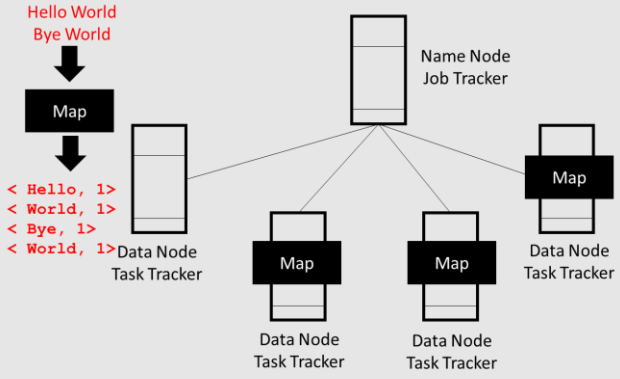
No Interactive Jobs
No Jobs Requiring Co-ordination
No Small Files

Hadoop Architecture

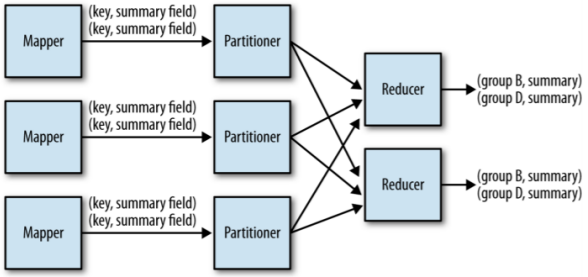


Map-reduce Model

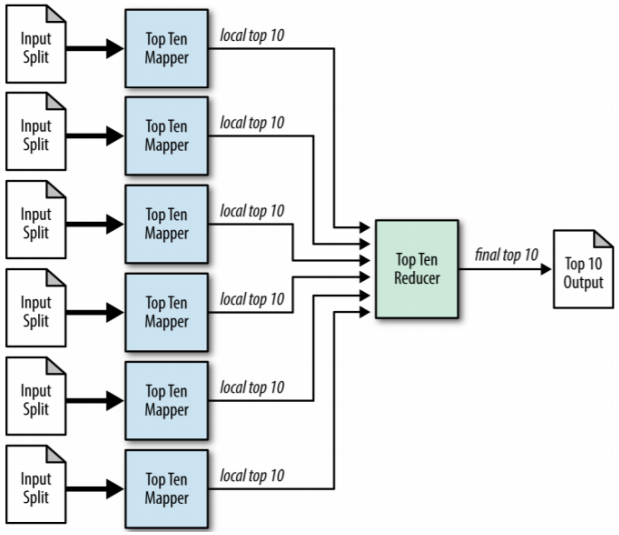




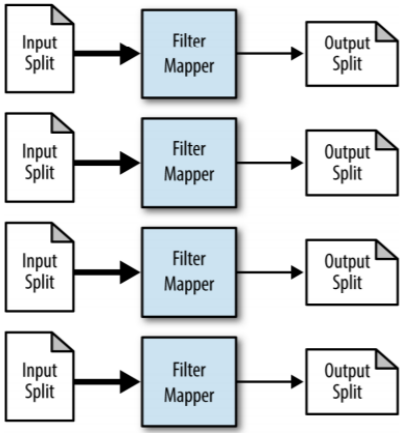
Big Data - Programming



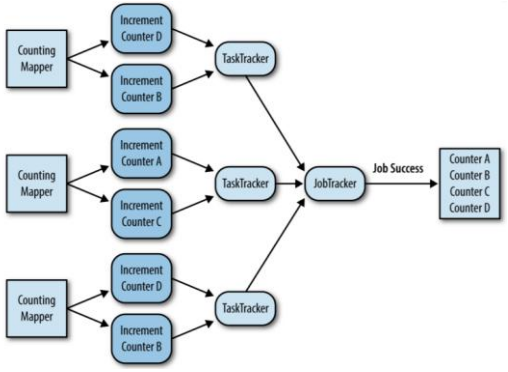
Summarization



Top 10

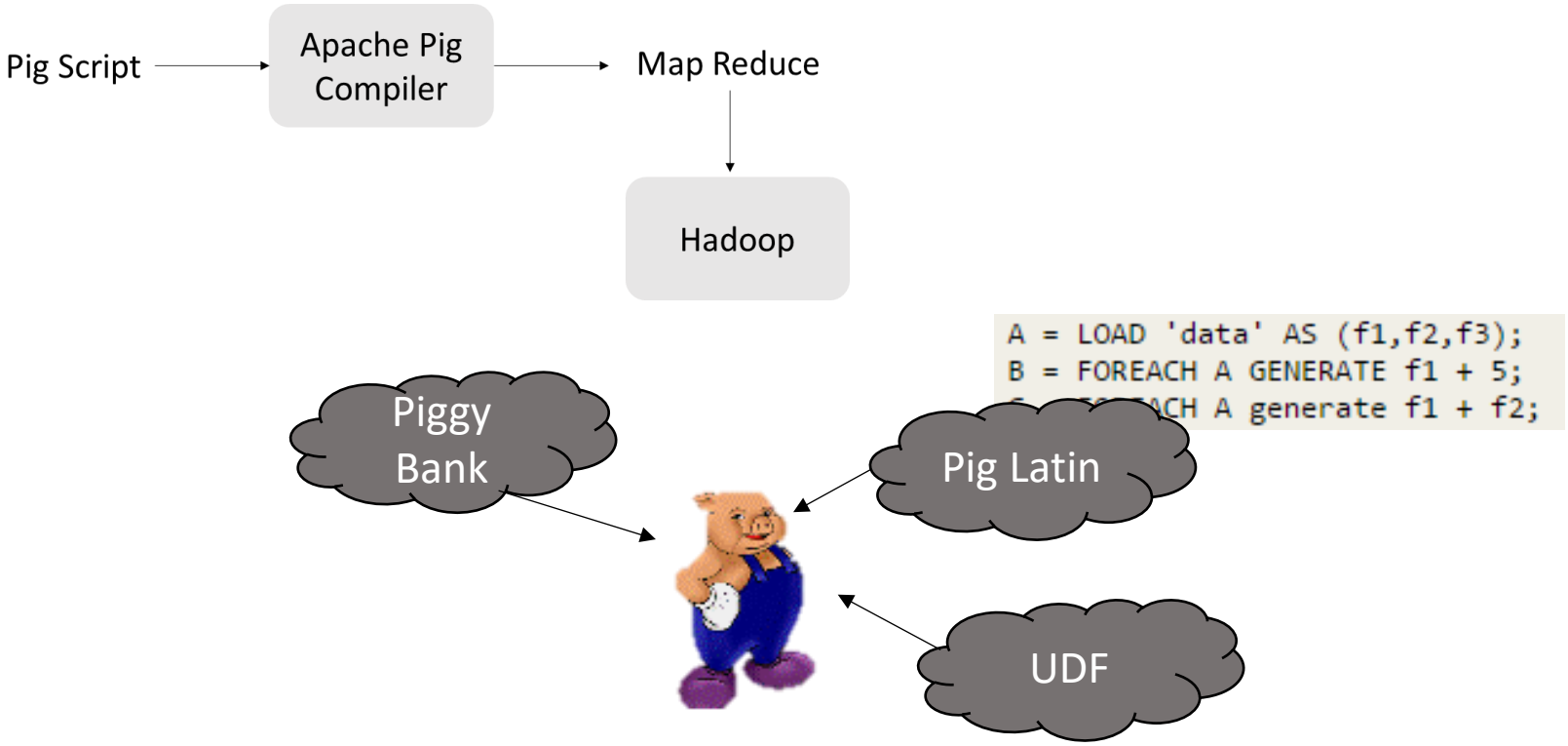


Filtering

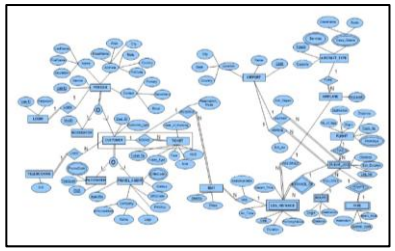


Counting

Apache Pig

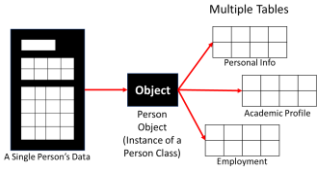

Pig Script
Apache Pig Compiler
Map Reduce
Hadoop
A = LOAD 'data' AS (f1,f2,f3);
B = FOREACH A GENERATE f1 + 5;
Piggy Bank
Pig Latin
UDF

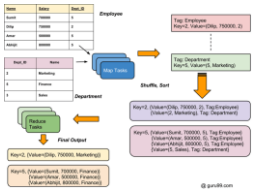
NoSQL



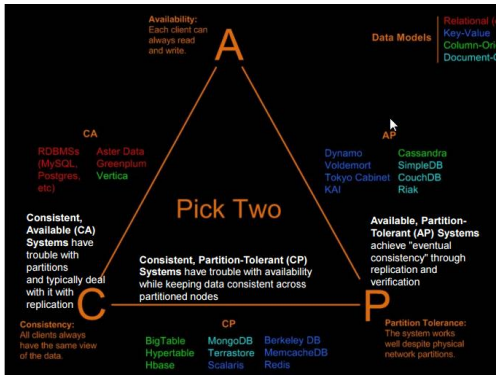
Schema-based Relational Model - maintenance problems

Impedance Mismatch





Scale-up Challenges



CAP Theorem

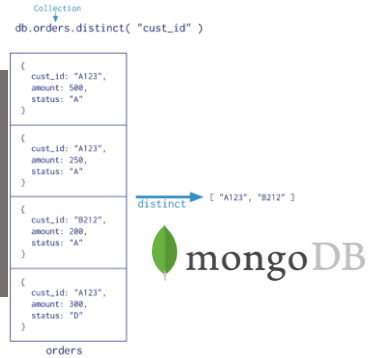
Types of NoSQL datastores

Key-Valuecv

```
redis> GET nonexisting
(nil)
redis> SET mykey "Hello"
"OK"
redis> GET mykey
"Hello"
redis>
```

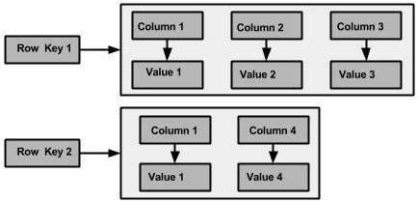
redis

Doc-based



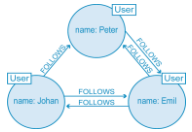
mongoDB

Columnar DB



Apache CASSANDRA

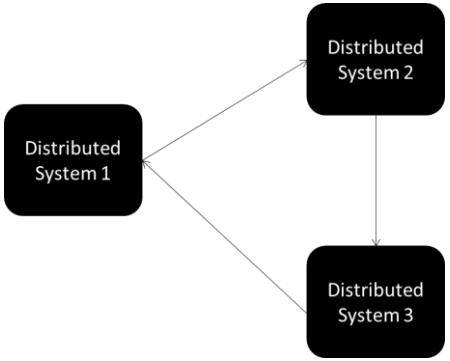
Graph DB



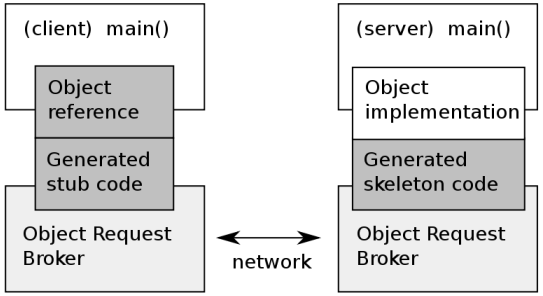
neo4j

Web Services

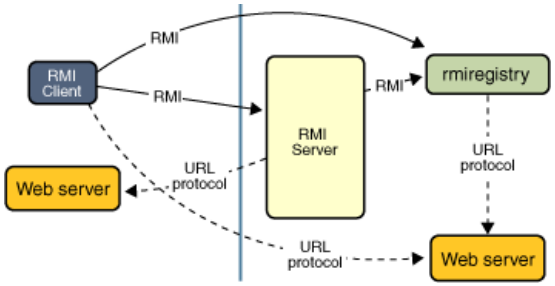
Interoperability



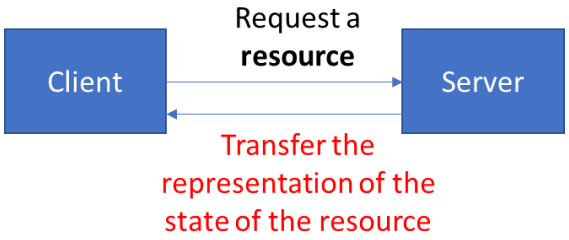
CORBA



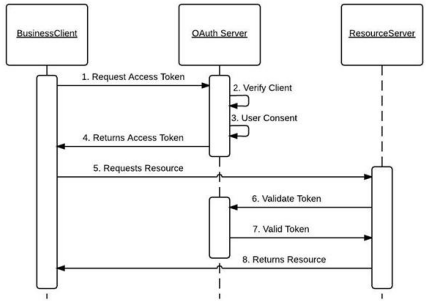
RMI

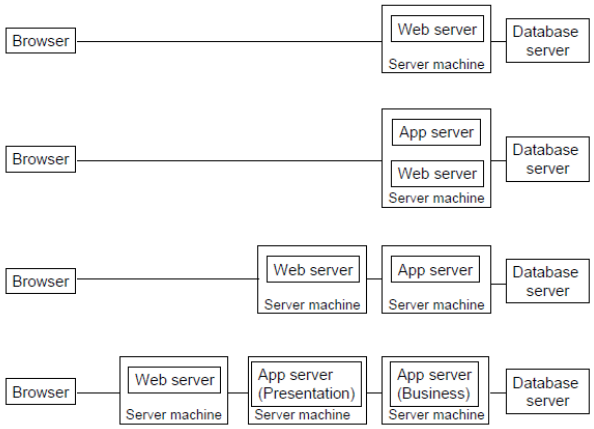


Web Services with REST API



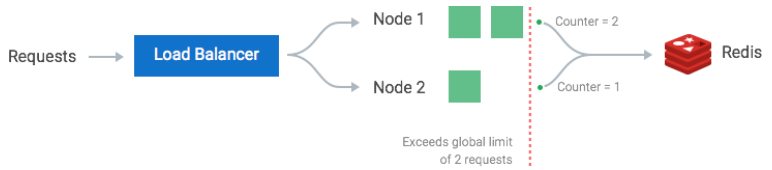
oAuth



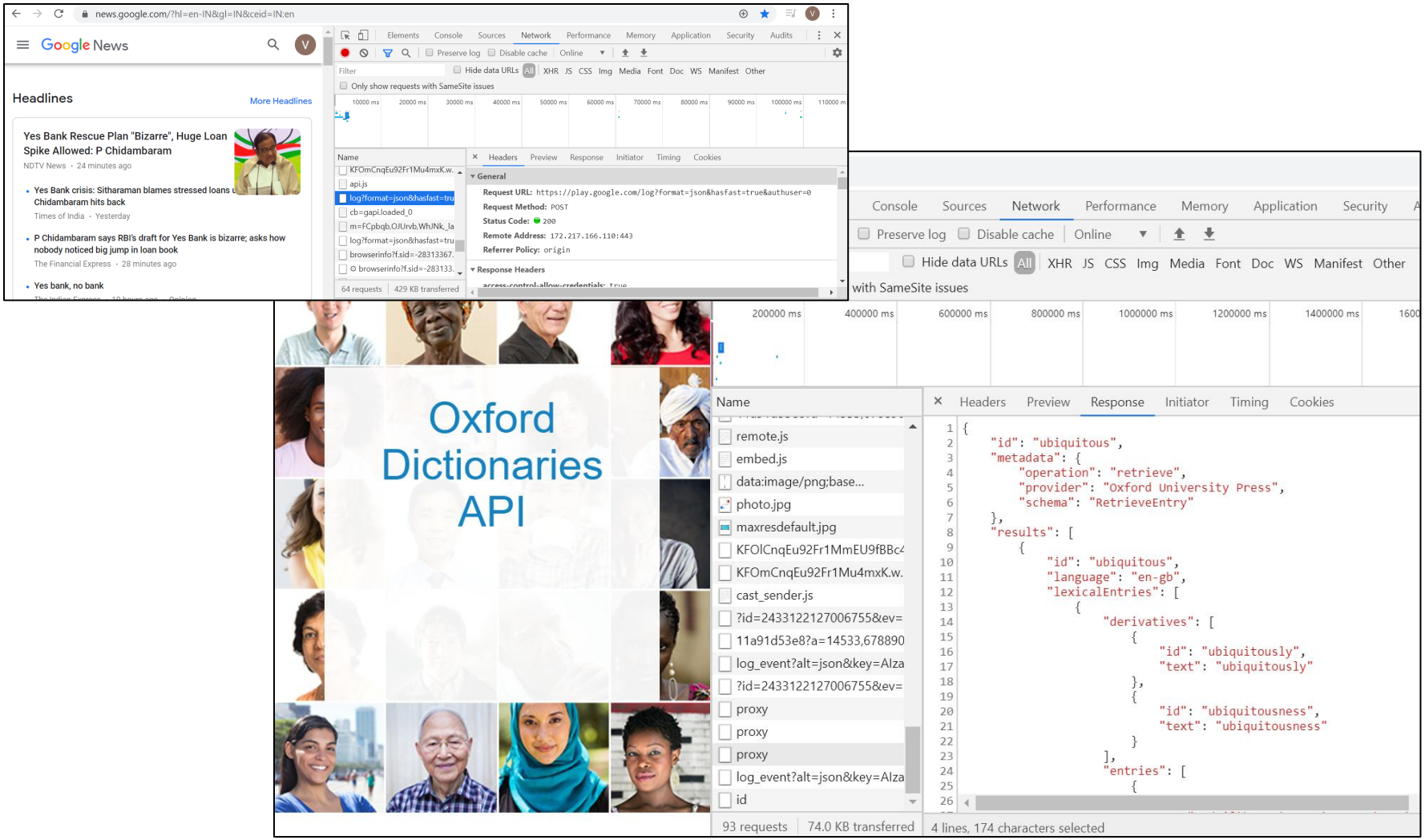


Evolution of Web and App Servers

Rate Limiting



Putting it all Together!



Thank You