

Cloud and Web Applications

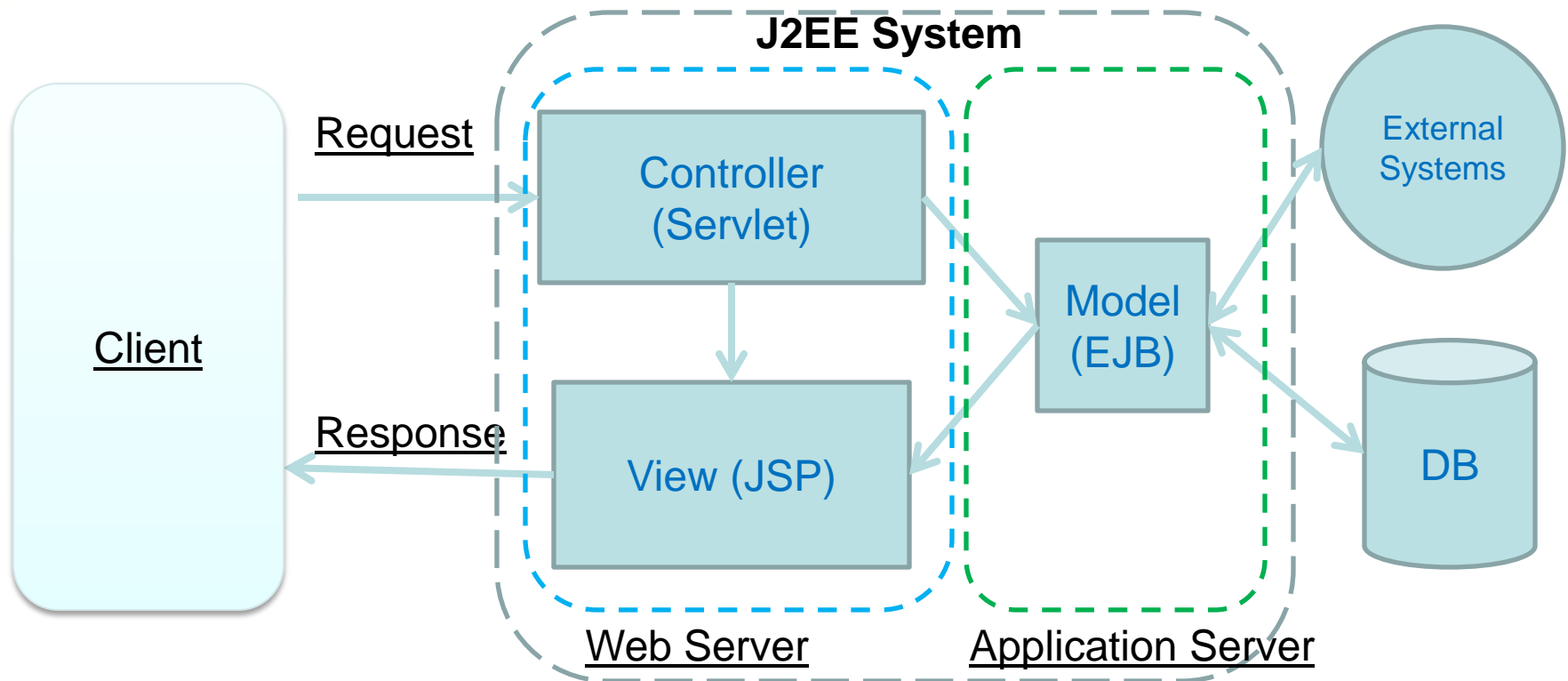
Part 3 : Server-Side Techniques

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- Node.js
- Database System
 - RDBMS
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- RESTful
- Develop Web Apps for Cloud

J2EE

J2EE Technology Overview



Technology Overview 2

- J2EE is a specification that different vendors implement
- J2EE Application Servers
 - For running full stack(Servlets, JSP, EJB)
 - jBoss, Oracle WebLogic, GlassFish, IBM Websphere ...
- Java WebServers
 - For running Servlets and JSP
 - Tomcat, Jetty,
- EJB-only server
 - OpenEJB

J2EE Technology Specifications

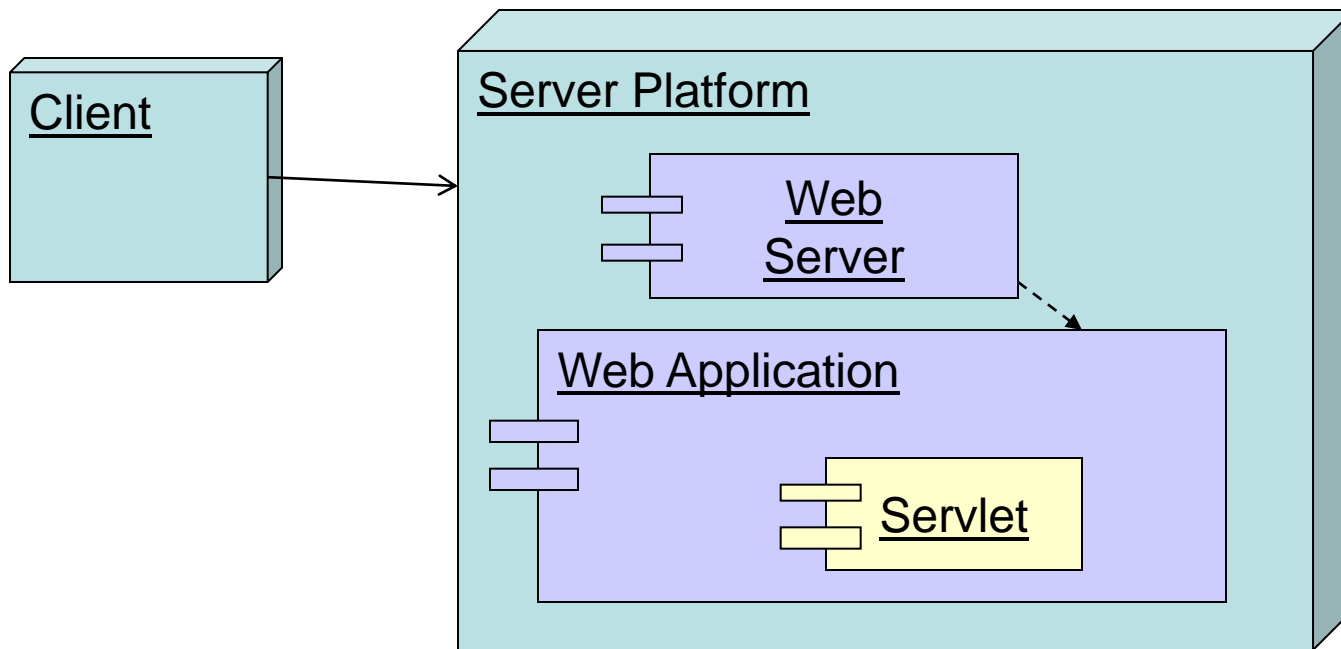
- Java API for RESTful Web Services (JAX-RS)
- Web Services 1.3 [JSR109](#)
- Java API for XML-Based Web Services (JAX-WS) 2.2 [JSR224](#)
- Java Architecture for XML Binding (JAXB) 2.2 [JSR222](#)
- Web Services Metadata for the Java Platform 2.1 [JSR181](#)
- Java API for XML-based RPC (JAX-RPC) 1.1 [JSR101](#)
- Java APIs for XML Messaging (JAXM) 1.3 [JSR67](#)
- Java API for XML Registries (JAXR) 1.0 [JSR93](#)
- Java Servlet 3.0 [JSR315](#)
- JavaServer Faces (JSF) 2.0 [JSR314](#)
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- Expression Language (EL) 2.2 [JSR245](#)
- JavaServer Pages Standard Tag Library (JSTL) 1.2 [JSR52](#)
- Enterprise JavaBeans (EJB) 3.1 [JSR318](#) Lite
- Java Persistence API (JPA) 2.0 [JSR317](#)
- Contexts and Dependency Injection for Java 1.0 [JSR299](#)
- Dependency Injection for Java 1.0 [JSR330](#)
- Common Annotations for the Java Platform 1.1 [JSR250](#)
- Java Message Service API (JMS) 1.1 [JSR914](#)
- Java Transaction API (JTA) 1.1 [JSR907](#)
- JavaMail API 1.4 [JSR919](#)
- Java Authentication Service Provider Interface for Containers (JASPIC) 1.0 [JSR196](#)
- Java Authorization Service Provider Contract for Containers (JACC) 1.4 [JSR115](#)
- ...

Web Technologies in J2EE

- Java Servlet 3.0
- JavaServer Faces 2.0
- JavaServer Pages 2.2/Expression Language 2.2
- Standard Tag Library for JavaServer Pages (JSTL)
- Debugging Support for Other Languages 1.0

Java Servlets

- A **servlet** is a Java program that is invoked by a web server in response to a request.
- Hosted by a **servlet container**

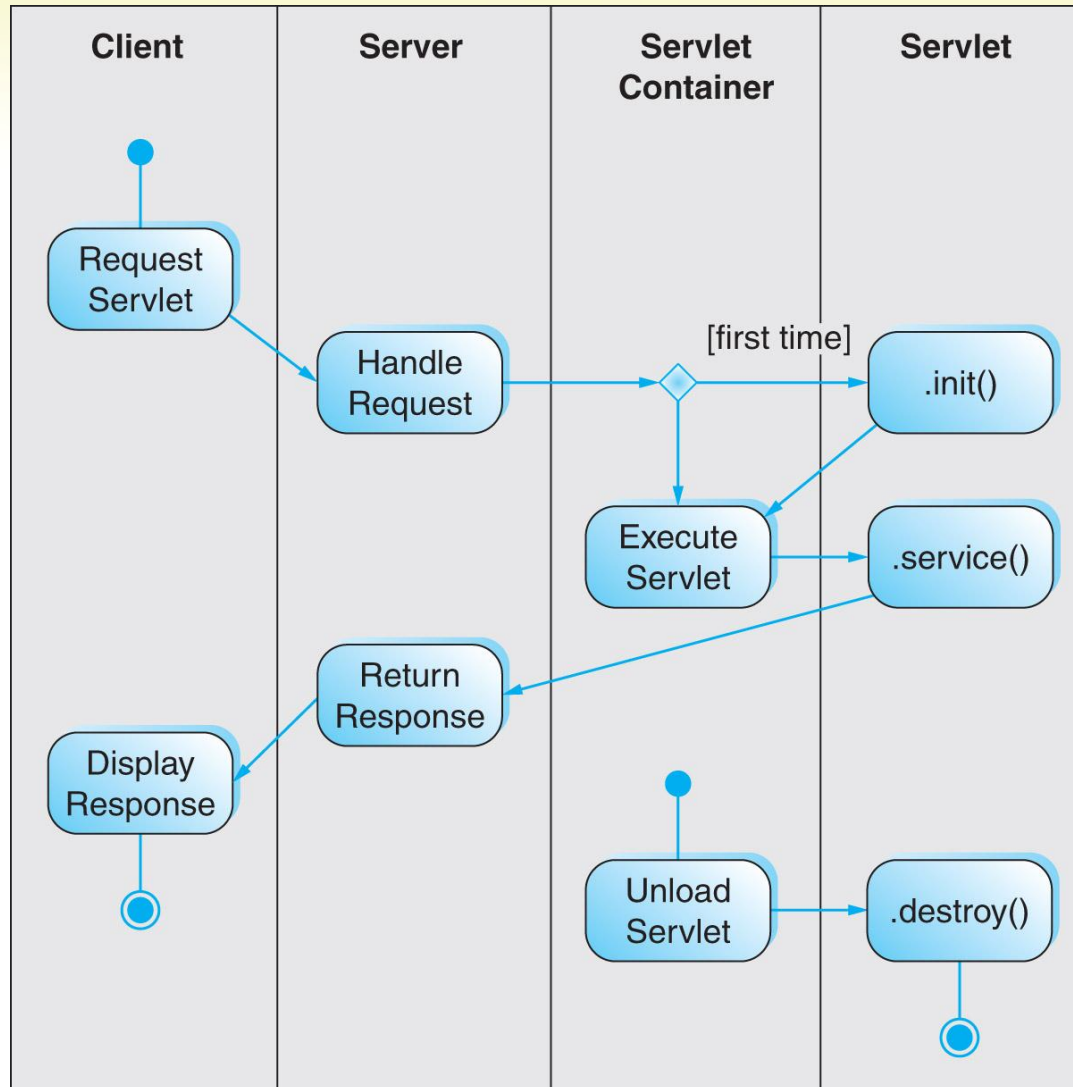


The web server handles the HTTP transaction details



Example: Apache Tomcat, both a web server and a servlet container

Servlet Operation



Servlet Example

- This servlet will say "Hello!" (in HTML)

```
package servlet;
import javax.servlet.http.*;

public class HelloServlet extends HttpServlet {
    public void service(HttpServletRequest req,
        HttpServletResponse res) throws IOException {
        PrintWriter htmlOut = res.getWriter();
        res.setContentType("text/html");
        htmlOut.println("<html><head><title>" +
            "Servlet Example Output</title></head><body>" +
            "<p>Hello!</p>" + "</body></html>");
        htmlOut.close();
    }
}
```

Servlet Configuration

- The web application configuration file, [web.xml](#), identifies servlets and defines a mapping from requests to servlets

An identifying name for the servlet (appears twice)

```
<servlet>
  <servlet-name>HelloServlet</servlet-name>
  <servlet-class>servlet.HelloServlet</servlet-class>
</servlet>
<servlet-mapping>
  <servlet-name>HelloServlet</servlet-name>
  <url-pattern>/hello</url-pattern>
</servlet-mapping>
```

The servlet's package
and class names

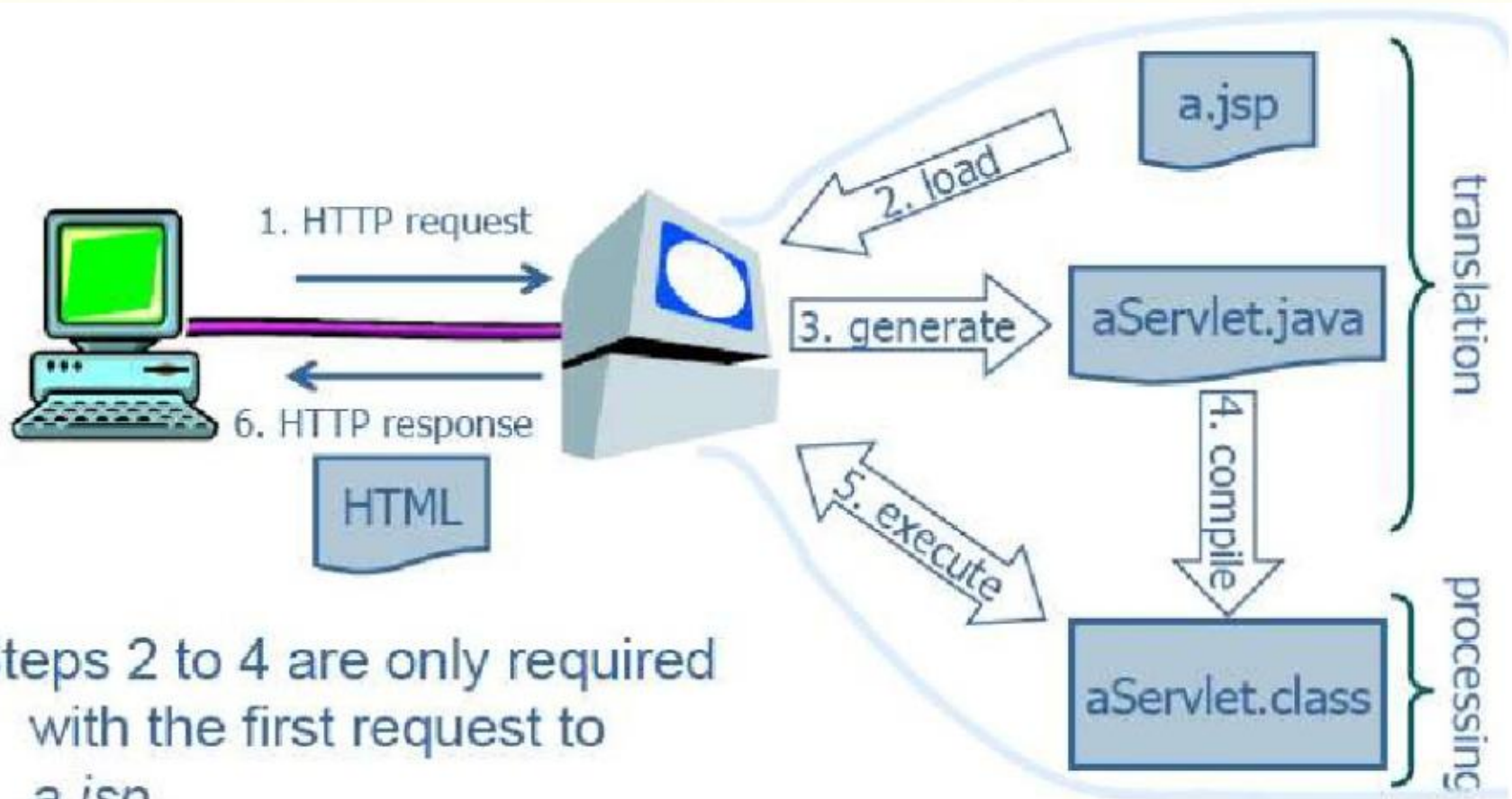
The pathname used to invoke the servlet
(relative to the web application URL)

Java Server Pages (JSP)

- HTML document with embedded Java code
- Translated into Java servlets when first used
- Allow static HTML content to be separated from dynamic content

```
<%@ page %>
<html>
<head><title>Example Page</title></head>
<body>
<h1>Example Page</h1>
<%
    String name = req.getParameter("name");
%>
<p>Hello, <%= name %></p>
...
</html>
```

Execution of JSP



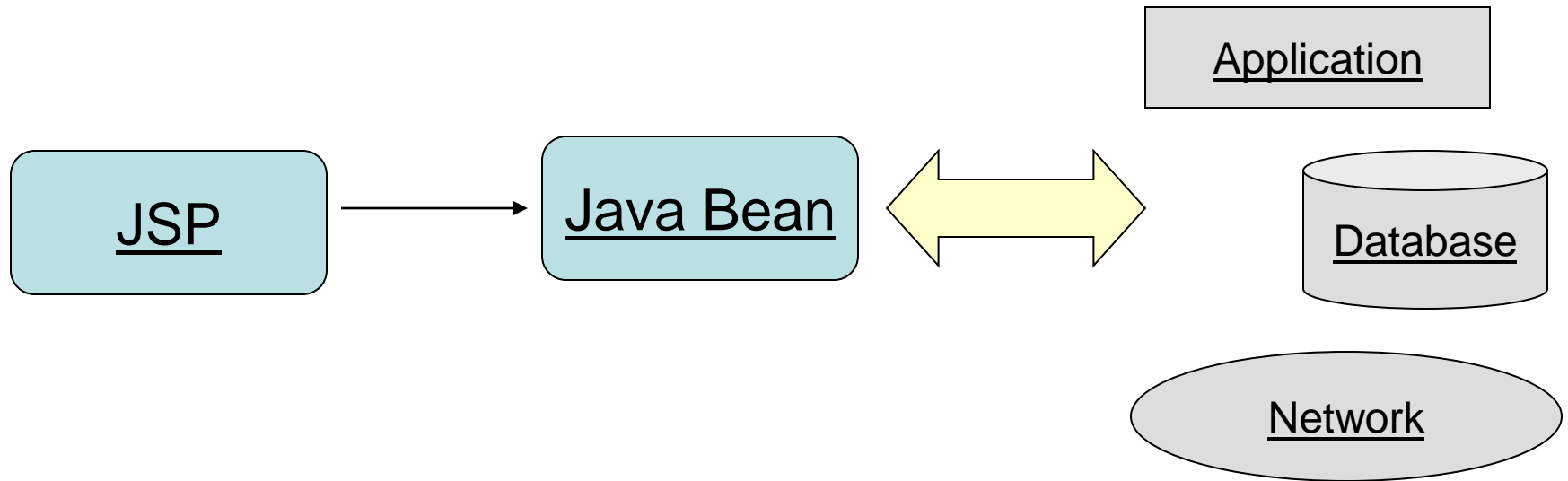
Steps 2 to 4 are only required with the first request to *a.jsp* .

Java Beans

- A Java Bean is a Java class that can be invoked from a JSP
- This allows complex processing required by a JSP to be separated from the JSP
- A JSP can instantiate an instance of a bean class and invoke its methods

Java Bean Uses

- Java Beans are typically used to encapsulate complex application logic, including calculations, database access, or network access



JSP and Java Bean Example

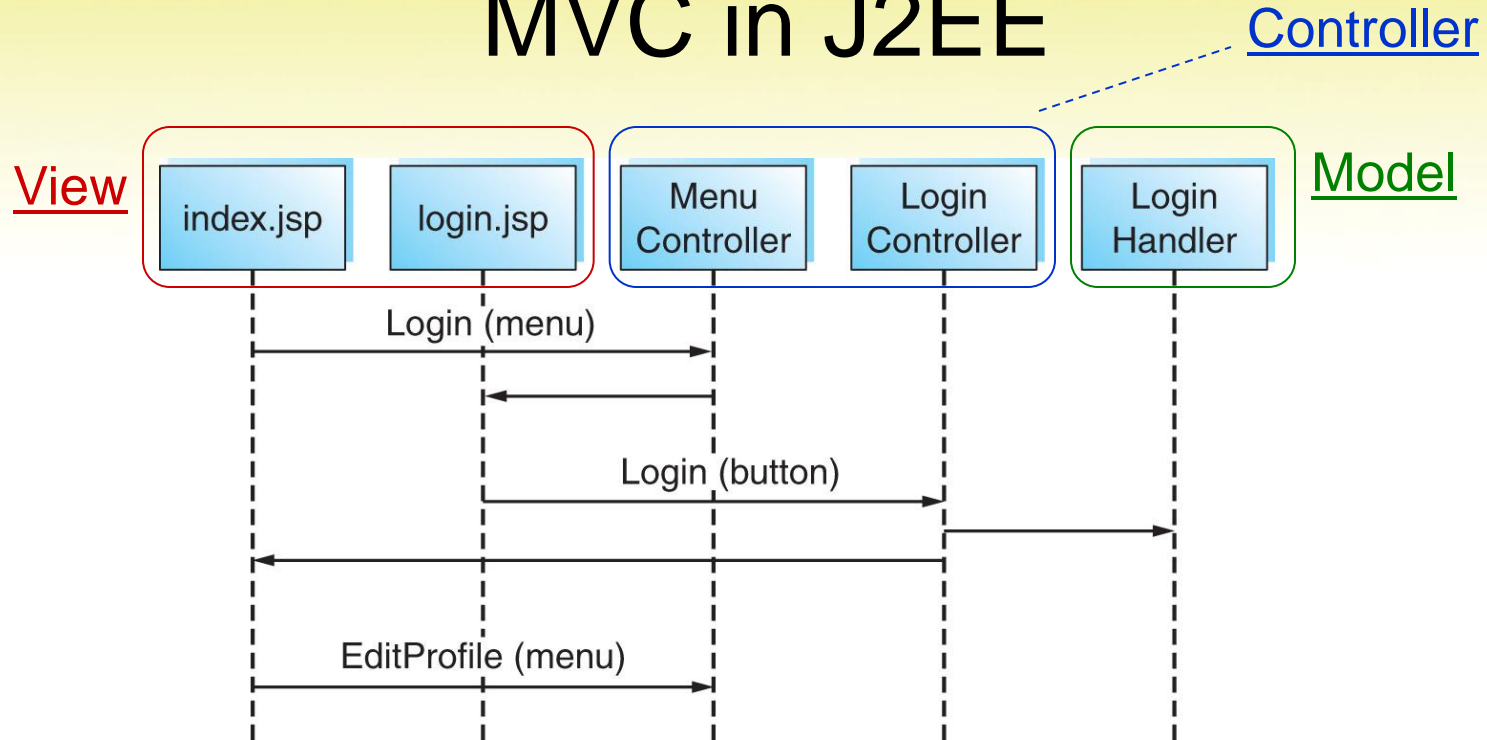
- Java Bean

```
package bean;  
public class AdderUtility {  
    public int add(int a, int b) {  
        return a + b;  
    }  
}
```

- JSP

```
<%@ page %>  
<jsp:useBean id="adder" class="bean.AdderUtility"  
    scope="session" />  
  
<%  
    int a, b, sum;  
    ...  
    int sum = adder.add(a, b);  
%>
```


MVC in J2EE



1. User requests "login" option; Controller sets "login.jsp" as the next view.
2. User enters credentials; Controller invokes LoginHandler to handle transaction
3. etc.

Traditional J2EE Users

- Examples of use
 - Insurance companies
 - Online banks
 - Manufacturing industries
 - Public sector

'Cobol of the 21st century'

New J2EE Techniques

- Many languages with seamless integration: you can share libraries, code, classes, etc.
 - Groovy
 - Object-oriented
 - Inspired by Java, Python, Ruby, Smalltalk
 - Scala
 - Functional, object-oriented
 - "Cutting away Java's syntactic overhead, adding power"
 - Inspired by Java, Scheme, Erlang, Haskell, Lisp
 - JRuby: implementation of Ruby on JVM
 - Jython: implementation of Python on JVM

Extensions to Core J2EE

- Grails (Groovy on Rails)
 - Interpreted script compiled to Java bytecode at runtime
 - Supports writing Java code directly
 - Java libraries, JPA models etc directly available
- Spring / Spring MVC
 - Abstraction, no need to work directly with Servlets etc
 - XML-based configuration
 - IoC/DI
 - Java EE 6 based on Spring
- JSF - Java Server Faces
 - Notation for generating JSF-pages (View), which communicate with managed beans(Controller)
- Struts
 - Custom tag libraries
 - XML-based

J2EE Trends

- Moving from single-tier or two-tier to **multi-tier** architecture
- Moving from monolithic model to **object-based** application model
- Moving from application-based client to HTML-based client

“Trendy” J2EE users: [LinkedIn](#)

- Started with Java platform, using Java EE and extensions
 - Spring Framework
 - Grails
- Now utilizing also Scala and JRuby
 - Scala for back-end processing
 - JRuby for integration interfaces

“Trendy” J2EE users: Twitter

- Started with Ruby on Rails
- Now using Java and Scala in back-end processing
 - Why?
 - Scalability and Performance
 - SOA
 - Encapsulation (re-use, maintenance)

“Trendy” J2EE users: Others

- Google, Amazon and many others use J2EE
- What about Facebook?
 - Writing PHP, which quickly lead to serious performance issues
 - Started compiling PHP to C++
 - Are now investigating using PHP on JVM

NODE.JS

Introduction to Node.js

“Node.js is a platform built on Chrome's JavaScript runtime for easily building fast, scalable network applications. Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient, perfect for data-intensive real-time applications that run across distributed devices.”

- nodejs.org

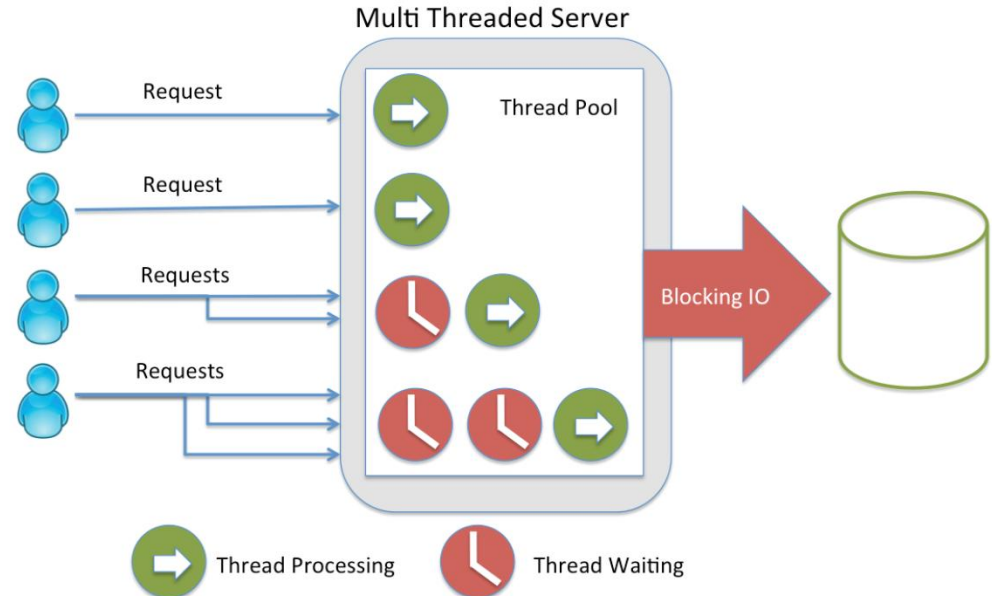
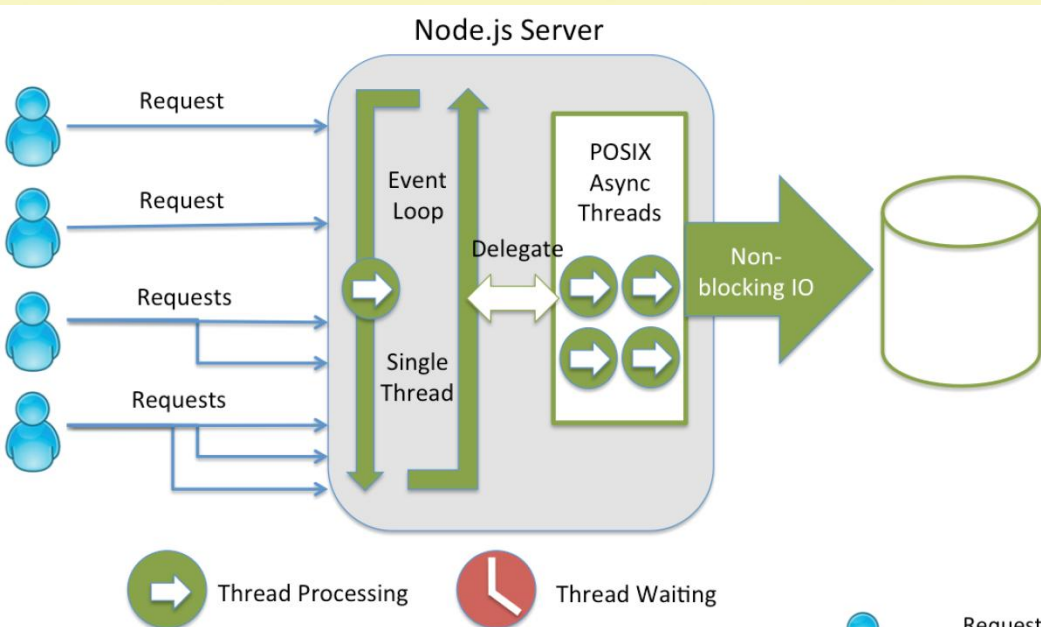
Preface

- Developed by Ryan Dahl pada tahun 2009
- Server Side JavaScript
- Built on Google's V8
- An environment for developing high performance web services
- Using event-driven, asynchronous I/O to minimize overhead and maximize scalability.
- The goal is to provide an easy way to build scalable network servers

Threads vs. Event-Driven

| Threads | Asynchronous Event-driven |
|---|---|
| Lock application / request with listener-workers threads | only one thread, which repeatedly fetches an event |
| Using incoming-request model | Using queue and then processes it |
| multithreaded server might block the request which might involve multiple events | manually saves state and then goes on to process the next event |
| Using context switching | no contention and no context switches |
| Using multithreading environments where listener and workers threads are used frequently to take an incoming-request lock | Using asynchronous I/O facilities (callbacks, not poll/select or O_NONBLOCK) environments |

Threads vs. Event-Driven (2)



Why Node.js Use Event-based?

In a normal process cycle the web server while processing the request will have to wait for the I/O operations and thus blocking the next request to be processed.

Node.JS process each request as events, The server doesn't wait for the IO operation to complete while it can handle other request at the same time.

When the I/O operation of first request is completed it will call-back the server to complete the request.

Node Potential Wins

- JavaScript is the popular language of the web
- Web applications spend most of their time doing I/O
- Can implement the same programming language on client and server. Code can be migrated between server and client more easily
- Common data formats (JSON) between server and client
- Common software tools, testing or quality reporting tools for server and client
- Node.js ships with a lot of useful modules, so you don't have to write everything from scratch.
- Thus, Node.js is really two things: a runtime environment and a library

Node.js vs. Apache

| Platform | Number of request per second |
|-----------------------|------------------------------|
| PHP (via Apache) | 3187,27 |
| Static (via Apache) | 2966,51 |
| Node.js | 5569,30 |

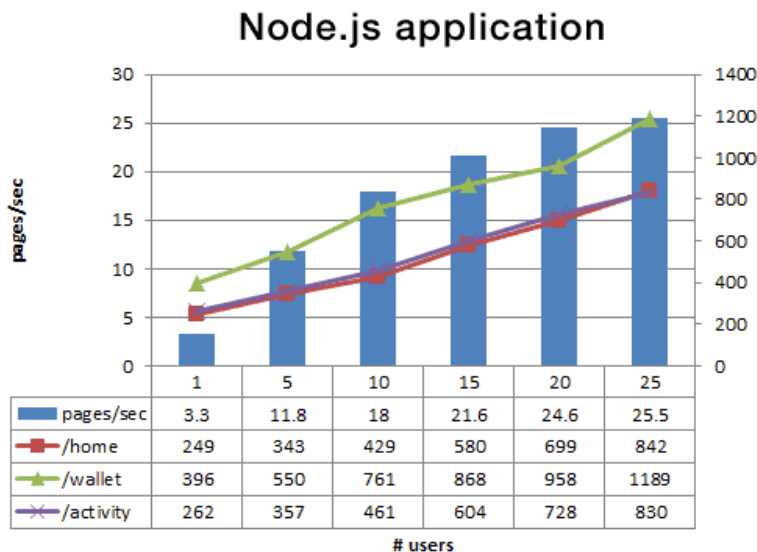
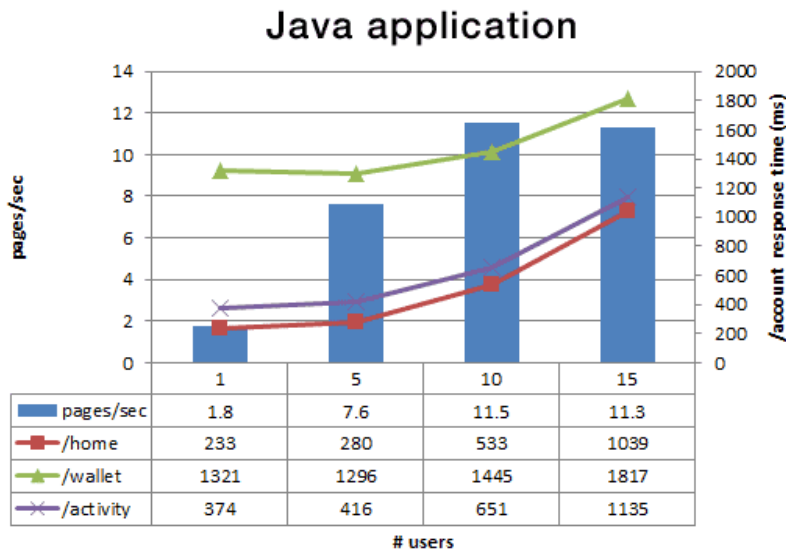
Node.js vs. PHP + Nginx

| Platform | Static (number of request per second) | Query MySQL (number of request per second) |
|-------------|--|---|
| PHP + Nginx | 3624 | 1293 |
| Node.js | 7677 | 2999 |

Node.js at PayPal

- PayPal's web applications are moving away from Java and onto JavaScript and Node.js.
- Comparing with Java, the Node.js app was:
 - Built almost **twice as fast with fewer people**
 - Written in **33% fewer lines of code**
 - Constructed with **40% fewer files**

Performance of PayPal App.



- Double the requests per second vs. the Java application.
- 35% decrease in the average response time for the same page. This resulted in the pages being served 200ms faster.

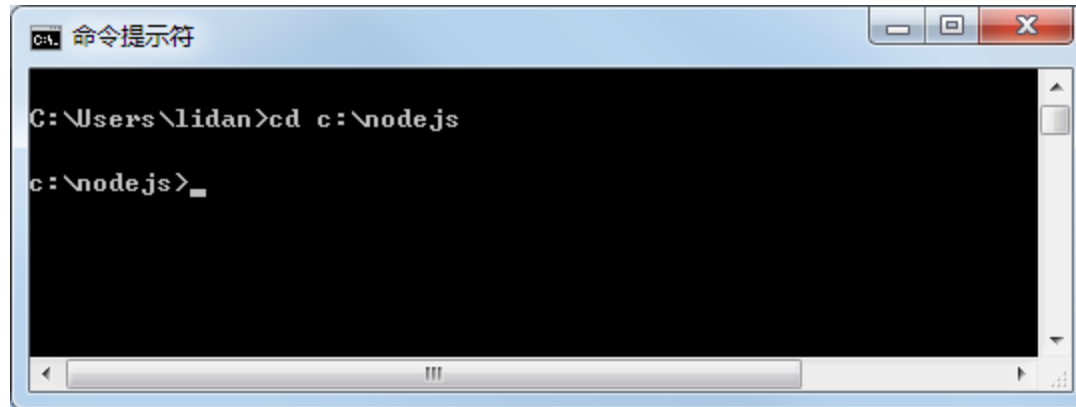
Open Command Prompt (cmd)

Cmd is the command line interface tool used to execute the various commands.

- Win XP: **Start button** -> **Run** -> type `cmd.exe`, press enter.
- Win 7: **Start button** -> type `cmd` in the search box -> Click on **cmd** the search results listing.
- Win 8: Swipe to **Apps** screen -> locate *Windows System* -> click on **Command Prompt**

Basic cmd commands

- **dir** : display a list of files and folders
- **cd <folder>** : change directory - move to a specific *folder*



- **md <name>** : create a new folder with *<name>* in the current folder.
- **ping <ip>** : test a network connection to the ip

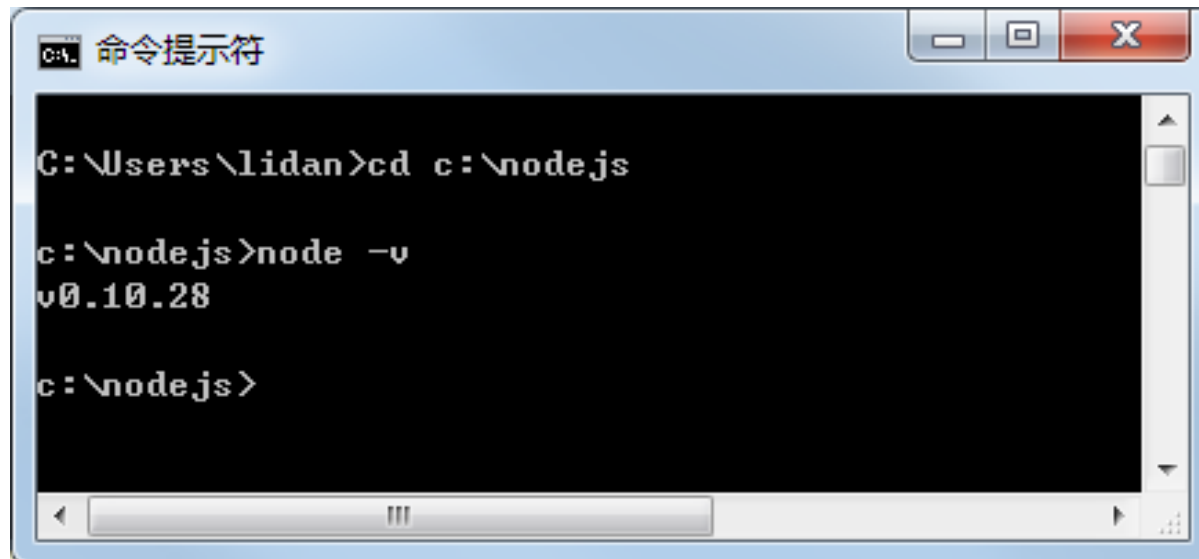
Lab : Install NodeJS

- Download and install node.js : <http://nodejs.org/>
 - Click 'Install' or go to the 'Downloads' page
 - Once downloaded, run the installer
 - Install Node.js in directory `c:\>nodejs`



Test the Installation

- Open a cmd, go to the **nodejs** directory
- Type **node -v** in command line
- If the version information is shown, Node.js is correctly installed.



A screenshot of a Windows Command Prompt window. The title bar shows '命令提示符' (Command Prompt) and the path 'C:\Users\lidan'. The command history shows the following sequence of commands and output:

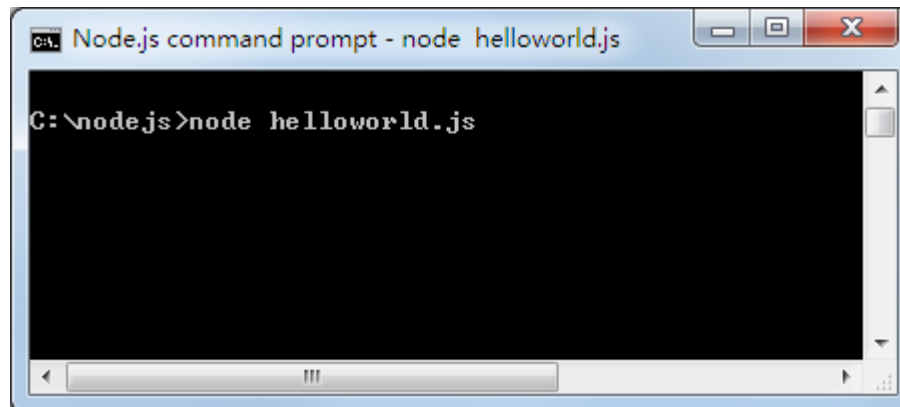
```
C:\Users\lidan>cd c:\nodejs  
c:\nodejs>node -v  
v0.10.28  
c:\nodejs>
```

A Basic HTTP Server

- Create `helloworld.js` file in the nodejs folder as the follows

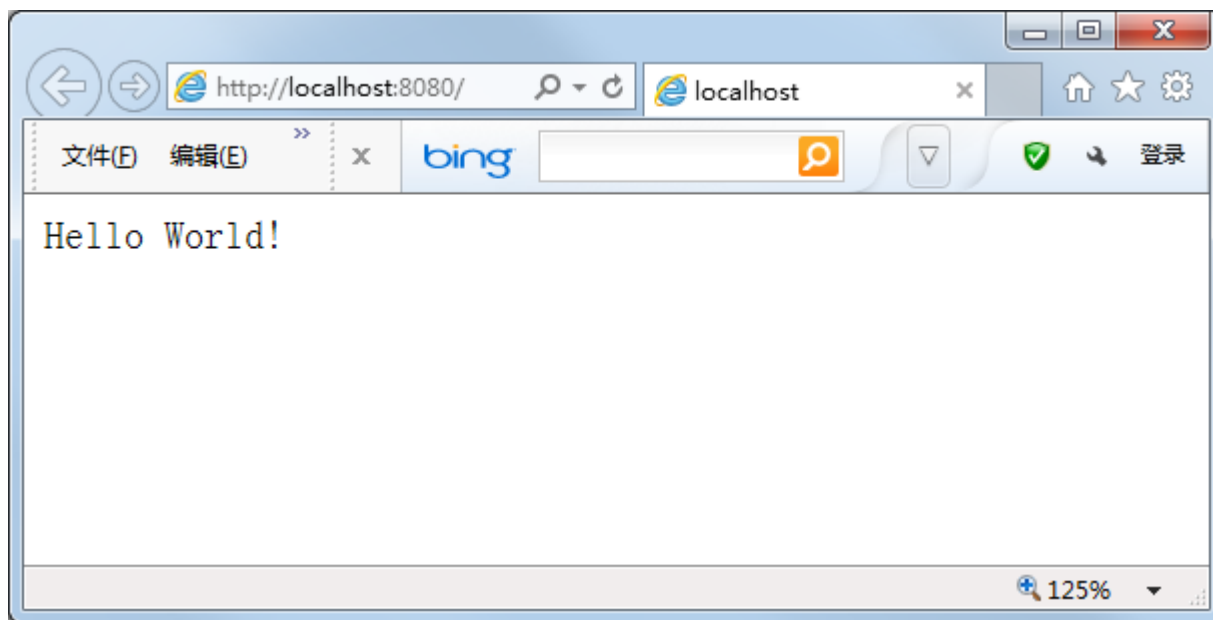
```
var http = require("http");
http.createServer(function(request, response) {
    response.writeHead(200, {"Content-Type": "text/html"});
    response.write("Hello World!");
    response.end();
}).listen(8080);
console.log("Server has started.");
```

- Execute the js file in Node.js:



Test the HTTP Server

- Open your browser and access <http://localhost:8080>. This should display a web page that says “Hello World”.



Analyzing the HTTP Server

requires the "http" module from Node.js library and assigns it to variable http

```
var http = require("http");
```

```
http.createServer(function(request, response) {  
    response.writeHead(200, {"Content-Type": "text/html"});  
    response.write("Hello World!");  
    response.end();  
}).listen(8080);
```

the parameter of the createServer: an anonymous function to callback when a http request is arrived

```
console.log("Server has started.");
```

*Invokes method listen of the object ,
listen to a http port*

*calls function createServer of the http
module, returns an object*

Another Version of the HTTP Server

```
var http = require("http");

function onRequest(request, response) {

    console.log("Request received.");

    response.writeHead(200, {"Content-Type": "text/plain"});
    response.write("Hello World");
    response.end();
}

http.createServer(onRequest).listen(8080);

console.log("Server has started.");
```

DATABASE SYSTEMS

RDBMS

- A Relational Database Management System (RDBMS) provides storage and access for structural data in web applications
- Examples: MySQL, SQL Server, Oracle, PostgreSQL

Other Types of Databases

- Hierarchical database
 - organizes data in a tree-like structure
 - defines a parent/child relationship
 - each parent can have many children but each child has only one parent
 - folder or directory structure for storing files on a computer is an example of a hierarchical data structure
- NoSQL- promotes the use of non-relational databases and does not require fixed table schemas as with the relational model

Relational Database Structure

- A database includes one or more **tables**
 - Each table represents one *type* of entity
- Example: Tables in a Library Database

User

Loan
(transaction)

Recording

Book

Relational Database Structure (2)

- Each table **field** represents an entity attribute
- Each table **row** represents one entity

Car table:

| <i>Year</i> | <i>Make</i> | <i>Model</i> | <i>Color</i> |
|--------------------|--------------------|---------------------|---------------------|
| 1973 | Volkswagen | Jetta | Red |
| 1992 | Ford | Aerostar | Blue |
| 2004 | Chevrolet | Suburban | Black |

row →

↖
field

Structured Query Language (SQL)

- Development since 1970 by IBM
- A standard language for creating and maintaining relational databases
- SQL statement types:
 - *data definition*: create databases and tables
 - *data manipulation*: add, modify, delete data
 - *data control*: set access permissions

Basic SQL Statements

- Data definition
 - CREATE, DROP
- Data manipulation
 - SELECT, INSERT, UPDATE, DELETE
- Data control
 - GRANT, REVOKE

CREATE

- Create a database or a table

```
CREATE DATABASE mydata
```

```
CREATE mydata.player (  
    playerNr int PRIMARY KEY,  
    name VARCHAR(30),  
    isCurrent BOOLEAN NOT NULL)
```

Example table creation

```
create table student  
(  
    id int,  
    name varchar(255),  
    major char(4),  
    gender char(1),  
    dob date,  
    constraint student_pk primary key (id)  
);
```

why did we specify
these attribute types?



student_pk is an arbitrary name



Basic SQL Data Types

- INTEGER
- DECIMAL(T, R)
 - T=total digits, R=right digits (after '.')
- FLOAT
- CHAR(N) N characters
- VARCHAR(N) up to N characters
- BOOLEAN
- DATE
- TIME

DROP

- DROP can be used to delete an entire database or a table

DROP mydata

DROP mydata.player

SELECT

- SELECT retrieves data from a database

```
SELECT field-list FROM database.table  
WHERE condition  
ORDER BY field-list
```

- *field-list* is a comma-separated list of fields from the named table (* means "all fields")
- *condition* is a Boolean condition using field names and/or constants

SELECT Example

- Example

```
SELECT * FROM mydata.player
```

```
SELECT playerNr, name FROM player  
WHERE isCurrent=TRUE
```

```
SELECT playerNr, name, status FROM player  
WHERE playerNr >= 90001  
ORDER BY status, name
```


INSERT

- INSERT adds a new row to a table

```
INSERT INTO player  
VALUES (23752, 'Jane Doe', TRUE)
```

UPDATE

- UPDATE changes one or more rows

```
UPDATE database.table  
    SET field-assignment-list  
    WHERE condition
```

```
UPDATE player  
    SET isCurrent=TRUE  
    WHERE playerNr=33256
```

DELETE

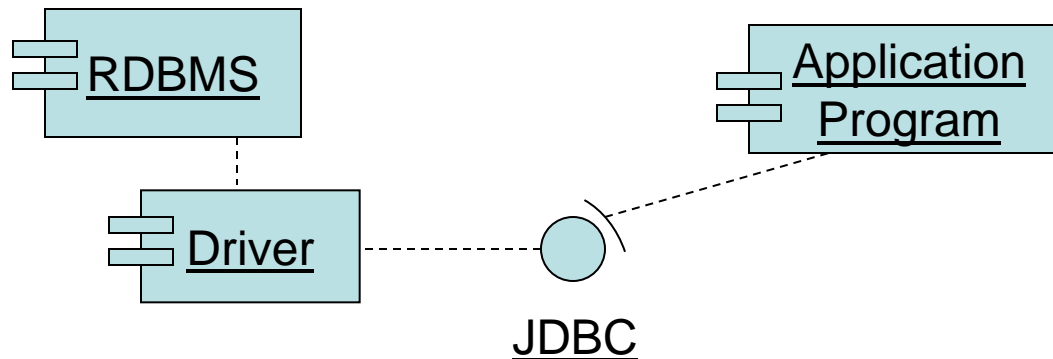
- DELETE removes one or more rows from a table

```
DELETE FROM database.table  
WHERE condition
```

```
DELETE FROM player  
WHERE playerNr=33523
```

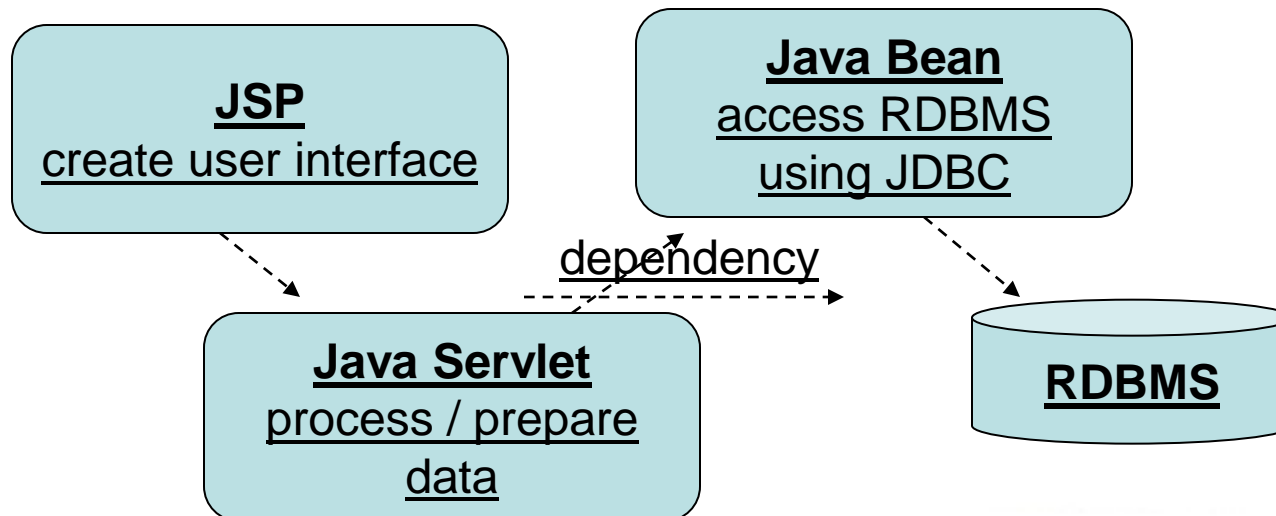
JDBC

- **Java Database Connectivity (JDBC)** is a Java API that allows Java programs to interact with relational database management systems
- Interaction also requires a **database driver**, which translates JDBC commands to procedure calls on the RDBMS



JDBC Design

- An effective design for database access:
 - JSP: user interface presentation
 - Java Servlet: application logic
 - Java Bean: database access (JDBC)



NoSQL Databases

- A NoSQL database provides a mechanism for storage and retrieval of data that employs less constrained consistency models than traditional relational databases.
- NoSQL databases only support eventual consistency which is a consistency model used in distributed computing that informally guarantees that, if no new updates are made to a given data item, eventually all accesses to that item will return the last updated value.

NoSQL Databases (2)

- NoSQL databases are often highly optimized key–value stores intended for simple retrieval and appending operations, with the goal being significant performance benefits in terms of latency and throughput.
- Key–value stores allow the application to store its data in a schema-less way.
 - The data could be stored in a datatype of a programming language or an object. Because of this, there is no need for a fixed data model.



NoSQL Market Data

2014 **8%**

% NoSQL Enterprise Adoption

2010 **5%** 2015 **20%**

RedMonk

"MongoDB is the new MySQL."

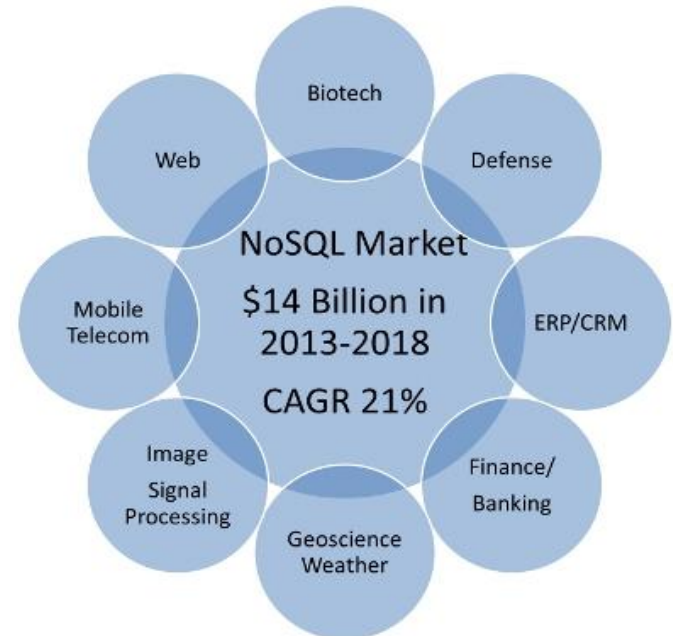
FORRESTER

"Current adoption of NoSQL in enterprises is 4% in 2010. expected to double by 2014, and grow to 20% by 2015. 10% of existing apps could move to NoSQL. [Sept 2011]"

Gartner

"NoSQL is in its infancy, many immature with only community support and limited tool capability; however, expect to see a few used more widely during the next 5 years."

- 2011: Market Research Media noted worldwide NoSQL market was expected to reach ~\$3.4B by 2018, generating \$14B from 2013-2018 with a CAGR of 21%
- Comparison: data implies NoSQL market ~\$895M
 - MySQL in 2011 ~\$100M



MongoDB Overview

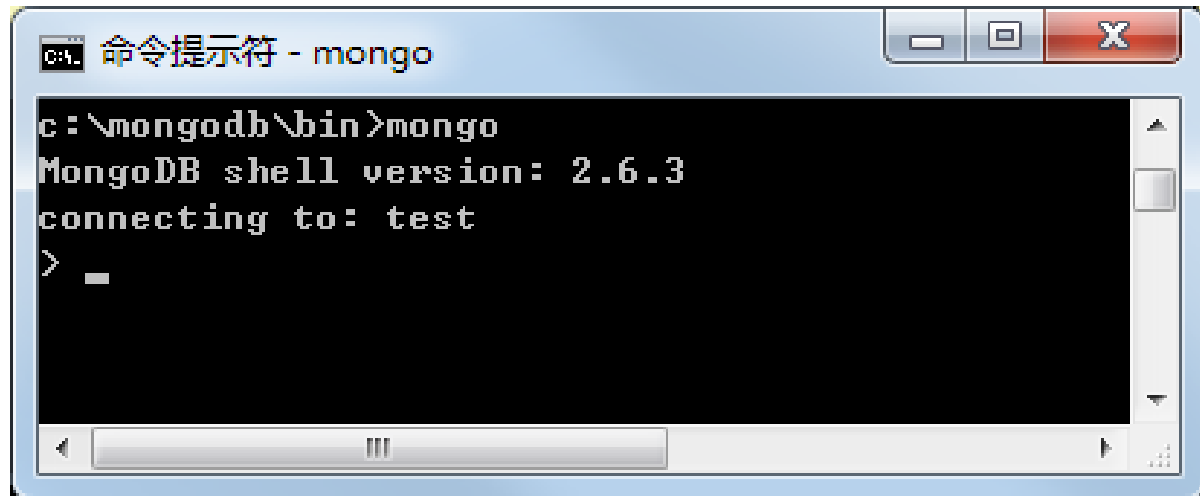
- Document oriented, not table/row oriented
- Collection of binary JSON (BSON) documents
- Schemaless
- No relations or transactions native in database
- Scalable and high-performance
- Fast In-Place Updates
- Map/Reduce
- Full index support
- Servers for all major platforms
- Drivers for all major development environments
- Free and open-source, but also commercial support

Lab : Install MongoDB

- Download mongoDB from <http://www.mongodb.org/downloads>
(msi for windows)
- Create a new folder *c:\mongodb*, and install mongodb to the folder
- Create a new folder *data* inside the folder *mongodb* to store data

Lab : Start MongoDB

- Open a cmd, goto folder `c:\mongodb\bin`
- Start monfoDB by typing
`mongod.exe --dbpath c:\mongodb\data`
- Open another cmd, goto folder `c:\mongodb\bin` ,
and type `mongo.exe` to open a management
window.



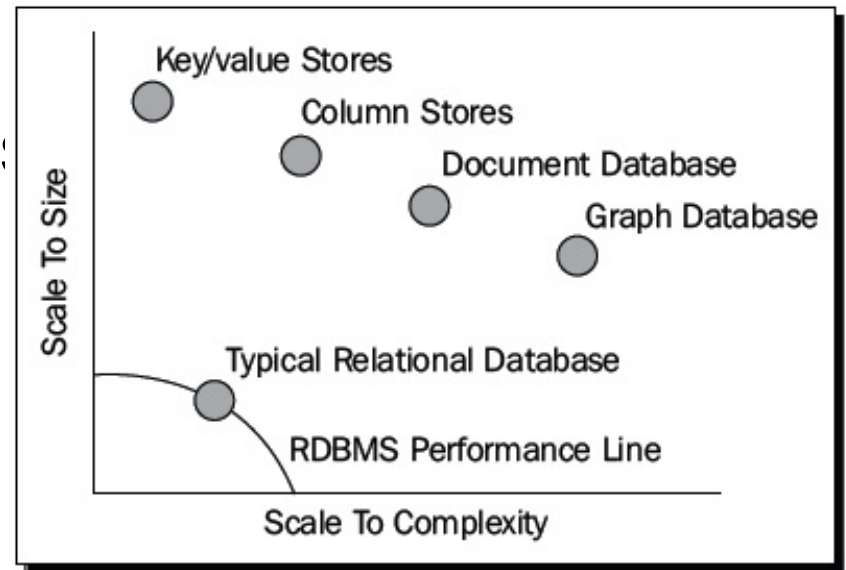
```
c:\mongodb\bin>mongo
MongoDB shell version: 2.6.3
connecting to: test
> _
```

Why MongoDB

- Rapid Application Prototyping
 - Schema rides as objects inside the JSON Script, not as a separate item.
 - Schemas change quite quickly in modern apps as business needs change.
 - Apps have shorter production lives and even shorter life-cycles as a result
- Scalability
 - Automatic data rebalancing across cheap, inexpensive commodity network hardware during the shard operation.
- Large amount of customers worldwide.
- Free basic edition
- Many related free software downloads

Use cases

- High performance and scalable applications
- Most web applications where you would previously use SQL



Do not use for:

- Transaction-critical applications

BSON - Data Type in MongoDB

- BSON is the binary representation of JSON.
- MongoDB drivers send and receive in BSON form.

```
{"hello":  
  "world"}      →  "\x16\x00\x00\x00\x02hello\x00  
                   \x06\x00\x00\x00world\x00\x00"  
  
{"BSON":  
  ["awesome",  
  5.05, 1986]}  →  "\x31\x00\x00\x00\x04BSON\x00\x26\x00  
                   \x00\x00\x020\x00\x08\x00\x00  
                   \x00awesome\x00\x011\x00\x33\x33\x33\x33\x33\x33  
                   \x14\x40\x102\x00\xc2\x07\x00\x00  
                   \x00\x00"
```

Terminology and Concepts

| RDBMS | | MongoDB |
|-------------|---|-----------------------|
| Database | ⇒ | Database |
| Table, View | ⇒ | Collection |
| Row | ⇒ | Document (JSON, BSON) |
| Column | ⇒ | Field |
| Index | ⇒ | Index |
| Join | ⇒ | Embedded Document |
| Foreign Key | ⇒ | Reference |
| Partition | ⇒ | Shard |

Schema Free

- MongoDB does not need any pre-defined data schema
- Every document could have different data!

```
{name: "will",  
  eyes: "blue",  
  birthplace: "NY",  
  aliases: ["bill", "la  
ciacco"],  
  loc: [32.7, 63.4],  
  boss: "ben"}
```

```
{name: "jeff",  
  eyes: "blue",  
  loc: [40.7, 73.4],  
  boss: "ben"}
```

```
{name: "brendan",  
  aliases: ["el diablo"]}
```

```
{name: "ben",  
  hat: "yes"}
```

```
{name: "matt",  
  pizza: "DiGiorno",  
  height: 72,  
  loc: [44.6, 71.3]}
```



CRUD

- Create
 - `db.collection.insert(<document>)`
 - `db.collection.save(<document>)`
 - `db.collection.update(<query>, <update>, { upsert: true })`
- Read
 - `db.collection.find(<query>, <projection>)`
 - `db.collection.findOne(<query>, <projection>)`
- Update
 - `db.collection.update(<query>, <update>, <options>)`
- Delete
 - `db.collection.remove(<query>, <justOne>)`

Example-Querying

```
> db.user.findOne({age:39})  
> db.users.find({'last': 'Doe'})  
// retrieve all users order by last_name:  
> db.users.find({}).sort({last: 1});
```

```
-    {"_id" : ObjectId("5114e0bd42..."),  
      "first" : "John",  
      "last" : "Doe",  
      "age" : 39,  
      "interests" : [  
        "Reading",  
        "Mountain Biking ]  
      "favorites": {  
        "color": "Blue",  
        "sport": "Soccer"} }
```

Advanced Querying

```
{ name: "Joe", address: { city: "San Francisco", state: "CA" } , likes: [ 'scuba', 'math', 'literature' ] }
```

```
// field in sub-document:
```

```
db.persons.find( { "address.state" : "CA" } )
```

```
// find in array:
```

```
db.persons.find( { likes : "math" } )
```

```
// regular expressions:
```

```
db.persons.find( { name : /acme.*corp/i } );
```

```
// javascript where clause:
```

```
db.persons.find("this.name != 'Joe'");
```

```
// check for existence of field:
```

```
db.persons.find( { address : { $exists : true } } );
```

Insert & Update

- Supports bulk inserts
- Default saves are upserts
- In place updating
- Atomic transactions for single documents
- Server side JavaScript execution

Insert & Update Example

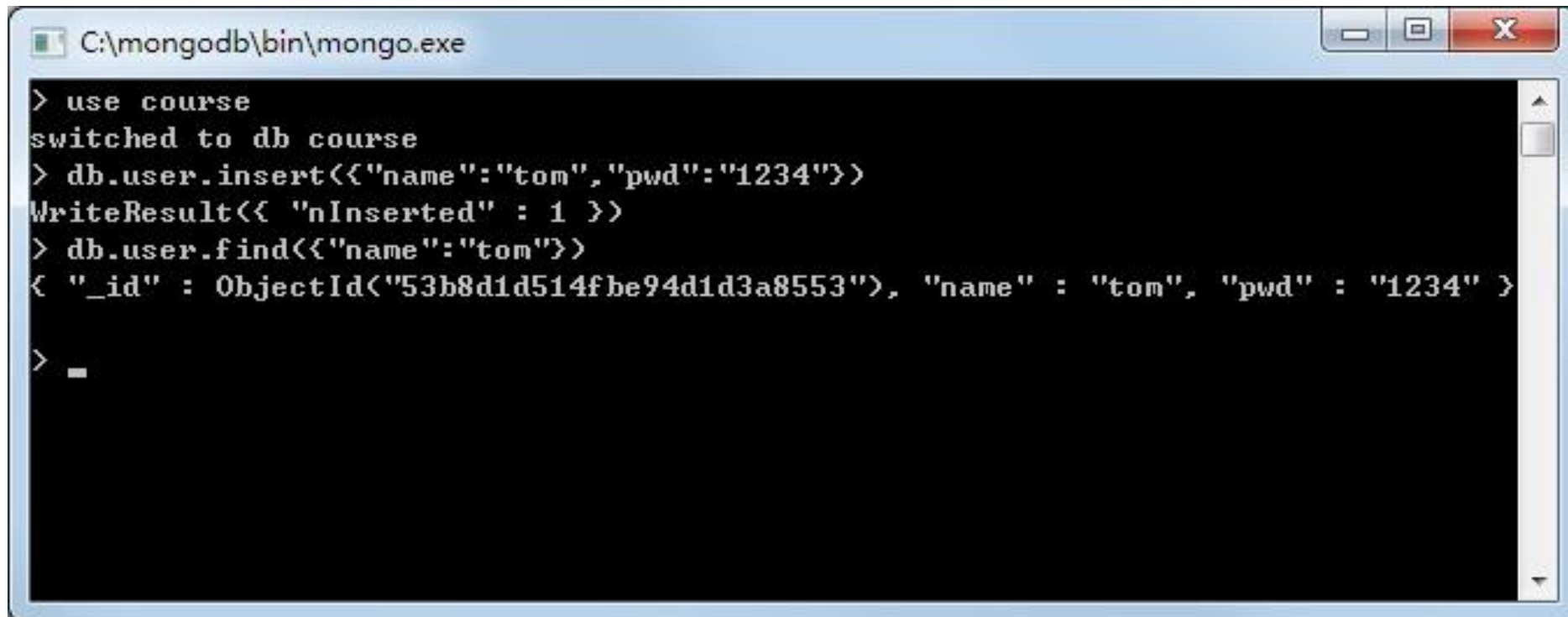
```
> db.user.insert({  
  first: "John",  
  last : "Doe",  
  age: 39  
})
```

```
> db.user.update(  
  {"_id" : ObjectId("51...")},  
  {  
    $set: {  
      age: 40,  
      salary: 7000}  
  })
```

```
> db.user.remove({  
  "first": /^J/  
})
```

Lab: Add a User to MongoDB

- Go to the management window and type:
 - > use course
 - > db.user.insert({name:"tom",pwd:"1234"})
 - > db.user.find({name:"tom"})

A screenshot of a Windows command prompt window titled "C:\mongodb\bin\mongo.exe". The window has standard Windows window controls (minimize, maximize, close) in the top right corner. The command prompt shows the following text:

```
> use course
switched to db course
> db.user.insert(<{"name":"tom","pwd":"1234"}>)
WriteResult(< "nInserted" : 1 >)
> db.user.find(<{"name":"tom"}>)
< "_id" : ObjectId<"53b8d1d514fbe94d1d3a8553">, "name" : "tom", "pwd" : "1234" >
> _
```

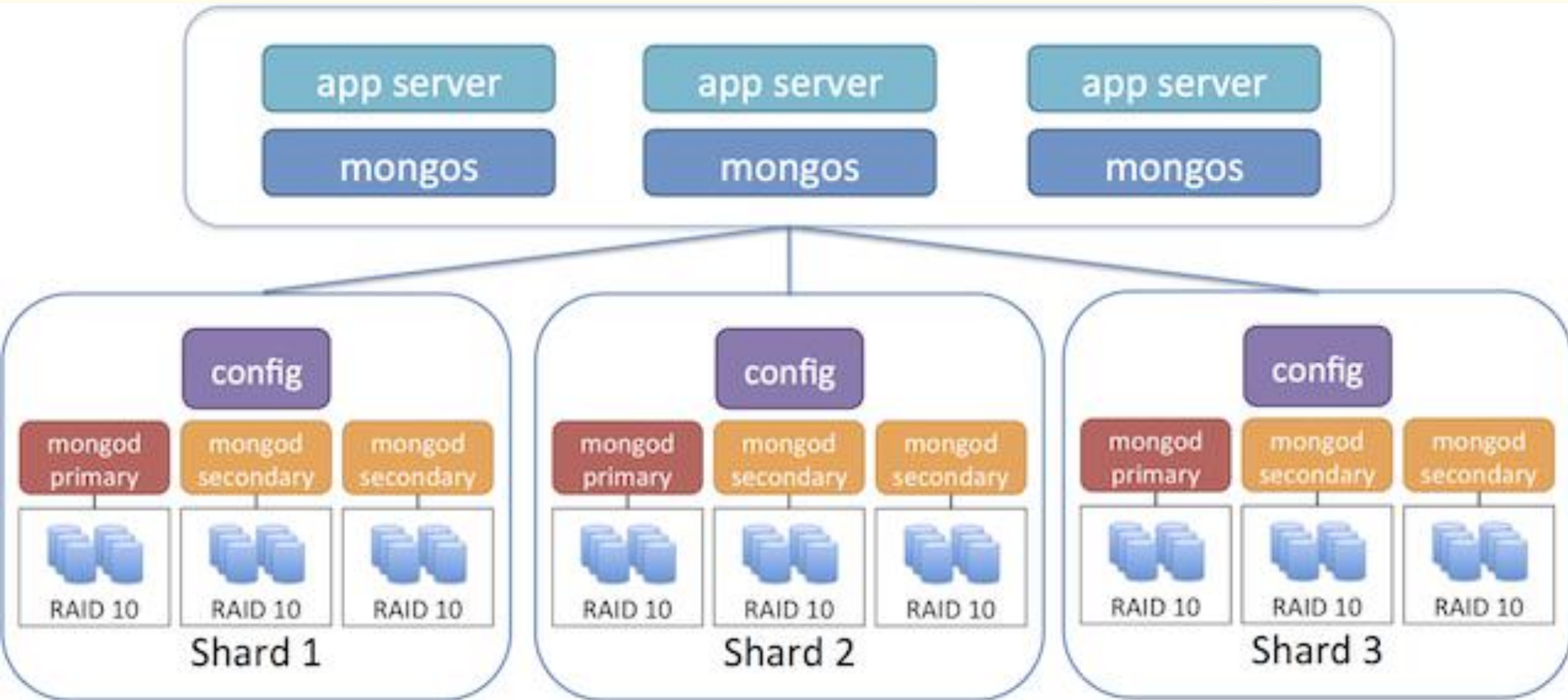
Indexes

- Unique index on primary key (*_id* field)
- Create index from application code (*ensureIndex*)
- Index on embedded documents and fields
- Index on array fields (*multikey index*)
- Geospatial index
- No native full text indexing

Auto-sharding

- Partitions data across *shards*
- Any BSON document resides on only one shard
- Increases write capacity and total data size
- Data automatically distributed
- Sharding transparent to application layer
- Partitioning based on client-defined shard key
- Good shard keys are highly distributed in value and write operations
- Sharding requires config servers (minimal 3) to maintain metadata

Mongo Sharding



GridFS

- Store and retrieve files that exceed the BSON-document size limit of 16MB.
- Large blob data, limited only by storage space
- Supports many thousands of files
- Supports often changing files



RESTFUL

What is REST?

- REST stands for *Representational State Transfer*.
- It describes an architecture for distributed information systems
- First described in the 2000 doctoral dissertation “Architectural Styles and the Design of Network-based Software Architectures” by [Roy Fielding](#).
- It's a description of how the Web works and why it works well

REST is about Architecture

- Software architecture
 - An abstraction of the elements, configurations, constraints, principles, and guidelines that govern a system's design and evolution.
- Software architectural style
 - A set of constraints that restrict a software architecture.

RESTful Examples

- Public services with RESTful APIs:
 - Twitter, Netflix, Dropbox, Flickr, Amazon S3, ...
- Products or tools with RESTful APIs
 - Glassfish Application Server Admin, Selenium WebDriver, ...
- RESTful Frameworks
 - Jersey (JAX-RS), Restlet, Restify, APEX RESTful Services, ...

Amazon S3

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- Amazon S3 is a Simple network Storage Service.
 - Provides cheap storage with read/write and pub/private access for the internet apps
- Support REST and SOAP APIs
 - REST API is quickly understood in 7-page tutorial
 - SOAP API WSDL is 7 pages of XML with no explanations at all!

Why REST?

- Scalable
- Human and machine usable
- Language agnostic
- Globally accessible resources
- Intuitively understandable URIs, resources, and actions.

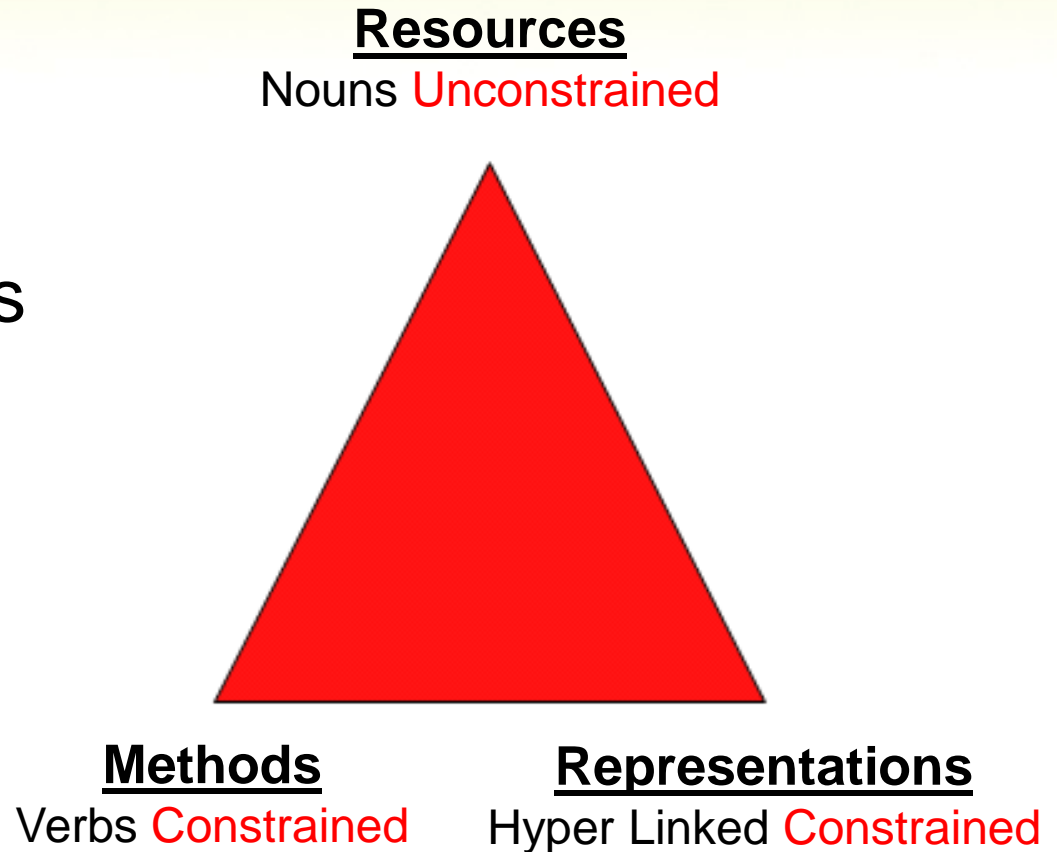
REST Properties

- Client/server model – request/response
- Stateless: no memory of prior communications
- Cacheable
- Layered system: may use intermediary servers
- Code on demand (optional)
- Uniform interface
 - Request response style operations on named resources through self descriptive representations where state changes are via hyperlinks

Uniform Interface

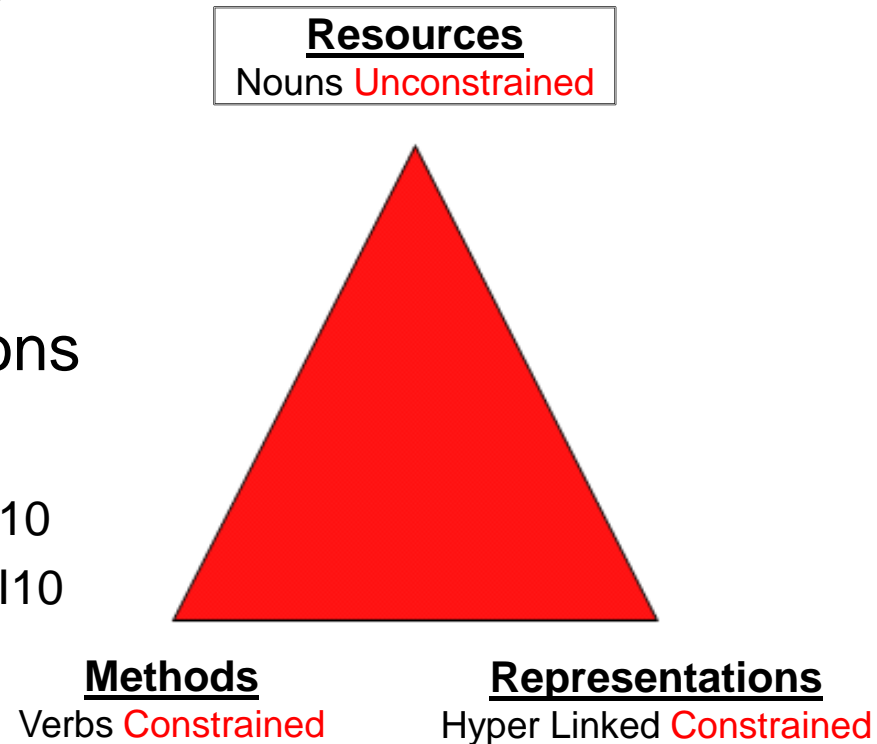
The REST Triangle:

- Resources
- Methods
- Representations



Uniform Interfaces - Resources

- Key abstract concept
- Identified by a URI
- Distinct from underlying storage
- Semantics fixed
- Value may change over time
- Can have multiple URIs
- Can have multiple representations
- Examples:
 - <http://example.org/NewOrleans/traffic/10>
 - <http://example.org/traffic/NewOrleans/I10>
 - <http://foo.com/store/orders>

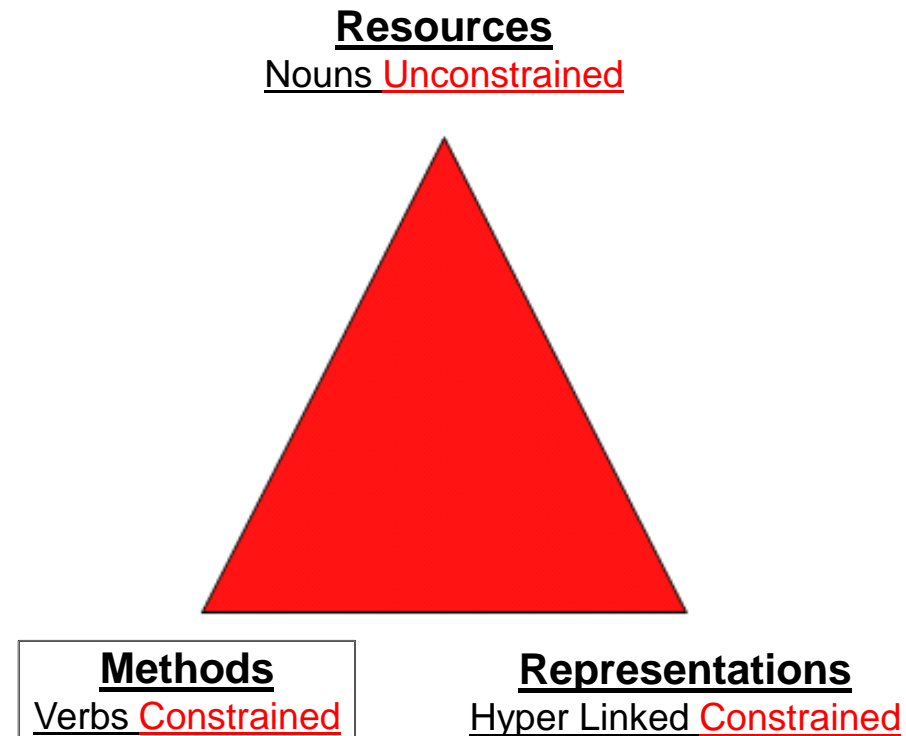


Resource Modeling - URIs

- Human readable (not necessary but it helps)
- Tends to form a hierarchy
- Use the query part appropriately
 - Use to search, filter, or possibly specify a mode
 - Identification of the resource is better in the path
 - (preferred) `http://example.com/orders/100234`
 - `http://example.com/orders?id=100234`
- Don't make them verbs!
 - (bad) `http://example.com/accounts/addaccount`

Uniform Interface - Methods

- HTTP method Applying to the resource
 - GET retrieve
 - PUT update (or create)
 - DELETE delete
 - POST create sub resource
- Response codes: HTTP
 - 1xx, 2xx, 3xx, 4xx, 5xx



REST Methods

- HTTP methods POST, GET, PUT, and DELETE are often compared with Create, Read, Update, and Delete (CRUD) operations associated with database functions:

| REST | CRUD | SQL |
|--------|------------------|------------------|
| GET | Read | SELECT |
| POST | Create | INSERT |
| PUT | Update or Create | UPDATE or INSERT |
| DELETE | Delete | DELETE |

A Example BBS System

- What message actions are required?
 - Create message
 - View message
 - View message for update
 - Delete message

RESTful Methods

- How do the message actions map in REST?

| Action | HTTP Method | URL |
|----------------|-------------|------------------------|
| Create Message | POST | http://bbs/messages |
| View Message | GET | http://bbs/messages/12 |
| Update Message | PUT | http://bbs/messages/12 |
| Delete Message | DELETE | http://bbs/messages/12 |

Design REST Methods

| Method | Requirement |
|--------|---|
| GET | Retrieve a resource. No modification should be done. No side effects allowed. Keep it safe. |
| POST | <i>Create or update a resource.</i> For non-safe, non-repeatable changes |
| PUT | <i>Update a resource.</i> Keep it repeatable with same results (idempotent). |
| DELETE | <i>Remove a resource.</i> Keep it repeatable with same results (idempotent) |

Idempotence

“Idempotent operations are operations that can be applied multiple times without changing the result”

- Idempotent tasks can be retried
 - Set Salary to 60K
 - If run twice, salary will still be set to 60k
- Non-Idempotent tasks cannot safely be retried
 - Retrieve current salary and increase by 10k
 - If run twice, salary will be increased 20k, not 10k

Common Pattern for Methods

messages /

- GET - Retrieves list of all messages.
- POST - Create a new message .

messages/{mesno}/

- GET - Retrieves details for a specific message .
- PUT - Updates the specific message .
- DELETE - Deletes the message .

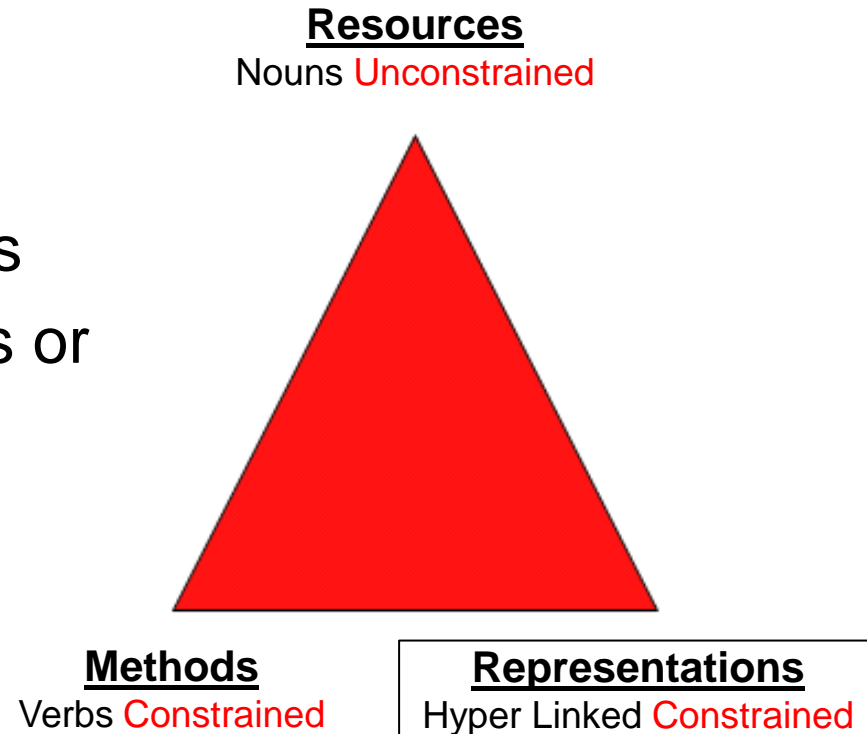
Are They REST ?

- How do these actions map to HTTP and Web pages?

| Action | HTTP Method | URL |
|----------------|-------------|---|
| Create Message | POST | http://bbs/msg.php?m=create |
| View Message | GET | http://bbs/msg.php?m=view&id=12 |
| Update Message | POST | http://bbs/msg.php?m=update&id=12 |
| Delete Message | GET | http://bbs/msg.php?m=delete&id=12 |

Uniform Interface - Representations

- Self-descriptive
- media type (Content-Type)
 - text/html
 - application/json
- Includes metadata
- Understood by all components
- May be for humans, machines or both
- Negotiated



Representation Example

Representation based on request type

- Request for XML output

```
GET /resources/forte HTTP/1.1  
Host: example.com  
Accept: application/xml
```

- Request for HTML output

```
GET /resources/forte HTTP/1.1  
Host: example.com  
Accept: text/html
```

- Could be any format you wish to support.

State Transfer Example

- Resources link together. State of the current system can be transferred along the links.

```
<resource self='http://example.com/resources/forte'>
  <name>forte</name>
  <hostname>forte.example.com</hostname>
  <status>up</status>
  <account
    ref='http://example.com/accounts/1212'>1212</account>
  <user ref='http://example.com/profiles/jdoe'>jdoe</user>
</resource>
```


REST vs. Web Services (RPC)

| | Web Services | REST |
|-------------------|--|---|
| Protocols | SOAP (Simple Object Access Protocol) over HTTP. | HTTP |
| Request Mechanism | XML over HTTP, usually POST | HTTP |
| Actions (verbs) | Many different actions, which are hidden within the request body. | Standard HTTP methods (GET, PUT, POST, DELETE) |
| Security | Additional SOAP-specific security layer. | Web server security |
| Web Server | HTTP and Web server are simple conduits with much of their power and capability are bypassed | HTTP and Web server exploited to fullest extent |

Example of RPC Application

- RPC Operations

```
getUser()      addUser()      removeUser()  updateUser()  
getLocation()  addLocation()  removeLocation()  
updateLocation()  listUsers()  listLocations()  
findLocation()  findUser()
```

- RPC Client Code

```
exampleAppObject = new ExampleApp('example.com:1234')  
exampleAppObject.removeUser('001')
```

Example of REST Application

- REST Define Resources

`http://example.com/users/`

`http://example.com/users/{user}` (1 for each user)

`http://example.com/findUserForm`

`http://example.com/locations/`

`http://example.com/locations/{location}`

`http://example.com/findLocationForm`

- REST Client Code

```
userR = new Resource('http://example.com/users/001')  
userR.delete()
```

Designing RESTful Services

- Key Principals
 - Everything gets a unique URI
 - Link resources together
 - Use standard methods
 - Resources have multiple representations
 - Communicate statelessly

Access RESTful Services

- REST is meant for interoperability.
- Built on same technology as the internet.
- Can be consumed in many different ways
 - Web browser
 - Web services
 - Lightweight clients
 - Command line (curl, wget)

REST Summary

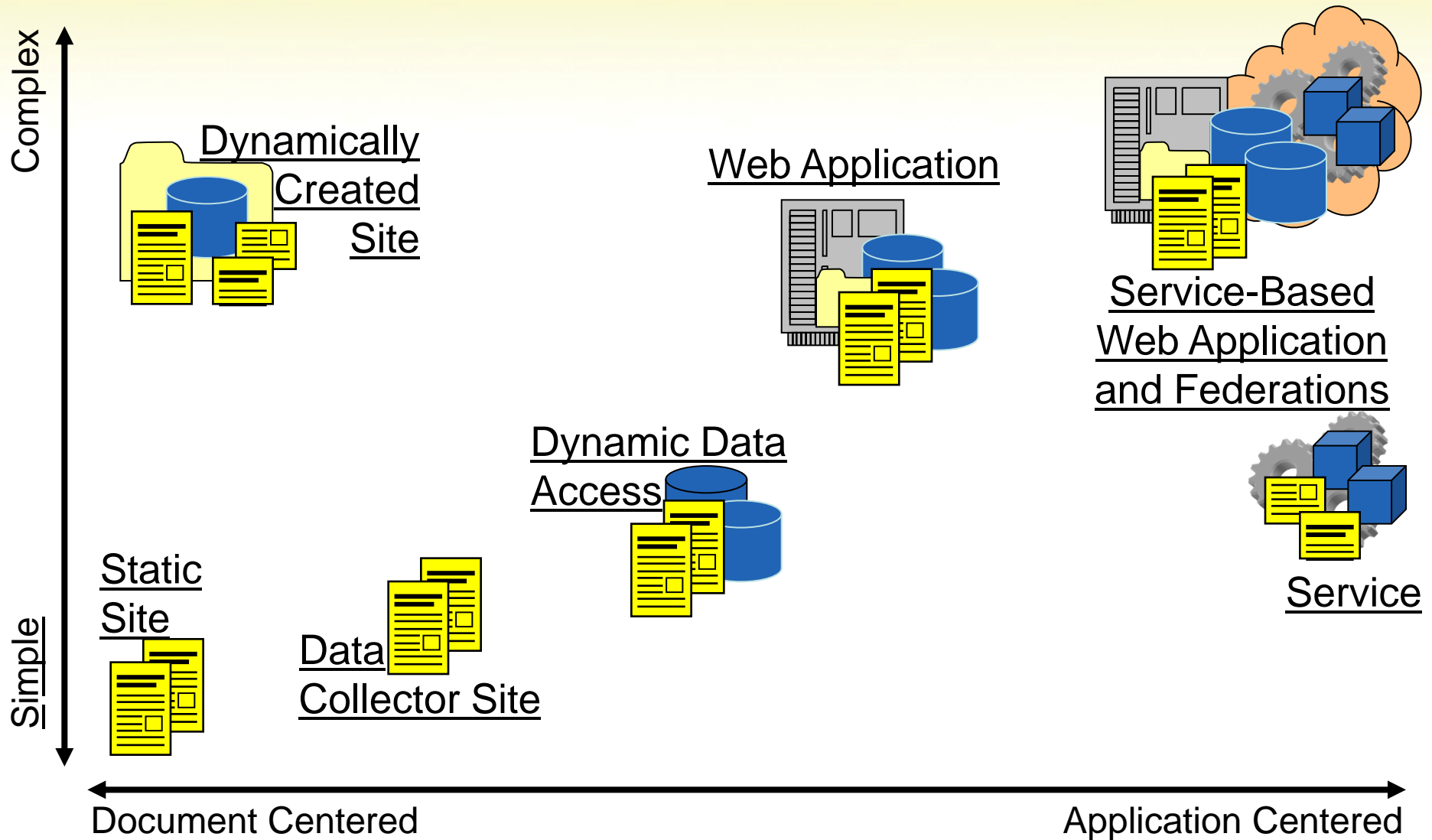
- REST is an architectural style that
 - Focuses on resources
 - Minimizes verbs
 - Leverages existing Web server capabilities
- REST encourages
 - Loose coupling
 - Separation of representation and process
 - Separation of security and logging from application
 - Maximum exploitation of Web servers and HTTP

DEVELOP WEB APPS FOR CLOUD

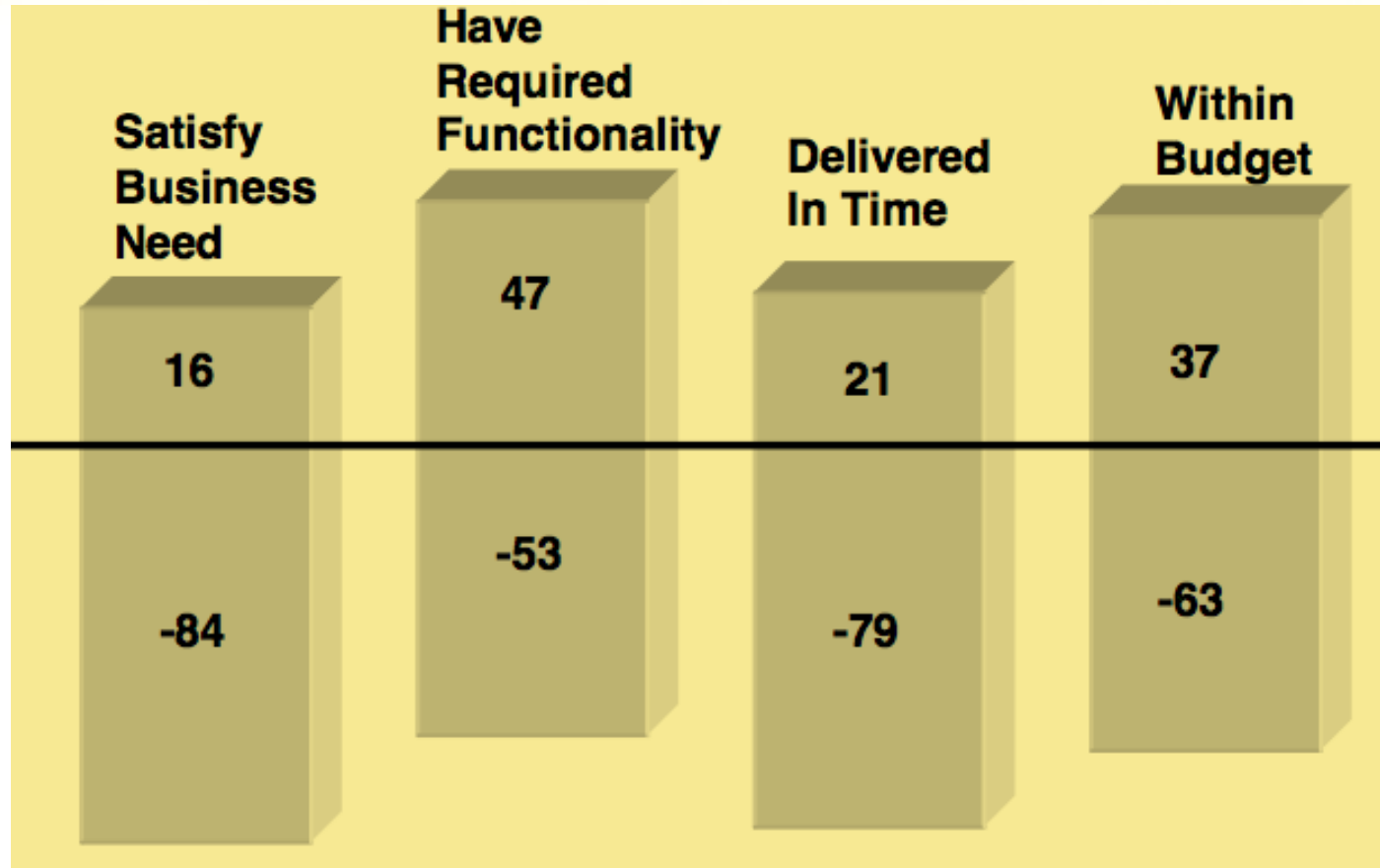
Characteristics of Web Apps

- Today's focus on large-scale and ubiquitously useable Web Applications
 - Many Users – many languages – many cultures
 - Different access mechanisms
 - Many User Agents
- Presents large volume of interrelated information (including different media) and processes
 - Appropriate presentation
 - Progression through activities – finish one thing before starting another
- Growing and increasing complexity
 - Many product iterations/versions/refinements (calls for Reuse)
 - Many developers and operators, complex handling of temporal media (e.g. publishing of company news)
 - Customization, personalization, security issues

Range of Complexity

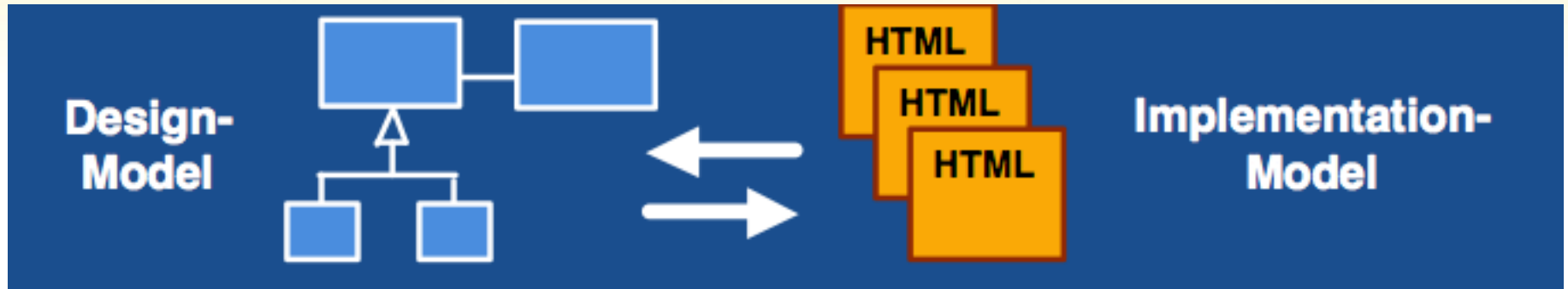


Problems with Large Web-based Projects



(Source: Epner, M., Cutter Consortium)

Web Application Development



- Still Ad-Hoc instead of a disciplined procedure
 - Lacks rigor, systematic approach
- Lack between design model and Implementation model
- Design concepts get lost in the underlying model
- Short lifecycle of a web application -> maintenance and Evolution issues -> reuse issues

Web App Design

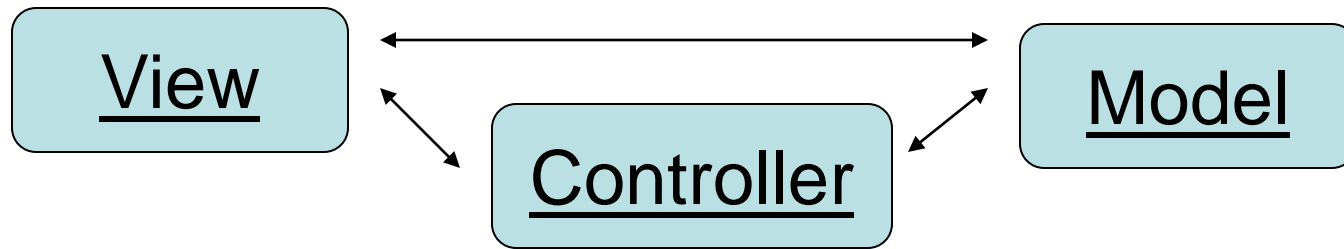
- Any complex system must begin with a cohesive fundamental design
- Multiple aspects of webapp design
 - Product Design: how the overall application will function, including:
 - Interaction (User-Interface) Design: The operation, look, and feel of the user interface
 - Software Design: The required software components and how they will interact

Design Patterns

- A software **design pattern** is an abstraction of some commonly used software design
- This abstraction includes enough information to enable reuse of the pattern with new applications
- A pattern for architectural (high-level) design is also called an **architectural style**

Model-View-Controller

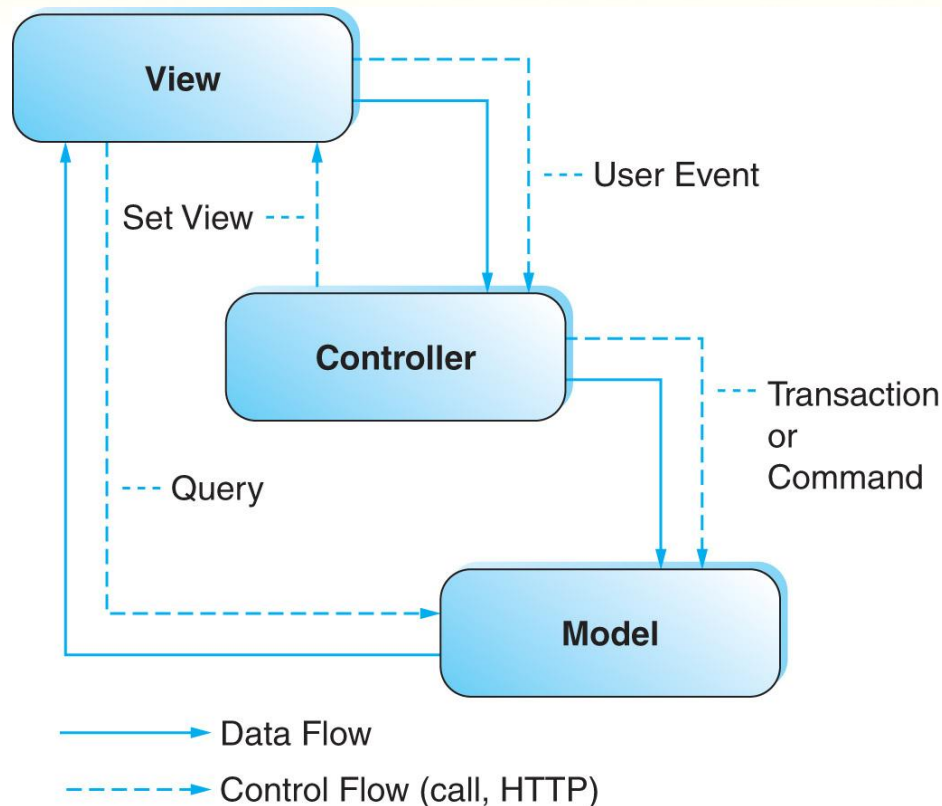
- Many webapps are based on the well-known **model-view-controller** design pattern



- The MVC pattern specifies the responsibilities of three major components, and the nature of their interactions

MVC Component Responsibilities

- View: Present the user interface
- Model: Maintain the application state
- Controller: Handle user actions



Model Role

- The Model maintains the application state, which includes:
 - persistent information stored in databases
 - current information related to active sessions
- Responsibilities include:
 - applying rules / transactions to modify state
 - providing information to the View as required
 - taking instructions from the Controller

View Role

- The View presents a user interface, including information and transactional controls
- Responsibilities include:
 - Present required information to user
 - Request data from Model as needed (to create displays for the user)

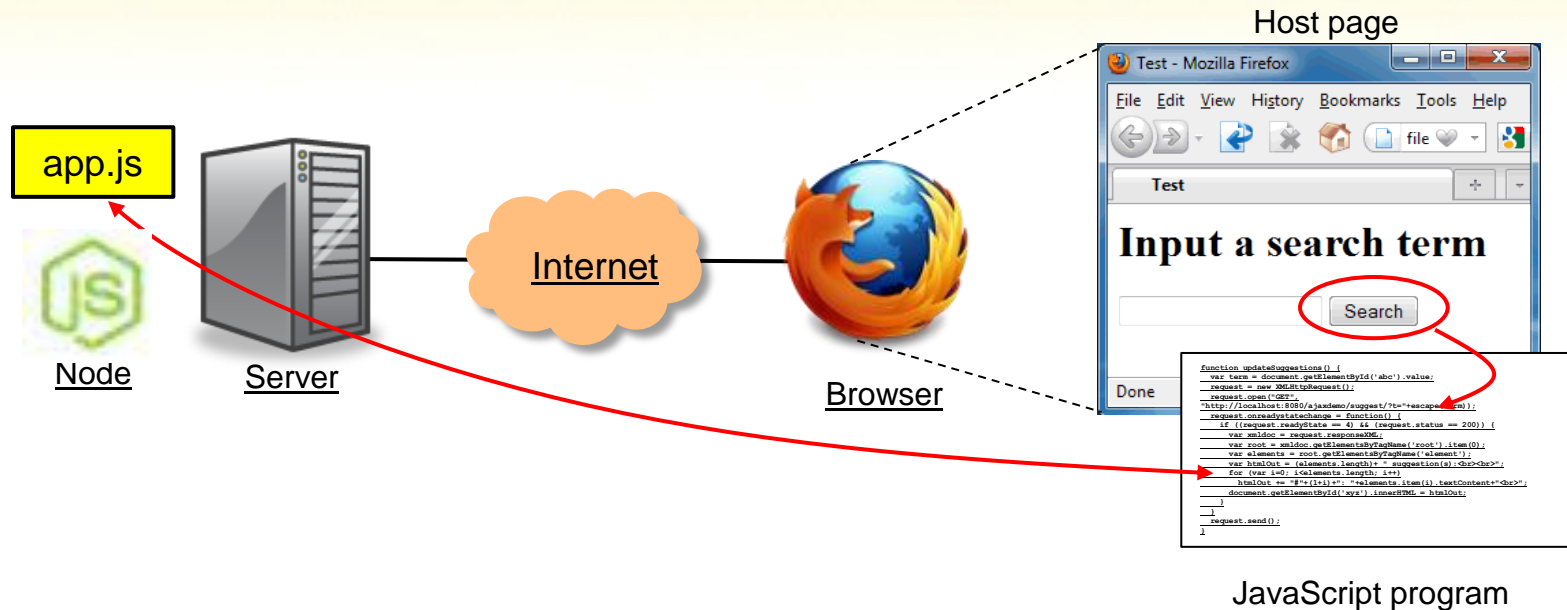
Controller Role

- The Controller handles user actions
- Responsibilities include:
 - Handle user actions
 - Validate user requests (correctness, completeness)
 - Invoke Model components to handle requested transactions
 - Set the appropriate next View perspective

Single-Page Web App

- One host (main) HTML file
- One screen at any given time
- Generating (or toggling) other screens dynamically, using JS
- Instead of navigating between different pages, one navigates between different sections of one web page
- Maintaining state – what's currently in the DOM
- Maintaining data – what's needed for generating DOM

Building Web Applications

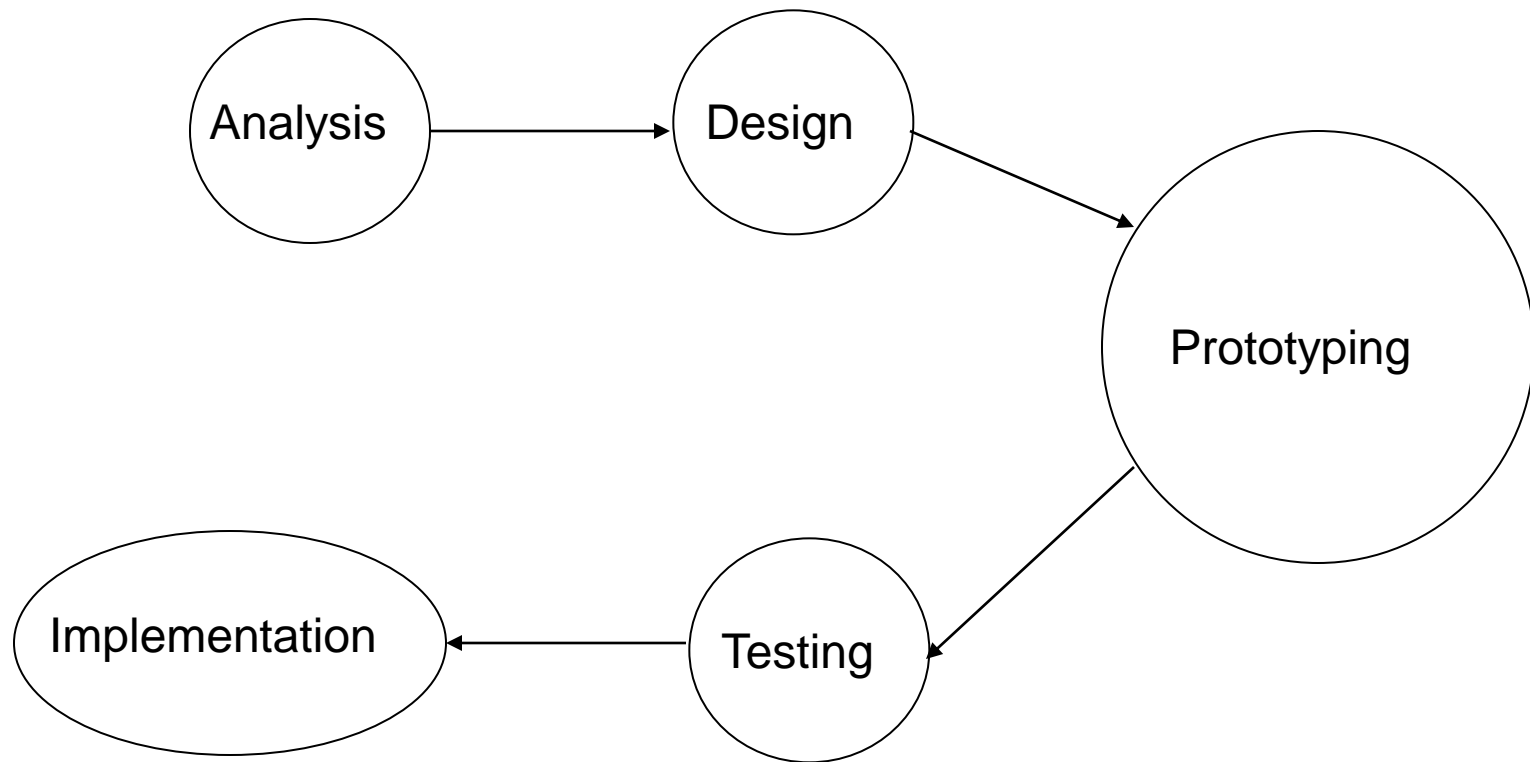


- **Host page**: A **HTML** page that we'd like to make interactive.
- **CSS** is used to decorate the main page.

Building Web Applications (2)

- **Client-side script:** A JavaScript program that
 - registers handlers for relevant **DOM** events, such as inputs or mouse clicks
 - requests additional data from the server using **Ajax**;
 - integrates the responses with the web page using the **DOM**
 - Send back to the server the user's data using **Ajax**
- **Server side:** A program that supplies and receives the data
- Client-side script runs in browser, server-side using Node.js

Web Development Cycles



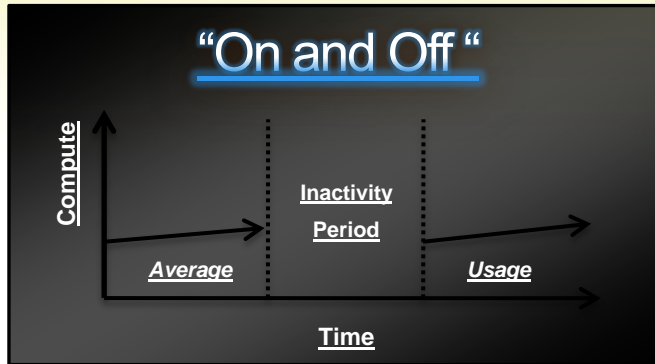
Security Requirements

- Privacy - All user information are protected
- Authentication/Access Control- Only authorized users are allowed to access the resources
- Integrity - User and application data cannot be tempered with
- Auditing - Keeping audit logs and audit trails and ensuring their integrity

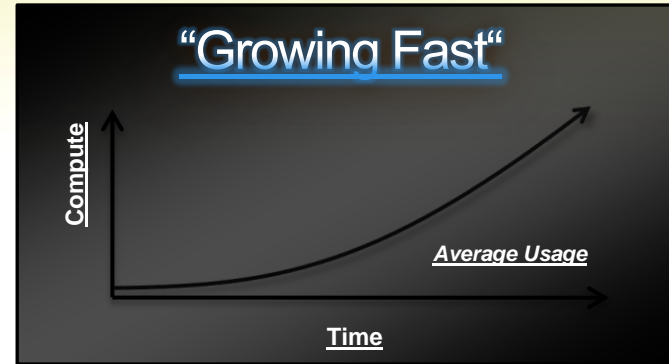
Cloud Apps Development

- Cloud software development
 - Design and develop an application for the cloud
 - Especially for the public PaaS cloud platforms
- Typical steps in cloud software development
 - Choose a development stack of technologies
 - Choose a cloud platform + services
 - Design the application for the cloud
 - Develop the application using the cloud APIs
 - Deploy and run the application in the cloud

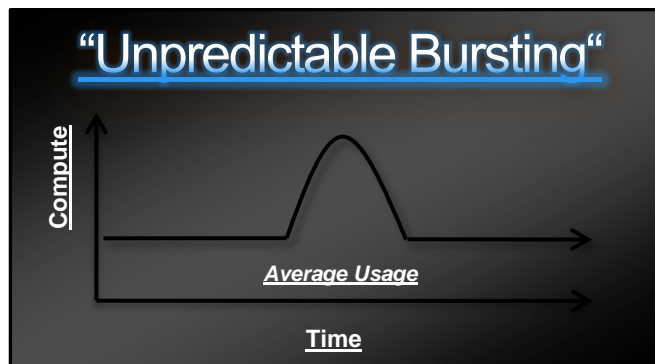
Applications Fit for Cloud



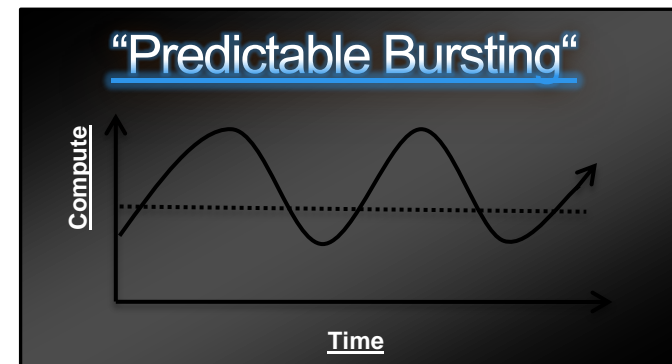
- On & off workloads (e.g. batch job)
- Over provisioned capacity is wasted
- Time to market can be cumbersome



- Successful services needs to grow/scale
- Keeping up w/ growth is big IT challenge
- Cannot provision hardware fast enough



- Unexpected/unplanned peak in demand
- Sudden spike impacts performance
- Can't over provision for extreme cases



- Services with micro seasonality trends
- Peaks due to periodic increased demand
- IT complexity and wasted capacity

Transition to Cloud Development

- Transition to cloud development
 - New architecture (based on SOA)
 - New programming paradigms
 - E.g. NoSQL databases
 - New APIs
 - E.g. Amazon S3
 - New deployment model
 - Git + vendor-specific continuous integration process

Moving an App to Cloud

