#### Web Application Development and Web Services

#### Venkatesh Vinayakarao

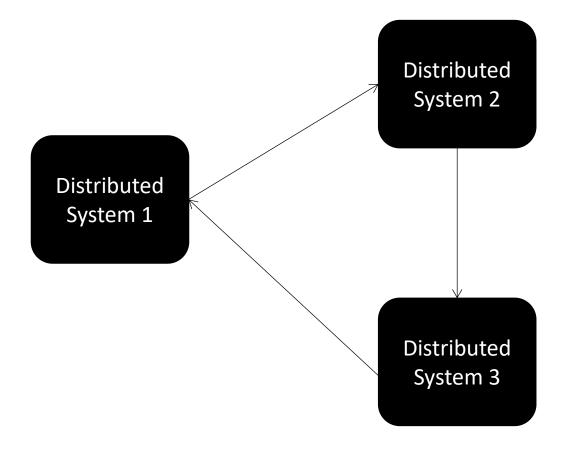
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#### Chennai Mathematical Institute

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

Venkatesh Vinayakarao (Vv)

#### How to Achieve Interoperability?

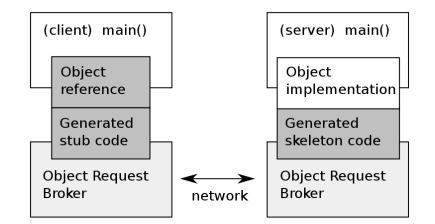


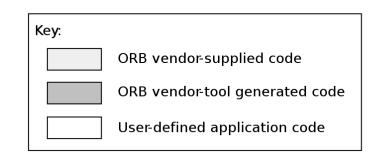
#### Interoperability Solutions

- 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, vendorneutral, and languageagnostic.
  - Communicate by message passing over network
  - Read <u>Corba: Gone But</u> (Hopefully) Not Forgotten, Queue Vol 5, No. 4.



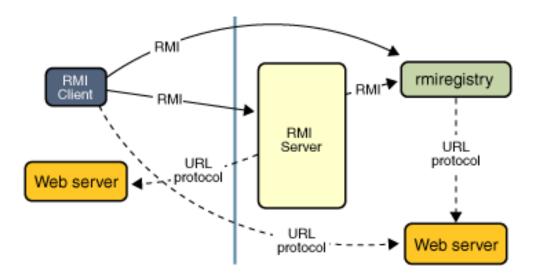


https://www.omg.org/spec/CORBA/

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=\"#FFFFF\"\n>"
```

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

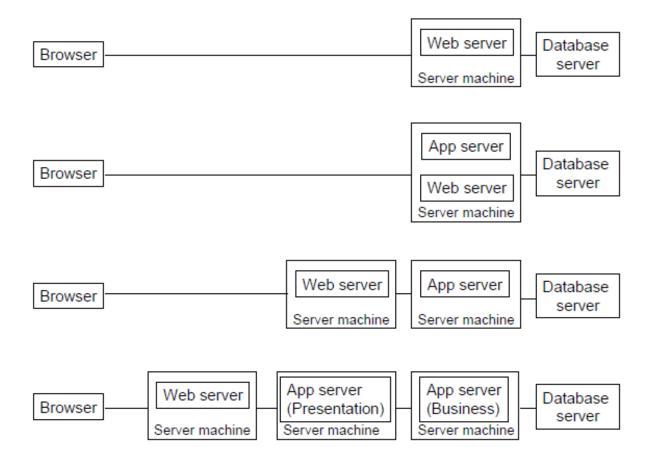
#### Server-Side (javascript) Scripting

```
<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("" +
                 "IDFirst NameLast Name \n");
             while(results.next()) {
                 write("" + results.au_id + " + "" +
                     results.au_fname + "" +
                     "  " + results.au_lname + "   \n");
             results.close(); write(" \n");
          }
          else {
             write("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>
      IDFirst NameLast Name
         <\% Do Until rs.EOF \%>
            <%=rs("au_id") %>
            <%=rs("au_fname") %>
            < \% 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



API Service from Oxford Dictionary https://developer.oxforddictionaries.com/ 1
"definitions": [
 "present, appearing,
or found everywhere"]
}

Response in JSON format

## Try this!

- Visit <u>https://www.oed.com/</u>
- 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.

				Google Password M Extensions	anager <mark>New</mark>	l.	
OED	Oxford English Dictionary			Zoom Print Cast	- 100	% +	Ctrl+F
Dictionary	↓ ubiquitous Q	Save page as	Ctrl+S	Cast Find More tools			Ctrl+I
		Create shortcut Name window Clear browsing data	Ctrl+Shift+Del	Edit Settings Help	Cut	Сору	Pa
	nistorical English dictionary	Performance New Task manager	Shift+Esc	Exit			
	e for researchers in any discipline to the meaning, history, and 000 words and phrases across the English-speaking world.	Developer tools	Ctrl+Shift+I				

# Try this!

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

Elements Console		rmance Memory Application >> 🔺 2 🗖 1 🔅 🗄 >
	log Disable cache No thro	ottling 🔻 🙃 土 🛓
Filter I	nvert 🗌 Hide data URLs 🗌	Hide extension URLs
All Doc JS Fetch/XHR CSS	Font Img Media Manifest	WS Wasm Other Delocked response cookies
Blocked requests 3rd-party	requests	
200 ms 400 ms	600 ms 800 ms 100	0 ms 1200 ms 1400 ms 1600 ms 1800 ms 2
Name	X Headers Payload Pre	eview Response Initiator Timing Cookies
dictionary/?scope=Entries&q=	▼ General	
jquery.js?version=1.43	Request URL:	https://www.oed.com/search/dictionary/?scope=Entries&q=ubiquitous
js.cookie.min.js?version=1.43	Request Method:	GET
chart-3.8.0.js?version=1.43	Status Code:	• 200 200
popper.min.js?version=1.43	Remote Address:	52.212.13.25:443
tippy-bundle.umd.min.js?versi	Referrer Policy:	strict-origin-when-cross-origin
main.js?version=1.43	▼ Response Headers	Raw
api.js?version=1.43		-
idm.js?version=1.43	Access-Control-Allow-	true
common.js?version=1.43	Credentials:	
😶 ntpagetag.js	Access-Control-Allow-Headers:	Authorization, Content-Type, Accept, X-Requested-With
8eb5e30dac7d493298287704a	Access-Control-Allow-Methods:	GET, HEAD, POST, PUT, DELETE, TRACE, OPTIONS
— logo3.svg	Cache-Control: Connection:	no-cache, no-store, max-age=0, must-revalidate
<ul> <li>mobile-logo.svg</li> </ul>	Connection: Content-Encoding:	keep-alive gzip
8eb5e30dac7d493298287704a	Content-Encoding: Content-Language:	gzip en-GB
☑ indexV1.css	Content-Type:	text/html:charset=UTF-8
account-white.svg	Date:	Mon. 06 Nov 2023 02:20:51 GMT
info-white.svg	Expires:	0
search-white.svg	Pragma:	no-cache
🖸 popper.min.js	Server:	Apache
😶 tippy-bundle.umd.js	Set-Cookie:	AWSALB=ALwiZ5AwjAT8U9fa8j7GljCeqzqFzOe7VzdALm/8RmDAp
-nFnOHM81r4j6k0gjAW3mujV		Ctec4iOQrTqo+85J6Oi90Wm1oJ6LjLMS5PNEy4+Vejl16VoxDPQ3e
Q search.svg		WFCHG1egrWCssMBwSVVmJSQpFL; Expires=Mon, 13 Nov 2023
😶 gtm.js?id=GTM-W55924M		02:20:51 GMT; Path=/
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memvYaGs126MiZpBA-UvWbX		mDApCtec4iOQrTqo+85J6Oi90Wm1oJ6LjLMS5PNEy4+Vejl16VoxD
data:image/svg+xml;		PQ3eWFCHG1egrWCssMBwSVVmJSQpFL; Expires=Mon, 13 Nov
OQIvMX1D_JOuMwr7Iw.woff2		2023 02:20:51 GMT; Path=/; SameSite=None; Secure
<ul> <li>oup-logo-white.svg</li> </ul>	Transfer-Encoding:	chunked
chevron-right-white.svg	Vary:	Accept-Encoding
tippy-bundle.umd.js	X-Content-Type-Options:	nosniff
<ul> <li>popper.min.js</li> </ul>	X-Frame-Options:	SAMEORIGIN
ntpagetag.gif?js=1&ts=16992	X-Xss-Protection:	1; mode=block
(i) dictionary/?q=ubiquitous	* Paguast Hand	- Paur
X close.svg		Raw
manifest.json	Accept:	text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,ima
		ge/webp,image/apng,*/*;q=0.8,application/signed-
		exchange;v=b3;q=0.7
	Accept-Encoding:	gzip, deflate, br
	Accept-Language:	en-GB,en-US;q=0.9,en;q=0.8
	Connection:	keep-alive
	C 11	ICECCIONID CECCOMMAND CD CEOCES 11 COM 10 COM 10 COM
	Cookie:	JSESSIONID=C56CB2A18BD6DCE905F4A61D427CD529-n1; search- scope=Entries;

### Try this!

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

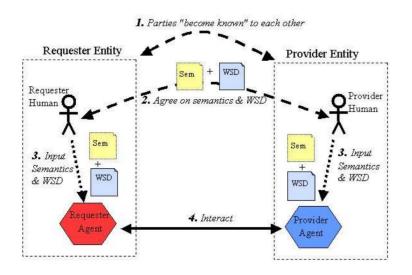
<ul> <li>mobile-log</li> </ul>	5	200	svg+xml	dictionary/?		2.0 kB	191 ms	
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account-v	Open in new tab		svg+xml	dictionary/?	<u>cop</u>	1.9 kB	185 ms	
☐ info-white			svg+xml	dictionary/?	<u>cop</u>	2.1 kB	181 ms	
search-wł	Clear browser cache		svg+xml	dictionary/?	<u>cop</u>	1.7 kB	361 ms	
😳 popper.m	Clear browser cookie	5	script / R	dictionary/?	<u>cop</u>	(disk cac	35 ms	
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🖸 gtm.js?id=	Block request domain		Copy respon	nse headers	212	(disk cac	4 ms	a
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X close.svg		200	Copy all as t	letch	212	1.6 kB	333 ms	
manifest.js	n	200	Copy all as I	Node.js fetch		1.4 kB	163 ms	
			Copy all as	:URL (cmd)				
			Copy all as	:URL (bash)				
			Copy all as I	HAR				

#### <u>Response</u>

[{"name":"ubiquitous","count":null,"label":"ubiquitou s","path":null},{"name":"ubiquitously","count":null,"l abel":"ubiquitously","path":null},{"name":"ubiquitous ness","count":null,"label":"ubiquitousness","path":n ull},{"name":"ubiquitous computing","count":null,"label":"ubiquitous computing","path":null}]

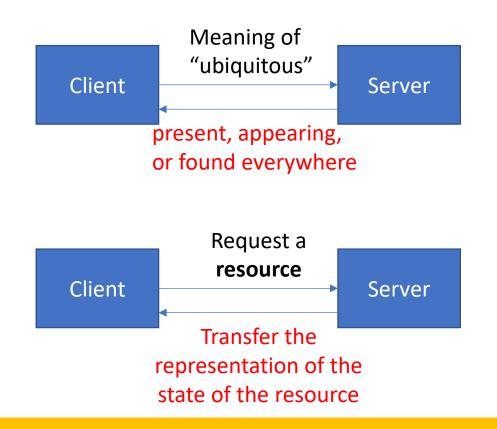
#### Web Services

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



#### **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:
  - <u>http://example.com/network-app/configurations/678678</u>
  - 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

#### **REST in Real World**

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	Filter	Preserve log       Disable cache       Online <ul> <li></li></ul>
Headlines More Headlines Yes Bank Rescue Plan "Bizarre", Huge Loan	Only show requests v	40000 ms         60000 ms         80000 ms         100000 ms         120000 ms         140000
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Yes bank, no bank The Indian Express + 10 hours and + Opinion	66 requests   430 KB tr	B transferred Line 1, Column 1

#### 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>
```

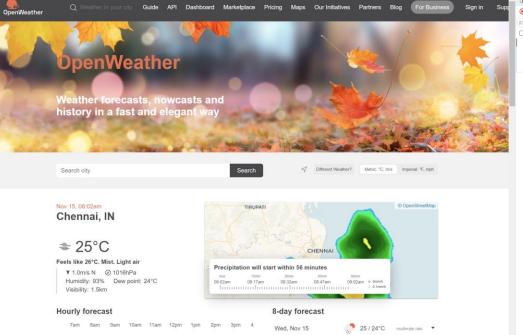
# Web Services for a Banking Application

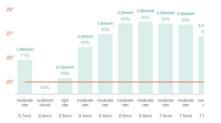
- Designing the REST API
  - Object Model
    - Customer, Account
  - Create Model URIs
    - /customers/{customerId}
    - /customers/{customerId}/accounts
    - /customers/{customerId}/accounts/{accountId}
  - Determine Representations
    - Represent all Account information as an XML/JSON
    - Represent 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/we ather?lat={lat}&lon={lon}&appid={API key}





				8-day forecast
*	moderate rain	25 / 24°C		Wed, Nov 15
	moderate rain	28 / 25°C		Thu, Nov 16
Ŧ	scattered clouds	29 / 26°C		Fri, Nov 17
×	broken clouds	29 / 26°C	~	Sat, Nov 18
¥	overcast clouds	29 / 27°C		Sun, Nov 19
	overcast clouds	29 / 26°C	-	Mon, Nov 20
*	broken clouds	29 / 25°C	-	Tue, Nov 21
*	few clouds	30 / 25°C		Wed, Nov 22

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Perform a request or hit  $\mathbf{Ctrl} + \mathbf{R}$  to record the reload.

Learn more

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	Humidity: 93% Dew point: 24°C 06 02am 06:17am Visibility: 1.5km	08:32am 08:47am	09:02am = 0mmh 1 = 0.1mmh										
	Hourly forecast	8-day forecast											
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		Wed, NOV 15	4/ 20124 C moderate rain +										
	28° 3.3mm/h 3.3mm/h 3.3mm/h 3.3mm/h	Thu, Nov 16	🔊 28 / 25°C moderate rain 🝷										
	2.Brmsh Barn	Fri, Nov 17	29 / 26°C scattered										
	27* 85% 8		Goods										
	85% 1.58mm3h	Sat, Nov 18	S 29 / 26°C broken clouds										
	26" 71%	Sun, Nov 19	\$ 29 / 27°C overcast clouds										
	0.75mm/h 85%												
	25"	Mon, Nov 20	S 29 / 26°C overcast clouds										
		Tue, Nov 21	S 29 / 25°C broken douds										
	moderate scattered light moderate	W- 1 N- 22											
	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 7.1	Wed, Nov 22	30 / 25°C few clouds *										

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# 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){
        ...
    }
}
```

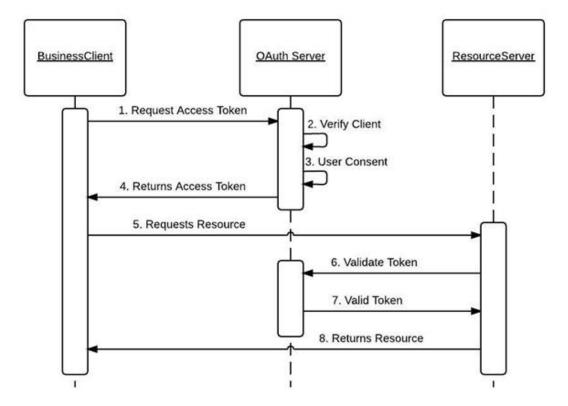
#### Authentication

- 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**

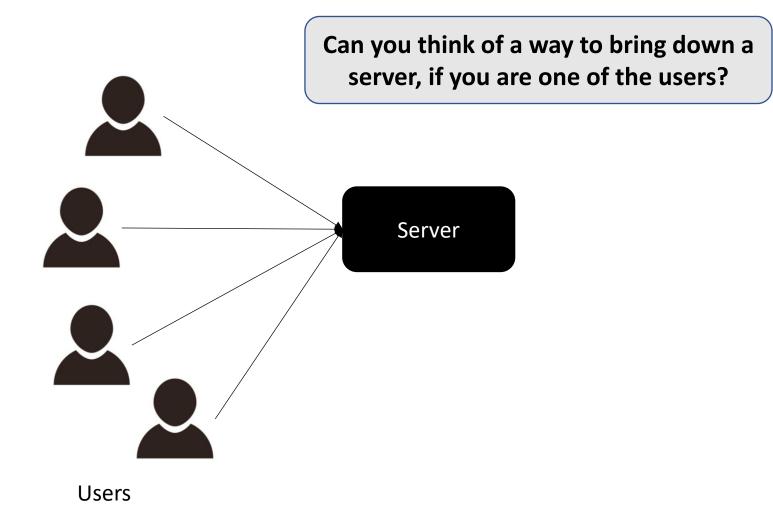
about:bla	ank × 🕀
€ → C	t nttp://localhost/members
	Authentication Required
	The server localhost:80 at Restricted Area requires a username and password.
	User Name:
	Password:
	Log In Cancel

#### oAuth 2.0 Architecture



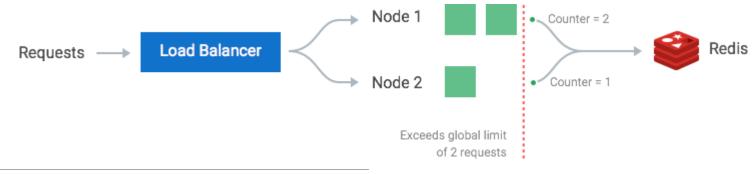
https://docs.oracle.com/cd/E82085\_01/160027/JOS%20Implementation%20Guide/Output/oau th.htm

#### Web Services – Rate Limiting



#### 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

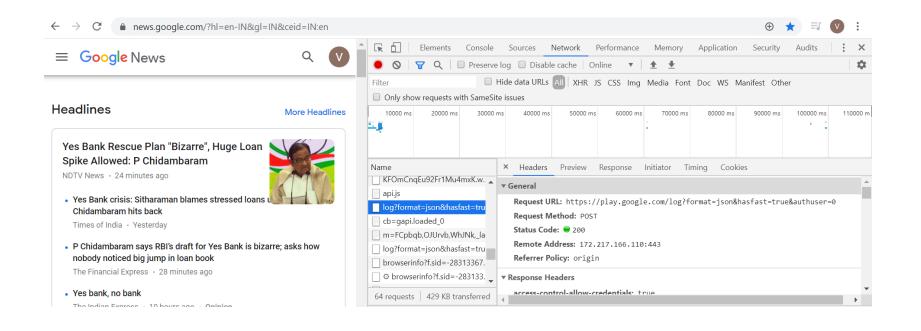
- Simple Scaling
  - Increase/Decrease the server instances
    - at specific times, or based on number of concurrent users, etc.
    - by a specific count (say, 10% or 10 instances)
  - Apply a cooldown time period to let the new servers come into action
- Target Tracking
  - Attempts to keep a specific 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

# Scaling in AWS

#### Create Auto Scaling Group

Increase Group	Size	8
Name:	Increase Group Size	
Execute policy when:	awsec2-rafal-test-autoscaling-group-increase	
	breaches the alarm threshold: NetworkOut > 30000 for 300 seconds	
	for the metric dimensions AutoScalingGroupName = rafal-test-autoscaling-group	
Take the action:	Add v 1 capacity units v when 30000 <= NetworkOut < +infinity	
	Add step (j)	
Instances need:	300 seconds to warm up after each step	
Create a simple scaling p		Ø
Name:	Decrease Group Size	•
Execute policy when:	awsec2-rafal-test-autoscaling-decrease	
	breaches the alarm threshold: NetworkOut <= 30000 for 300 seconds	
	for the metric dimensions AutoScalingGroupName = rafal-test-autoscaling-group	
Take the action:	for the metric dimensions AutoScalingGroupName = rafal-test-autoscaling-group Remove  1  capacity units  when 30000 >= NetworkOut > -infinity	

# 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 thirdparty 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

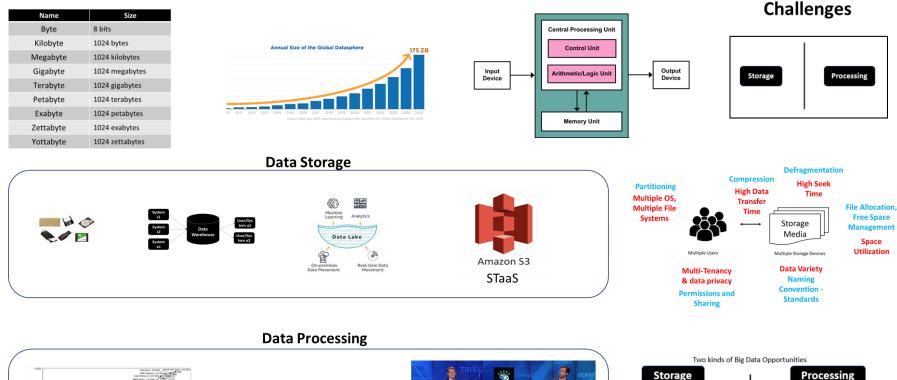
- Research Trends
  - Big Data Analysis
    - Knowledge Discovery, Data Mining, ...
  - Big Data Storage
    - Knowledge Management, Principles of Database Systems, ...
  - Big Data Applications
    - Web Search, Ecommerce, Recommendation systems, ...
- Trending among Practitioners
  - Business Intelligence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

# Summary

### What Comes Next?

byte kilobyte megabyte gigabyte ?? ??? ???? <u>;;;;;</u>

# Data Storage, Processing & File Systems



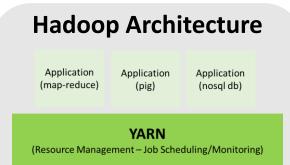


# Hadoop, HDFS and Map-Reduce

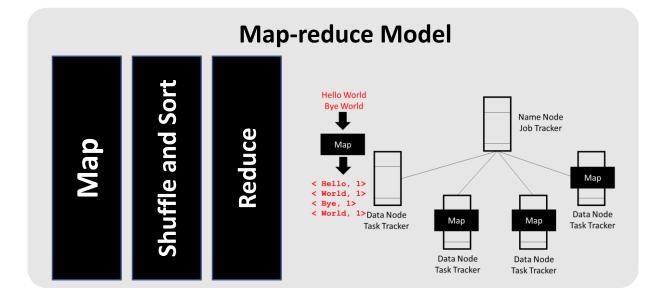
#### When not to use Hadoop?



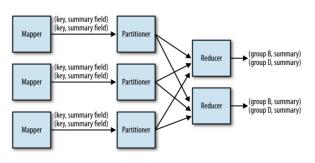
No Interactive Jobs No Jobs Requiring Co-ordination No Small Files



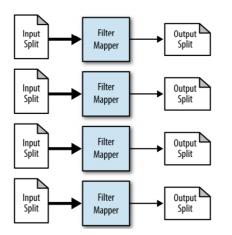
HDFS (Replicated Reliable Storage)



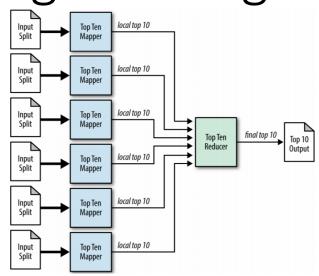
### Big Data - Programming



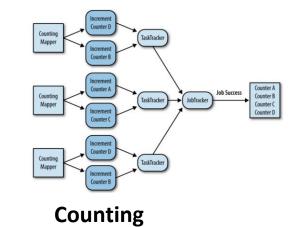
#### Summarization



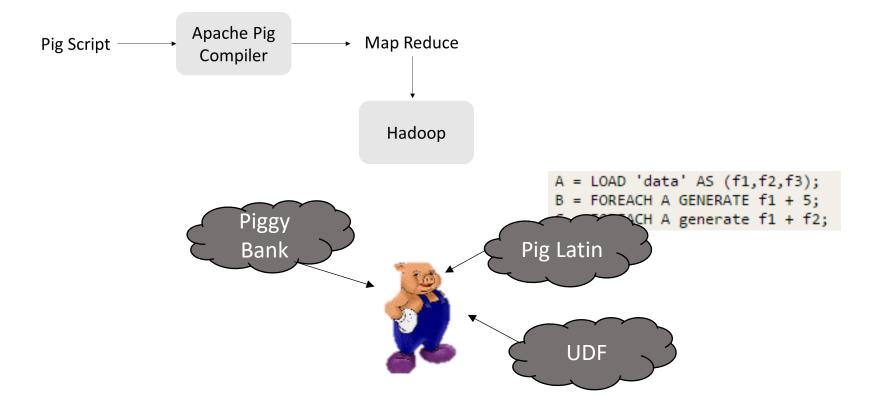
Filtering



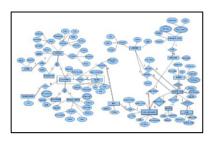
**Top 10** 



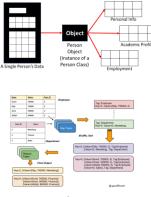




# NoSQL



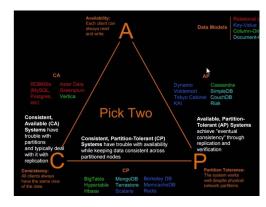
Schema-based Relational Model maintenance problems



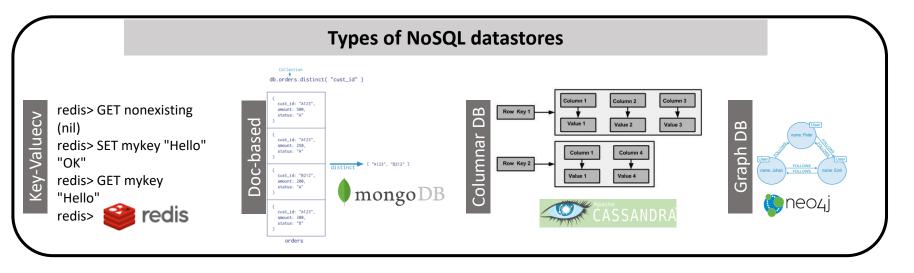
Impedance Mismatch

Multiple Tables

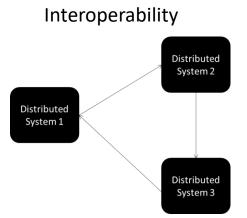
Scale-up Challenges

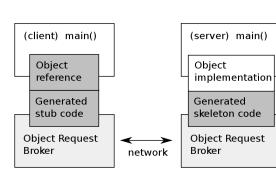


**CAP** Theorem



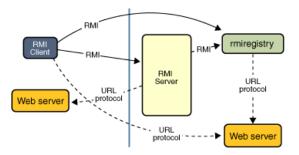
# Web Services





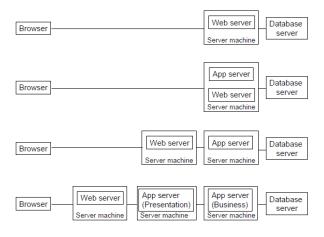
CORBA



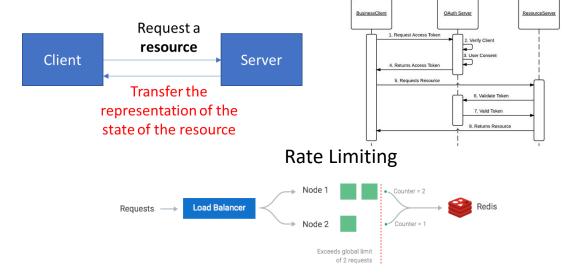


oAuth

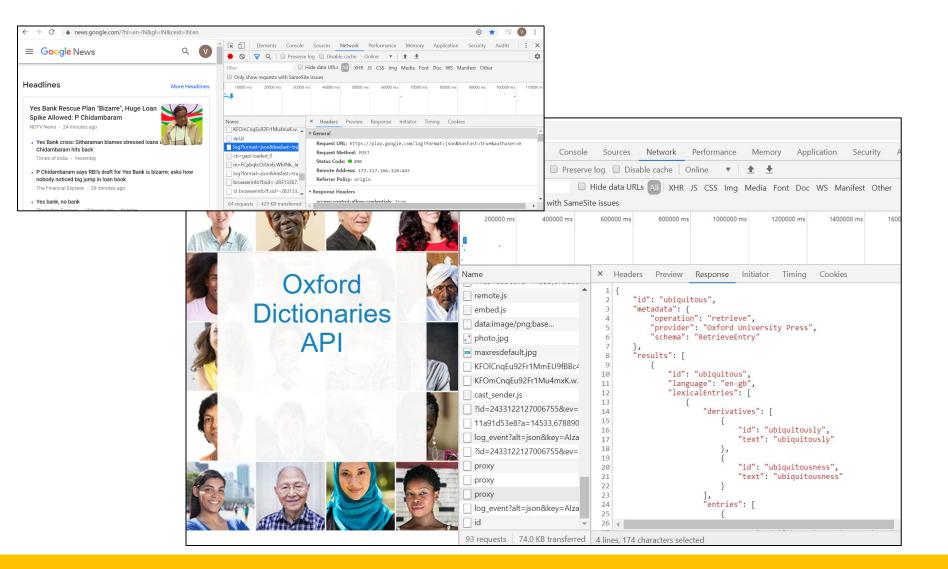








## Putting it all Together!



# Thank You