CS1320
Creating Modern Web and Mobile Applications

Lecture 15

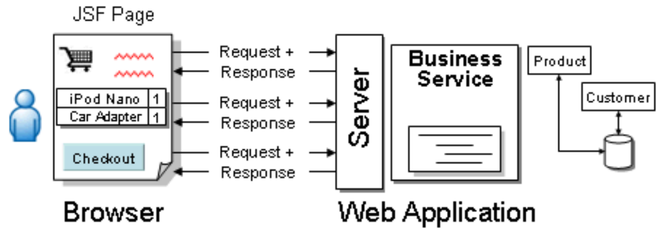
Web Application Architectures II

CDQuery User Library

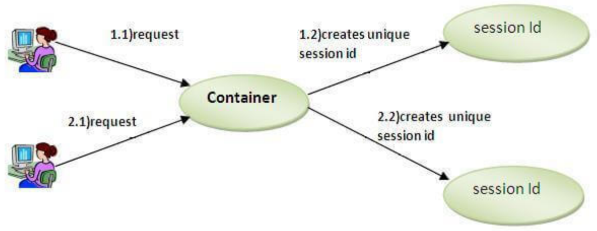
- Suppose CDQuery were modified to know the user's current collection
  - Understand what CDs they owned
  - Use this information in querying and display
- Then the application would need to know who the user was
  - Why is this problematic?

Web Applications and HTTP

- The web application assumes it knows the user
  - One request follows another
  - Common shopping cart for the user
  - Look up information based on the user
  - Server needs to know who the user is
    - Even if they haven't logged in
- HTTP is stateless
  - Each request is independent of previous requests
  - Requests come on different sockets at different times
- This disparity is addressed using *sessions*



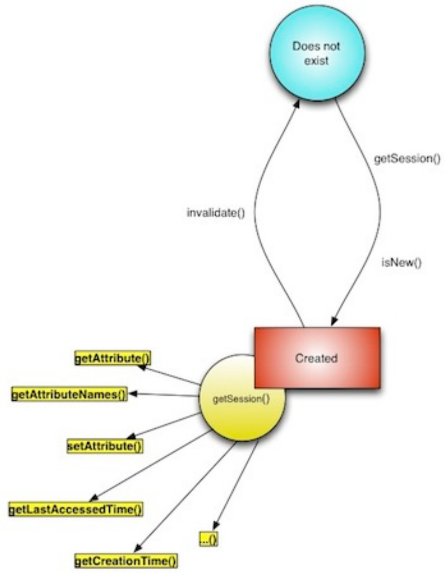
What is a Session



- A mechanism for maintaining state
  - For the particular user and the particular web app
  - Within the server
  - Somewhat independent of the browser
- The session contains information about the current state
  - Information about the particular user
  - Information for the particular application
  - Information for this particular use of the application

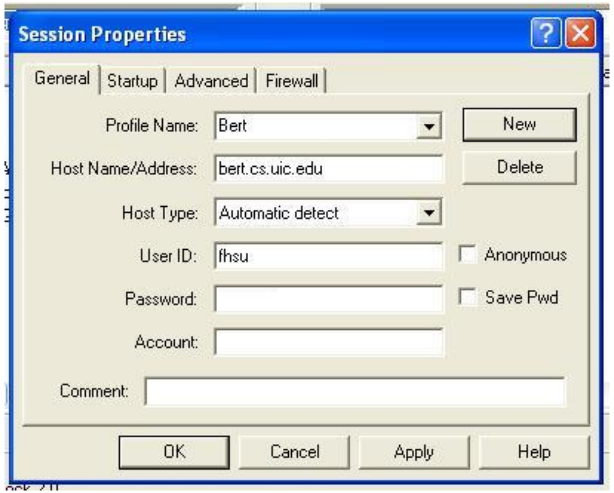
Sessions

- Represent a connected series of user actions
  - Example: log-in, select-items to purchase, check-out, log-out
  - Example: select source/destination cities, dates; request schedules; select flights; login; purchase tickets
- Needs to have a fixed start
  - Might have a fixed end (log-out request)
  - More likely, time-out if unused; exit when browser closes



Session Properties

- What information needs to be kept with the
  - Depends on the application
- Sample information
  - User id if one exists
  - Host, last-used time
  - Shopping cart
    - Associated with user id?
    - How to handle log in afterwards
  - Input values for forms (to be (re)filled automatically)
  - Previous searches or history
  - Site customization values


Session Properties

General | Startup | Advanced | Firewall

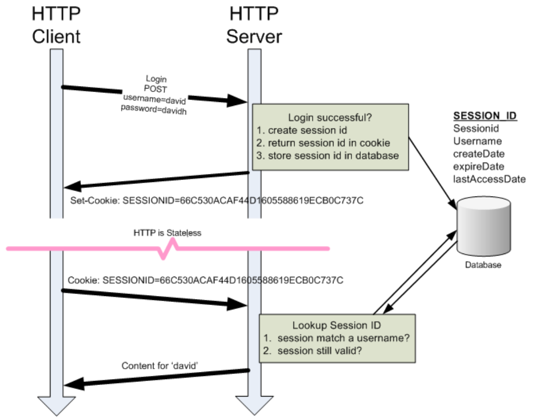
Profile Name:	Bert	New
Host Name/Address:	bert.cs.uic.edu	Delete
Host Type:	Automatic detect	
User ID:	fhsu	☐ Anonymous
Password:		☐ Save Pwd
Account:		
Comment:		

Tracking Sessions

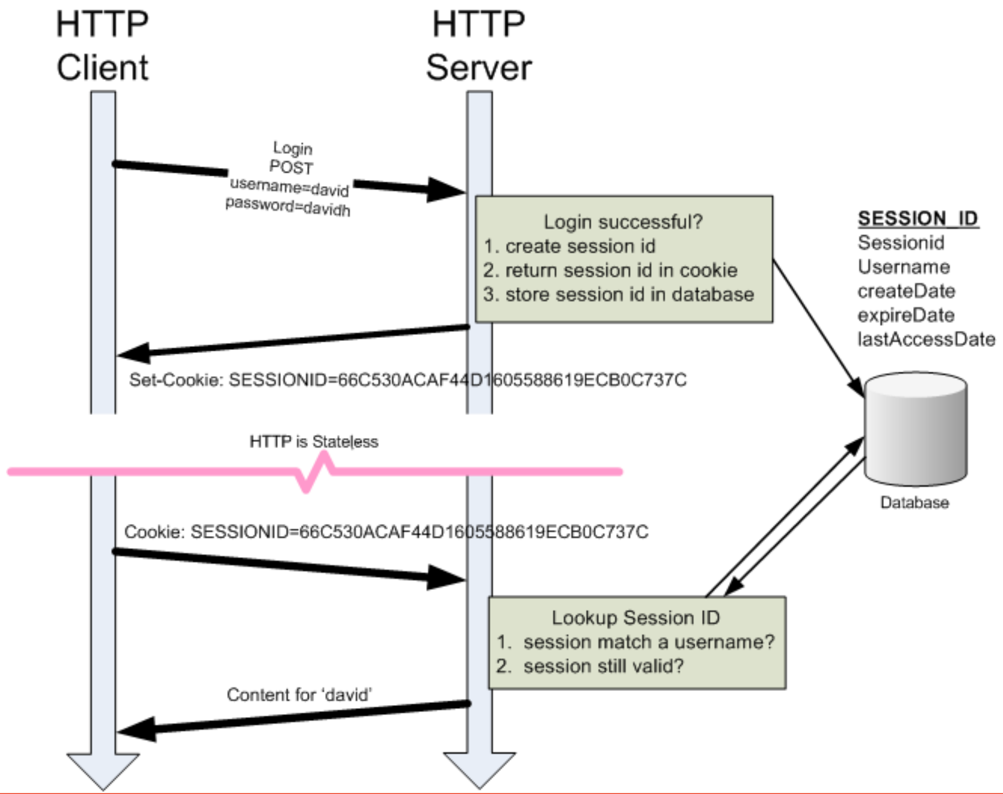
- Should the CLIENT track the session
  - If you don't browse off the page, these can be kept in html
    - Hidden fields, JavaScript variables, separate DOM tree, etc.
  - But if you replace the page, they disappear
  - Also, if there are multiple pages up, what is used
- HTML 5 Local storage
  - Key-value pairs for the same domain
  - Settable and gettable from JavaScript
  - Works if the information is local & HTML5 is available
    - And users always use the same browser and same machine (without incognito mode)

Tracking Sessions

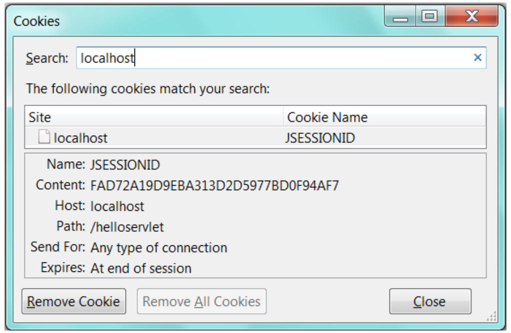
- Should the SERVER track the session
  - Maintain as part of state for user
  - But need to send/get it from the browser
    - Server needs to tell the browser the state for new pages
    - Browser needs to tell the server the state for all requests
  - What happens if there are multiple pages displayed
  - What happens with back and forward buttons
- Client and Server both track the session
  - Typically using cookies


HTTP Client
HTTP Server
Login POST username=david password=davidh
Login successful?
1. create session id
2. return session id in cookie
3. store session id in database
SESSION_ID
Sessionid
Username
createDate
expireDate
lastAccessDate
Set-Cookie: SESSIONID=66C530ACAF44D1605588619ECB0C737C
HTTP is Stateless
Database
Cookie: SESSIONID=66C530ACAF44D1605588619ECB0C737C
Lookup Session ID
1. session match a username?
2. session still valid?
Content for 'david'

Tracking Sessions



Cookies



Search: localhost

The following cookies match your search:

Site	Cookie Name
localhost	JSESSIONID

Name: JSESSIONID
Content: FAD72A19D9EBA313D2D5977BD0F94AF7
Host: localhost
Path: /helloservlet
Send For: Any type of connection
Expires: At end of session

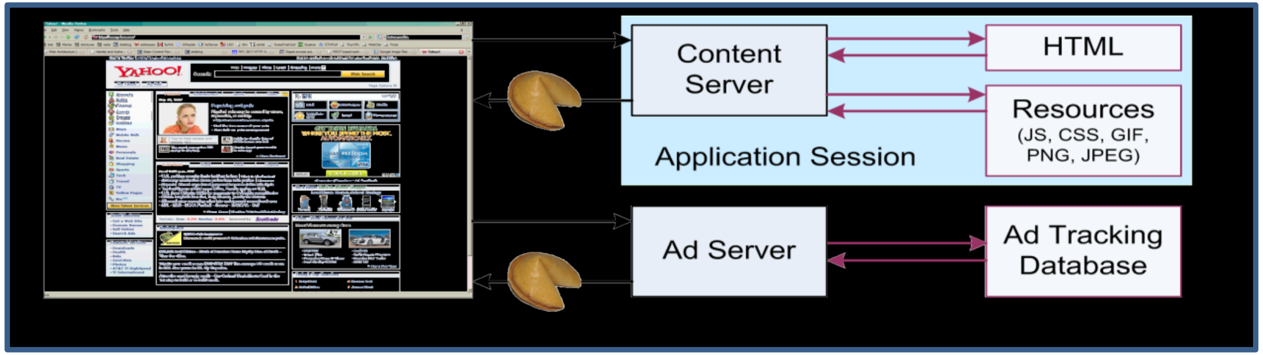
- Cookies are a general mechanism
  - For conveying information between browser and server
  - Name-value pairs associated with a particular URL
    - Can have multiple pairs
  - Sent automatically by the browser as part of the HTTP header
    - With any request to that particular URL
- Can be set either by server or browser
  - Communications: header on a page can request a cookie set
  - Defining: JavaScript functions to define cookies

Cookie Properties

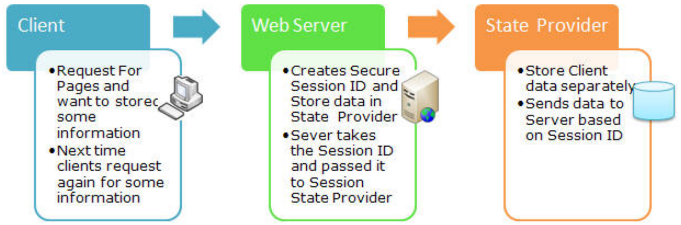
- Name and the value associated with that name
- Maximum age
  - When the cookie should be ignored/removed by browser
  - 0 means when the browser closes
- Domain/port and path
  - When to include the cookie in a HTTP request
  - Domains can be as specific as desired
  - cs.brown.edu, taiga.cs.brown.edu, taiga.cs.brown.edu/myapp
- If you need security, use HTTPS
  - Cookies can be restricted to only work with HTTPS

Cookie Management

- Libraries in server to manage cookies
  - Call to add/set a cookie (language-dependent)
  - Call to read cookie value
  - Added to headers on output pages
  - Used to extract session ids
- Similar libraries exist in the client (not widely used)



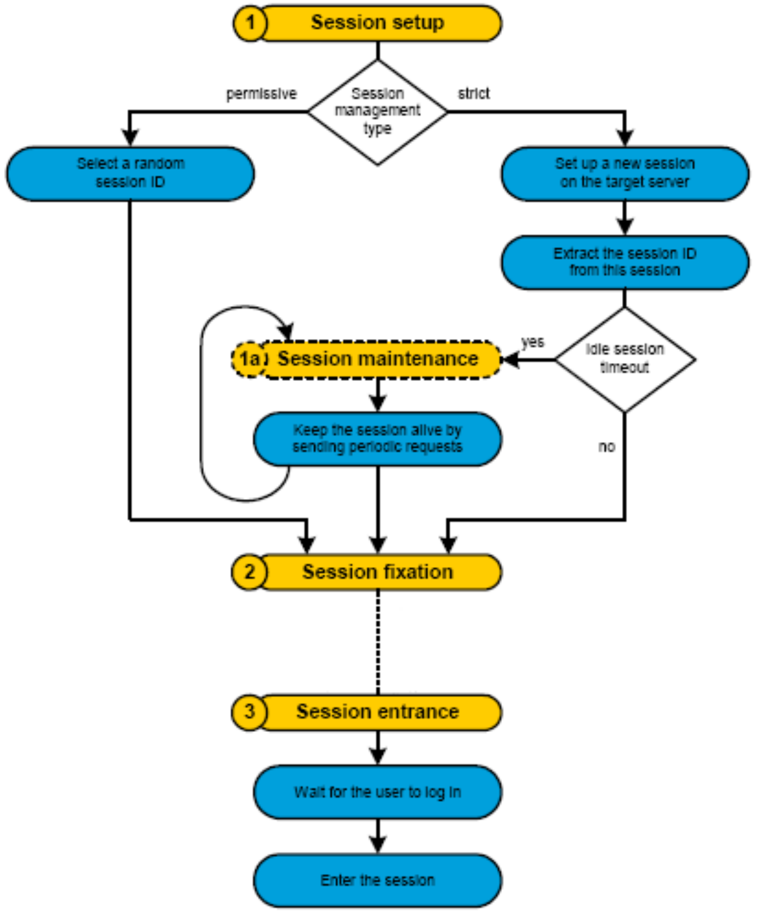
Session Identifiers


Client
•Request For Pages and want to storec some information
•Next time clients request again for some information
Web Server
•Creates Secure Session ID and Store data in State Provider
•Sever takes the Session ID and passed it to Session State Provider
State Provider
•Store Client data separately
•Sends data to Server based on Session ID

- How much information needs to be conveyed to and from browser?
  - We've talked about lots of things, some can be large
  - Really only need one piece of data
    - Use this as an index to a table (or database) on the server
    - Table holds all the information related to the session
  - This is the **session ID**
- Tracking Session Ids is difficult
  - Ensure validity (difficult to spoof; only server-generated Ids)
  - Ensure it is coming from same machine
  - Setting and checking cookies correctly
  - Time out if not used for certain amount of time
  - Handling explicit end of session

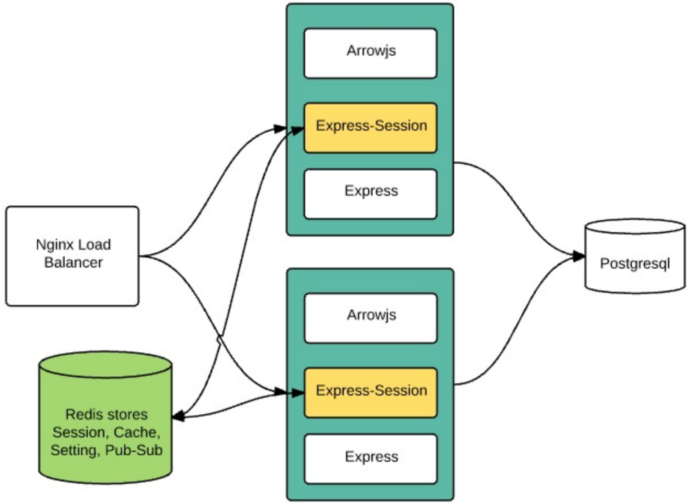
Session Management

- Use built in session-support
  - For your server
  - Call to begin/enter session
    - Automatically looks at cookies or url
    - Validates the session
    - Makes session data available
  - Call to terminate session
- Can store arbitrary information with se
  - Can be stored in memory (not ideal)
  - Can be stored in application database
  - More often stored separately (REDIS)

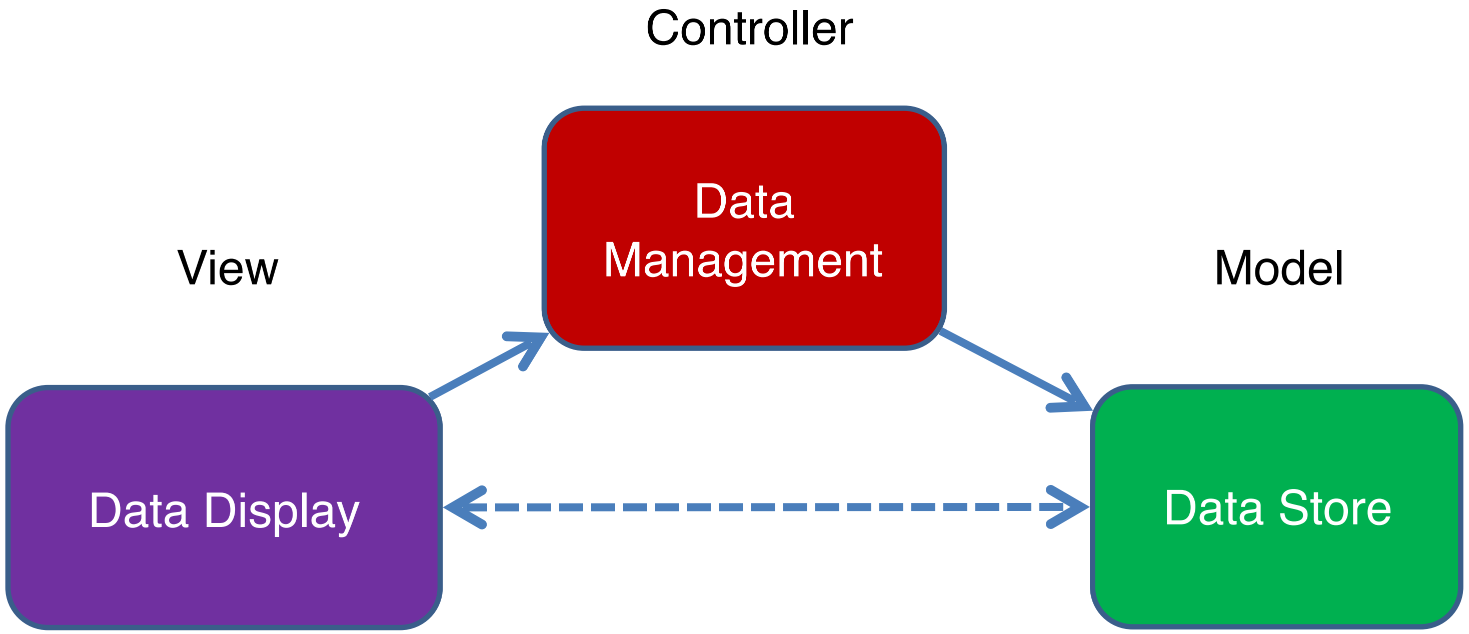

1 Session setup
Session management type
permissive
strict
Select a random session ID
Set up a new session on the target server
Extract the session ID from this session
Idle session timeout
yes
no
1a Session maintenance
Keep the session alive by sending periodic requests
2 Session fixation
3 Session entrance
Wait for the user to log in
Enter the session

Cookies, Sessions and Express

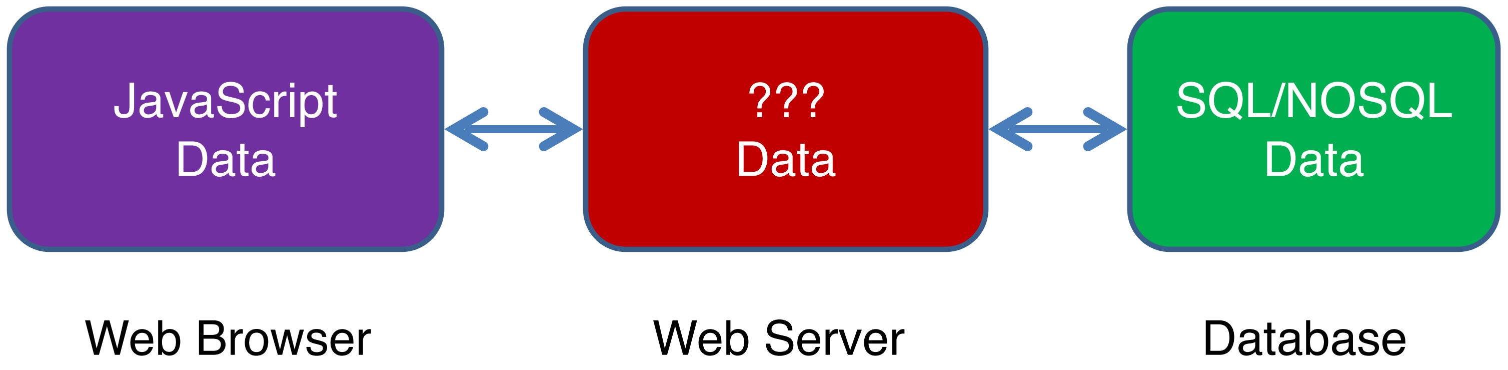
```
var session = require(‘express-session’);
var cookieparser = require(‘cookie-parser’);
…
app.use(cookieparser(“KEY”));
app.use(session { secret : “KEY”, store: new RedisStore(), …})
app.use(sessionManager);
…
function sessionManager(req,res,next) {
        if (req.session.uuid == null) {
                req.session.uuid = <unique id>
                req.session.save();
        }
        next()
}
…
req.session.<field>
```



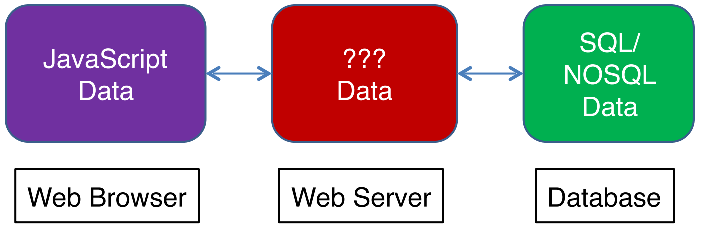
Model-View-Controller



Data Manipulation



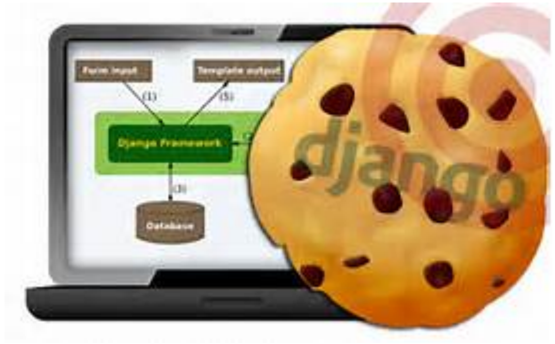
DRY Principle



- Don’t Repeat Yourself
  - Every piece of knowledge must have a single unambiguous authoritative representation within a system
- Why have 3 different representations of
  - More code to maintain
  - More code to change when data changes
  - More chance for bugs

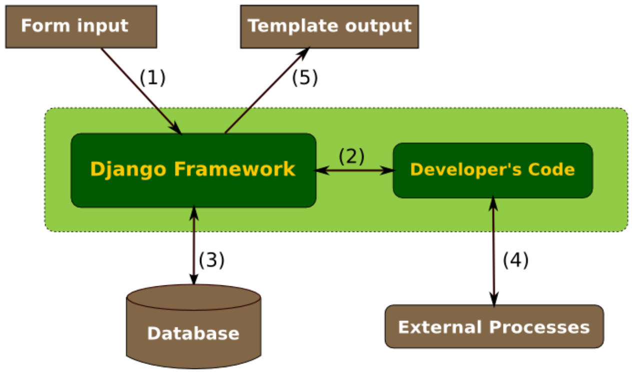
Django and Ruby on Rails (and Flask)

- Widely used
  - Django: instagram, pinterest, …
  - Ruby/rails: github, basecamp, …
- Similar frameworks exist (e.g. Flask)
- Mostly a back end technology
  - Can be paired with a templating engine
  - Can be paired with front end templating as well
- Require knowing Python/Ruby
  - In addition to JavaScript, HTML, …

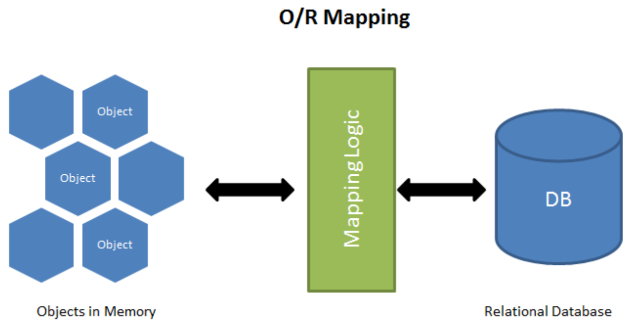


Django/Ruby Frameworks

- Express-like dispatch
  - Based on static tables, not executed code
  - With functions to handle the results
- Logic to control deployment, server
- Libraries to handle common web ap
- Simple connection to database
- Simplified Data Management



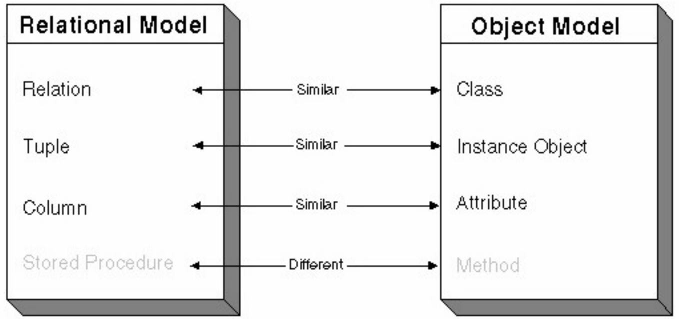
DJANGO and Ruby/Rails



- Map from internal objects to SQL automa
  - Changes in the object -> SQL updates
  - Objects created automatically from SQL database
  - SQL Tables created automatically from object definition
  - Changes to object definition change the database
- Map from internal objects to HTML automatically
  - Using templates
- Map from internal objects to JSON automatically
  - Changes in the object -> go to web site if needed
- OBJECT-RELATIONAL MODELING

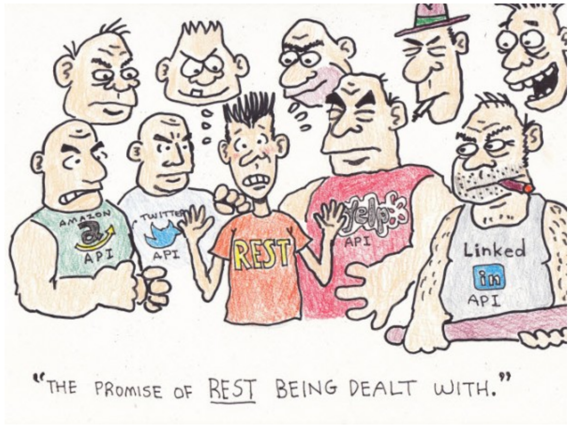
Object-Relational Modeling

- Not limited to Django-Ruby
  - There are libraries to provide some of this functionality
  - Even for Node.JS
- Not limited to SQL back ends
  - NoSQL databases can be used as
    - Direct mapping to object from json
  - Cache the current state in memory as objects
    - This allows fast query at times
  - Update updates memory and the database
- What are the problems with ORM?



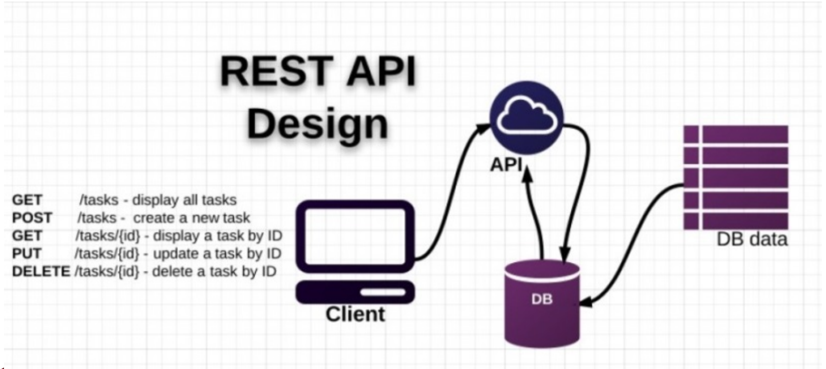
RESTful Web Applications

- Client-Server model
  - Client handles presentation, server handles storage
  - MVC : client = view, server = model; controller can be either, generally client
- Stateless
  - All data needed for request is passed
- Client maintains data
  - Sends updates, requests to server
  - Using commands encoded in URL



RESTful API HTTP Methods

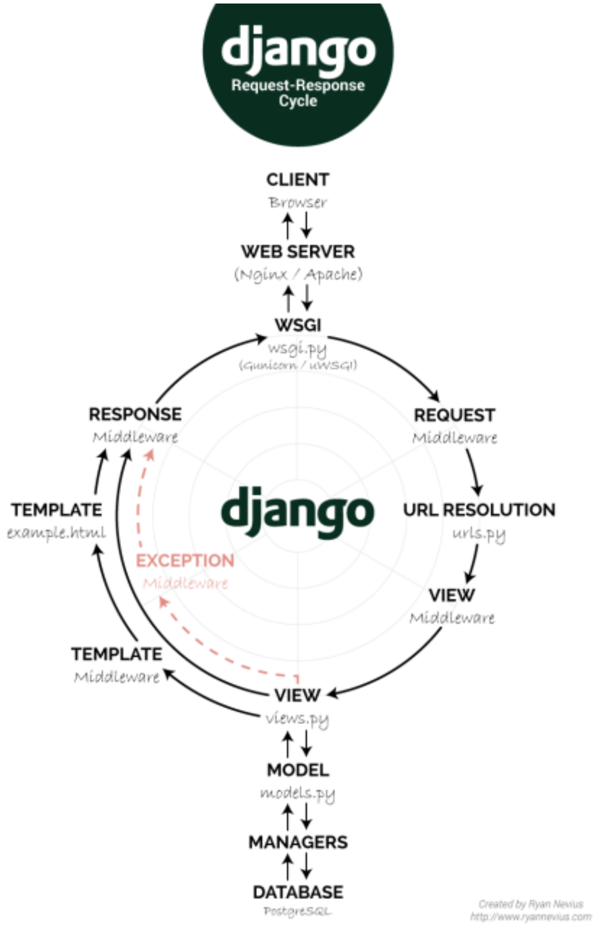
- Collection API …/collection
  - GET : return list of elements in the collection
  - PUT : Replace the entire collection
  - POST : Add an entry to the collection
  - DELETE : Delete the entire collection
- Element API: …/collection/:item
  - GET : Retrieve the given item
  - PUT : Replace or create the given item
  - DELETE : delete the given item
- Action API: …/collection/:item/verb



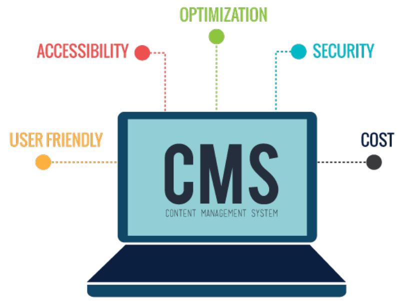
GET	/tasks - display all tasks
POST	/tasks - create a new task
GET	/tasks/{id} - display a task by ID
PUT	/tasks/{id} - update a task by ID
DELETE	/tasks/{id} - delete a task by ID

DJANGO/RUBY with REST

- URL identifies the object in the server
  - What field to access or change
  - New value of the field (using PUT)
- Front end makes changes to long term
  - By sending POST requests
- Front end gets current state of objects
  - By sending GET requests



Content Management Systems



- Creation and Modification of digital content
  - The contents of the web site
- Easy to create good-looking sites
  - With modern bells and whistles (e.g. slide shows)
- Easy to update the contents
  - For a non-programmer
- Standard interaction mechanisms often included
  - User accounts, …
  - Blogs, Wikis, …

Content Management Systems

- WordPress
  - The standard
  - PHP based
  - Extensible with modules or your own php code
- Drupal
  - Relatively common, more flexible
  - Fewer modules and features
  - PHP Based
- Django-CMS
  - Used for Brown CS web site
  - Python (Django) based
- Lots of others available

CMS Features

- Templating engine
  - MVC model – separate presentation from application logic
  - Reusable pieces
- Roles and permissions
  - Authentication
  - Roles: admin, author, editor, user, …
  - Hide complexity

CMS Features

- In-Browser Editing
  - Either separate editor on on-page editing
  - Layout and style
  - Images and media
  - Plugins such as Google maps
  - EXAMPLE: Brown CS web pages
- Publishing workflow
  - Create -> Edit -> Approve -> Publish -> Update -> Approve …
- Versioning
  - Revert, record of who did what

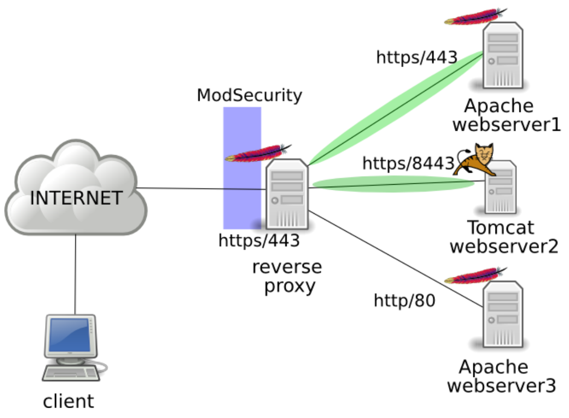
CMS Features

- Multilingual
  - Support for different languages
- Accessibility support
- Multi-site
  - Multiple sites running on one server
- Tree-like page structure
  - With appropriate permissions
- RESTful URLs
- Analytics

CMS Integration

- Can use CMS as a part of the web site
  - For the appropriate pages
- Code the other pages separately
  - Node.JS or other front end
- Integration in various ways
  - Django with Django-CMS
  - Reverse Proxy
    - Front end server redirects to appropriate back end

Apache + ModSecurity: Reverse Proxy.



Next Time

- Node.JS lab

Next Time

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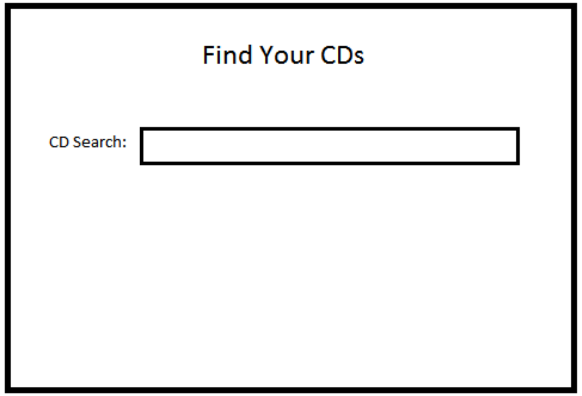
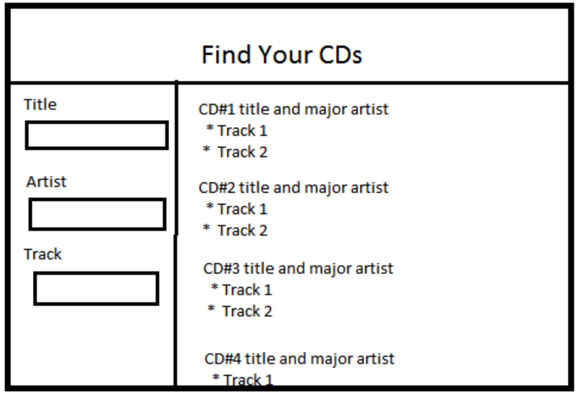
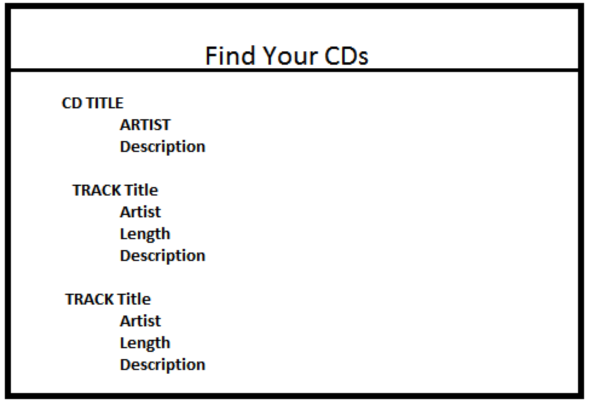
- Homework: Prelab for Node.JS

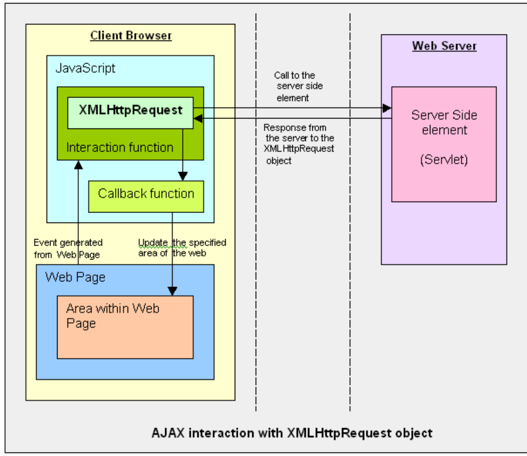
CDQuery (Again)




Find Your CDs
Title
Artist
Track
CD#1 title and major artist
* Track 1
* Track 2
CD#2 title and major artist
* Track 1
* Track 2
CD#3 title and major artist
* Track 1
* Track 2
CD#4 title and major artist
* Track 1

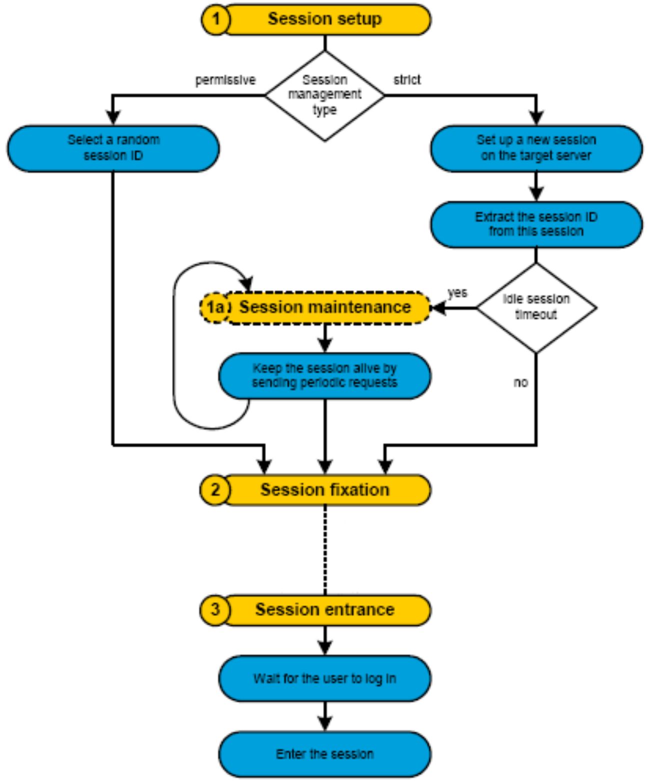


XMLHttpRequest


Client Browser
JavaScript
XMLHttpRequest
Interaction function
Callback function
Event generated from Web Page
Update the specified area of the web
Web Page
Area within Web Page
Call to the server side element
Response from the server to the XMLHttpRequest object
Web Server
Server Side element
(Servlet)
AJAX interaction with XMLHttpRequest object

```
var req = new XMLHttpRequest();
req.onreadystatechange = function () {
        if (req.readyState == req.DONE) {
                if (req.status == 200) << Handle returned data  req.responseText>>
                else << Handle error >>
        } };
req.open(“POST”,”/url/…”);
rq.setRequestHeader(“Content-type”, “application/json”);
rq.send(<data to send>);
```

Session Management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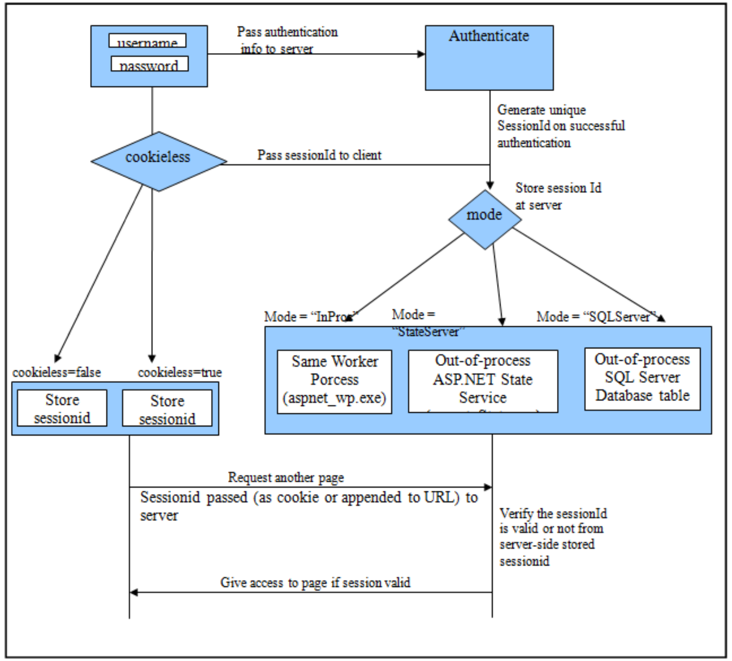
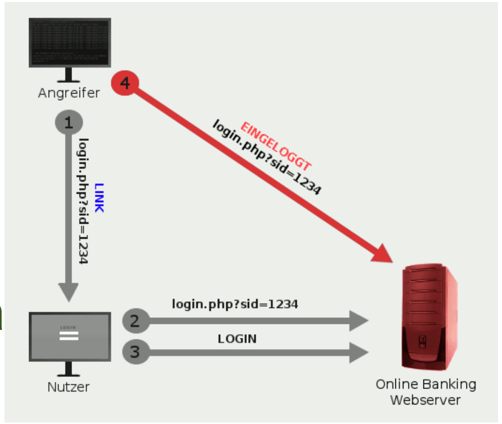
Wait for the user to log in
Enter the session

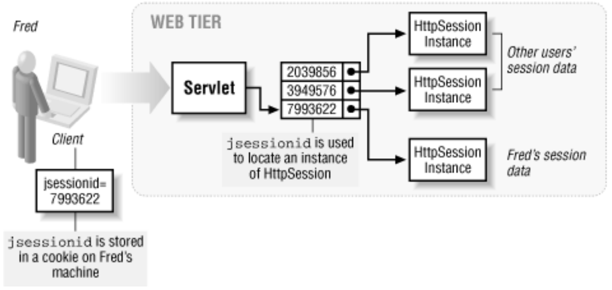

username
password
Pass authentication info to server
Authenticate
Generate unique SessionId on successful authentication
cookieless
Pass sessionId to client
Store session Id at server
mode
Mode = "InProc"
Mode = "StateServer"
Mode = "SQLServer"
cookieless=false
cookieless=true
Store sessionid
Store sessionid
Same Worker Porcess (aspnet_wp.exe)
Out-of-process ASP.NET State Service
Out-of-process SQL Server Database table
Request another page
Sessionid passed (as cookie or appended to URL) to server
Verify the sessionId is valid or not from server-side stored sessionid
Give access to page if session valid

Sessions in URLs



- Putting sessions Ids in URLs is not a good idea
  - Especially if the URL is public (GET rather than POST)
- Problems
  - GET requests may be logged; server logs now contain private information
  - Copy and paste of URLs can confuse the server
  - Server might use the passed in session id, allowing attacker to steal information
- Solution: use cookies
  - But what if cookies aren't enabled?

Session Tracking Mechanisms



- Encode the session id in the URL
  - All requests from the browser are URLs
  - The ID can be part of each request
    - http://....?SID=xxxxxxxxxxxxxxxx&...
- How to get this into the URLs on the page
  - If requests come from forms, add a hidden field
  - Requests for new pages, replace the URL on generation
  - How to get all URLs on the page
  - Problems?

Question

- Which is not true about sessions in a web application?
  A. Sessions represent a connected series of user actions
  B. Sessions must have a fixed start
  C. Sessions must have a fixed end
  D. Sessions can include a variety of different types of information
  E. Sessions can be supported by cookies or URL query or post data

XMLHttpRequest (using jQuery)

- Syntax

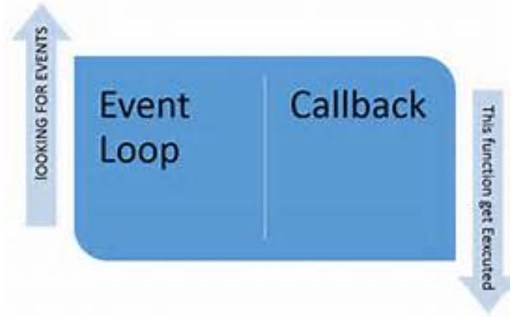
```
var req = $.ajax({ method: “POST”, url: “/url/…”,
                   data: { data to send },
                   success: function(data,sts) { … },
                   error: function(msg,sts,err) { … }
 });
```

- Request gets sent when JavaScript returns
- Other parameters and events are available

CQ Query Tasks

- Primary Tasks
  - Initial Search For CDs
  - Look at the details of a specific CD
  - Refine initial search by title, artist, track, genre; sort results
- Should these be done client-side or server-side?
  - All server side
  - Initial search server side, rest client side
  - Refinement & detail client side, rest server side
  - Detail page client side, rest server side
  - All client side

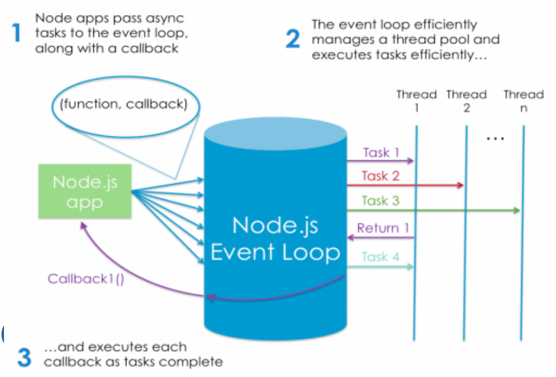
Node.JS Event Example



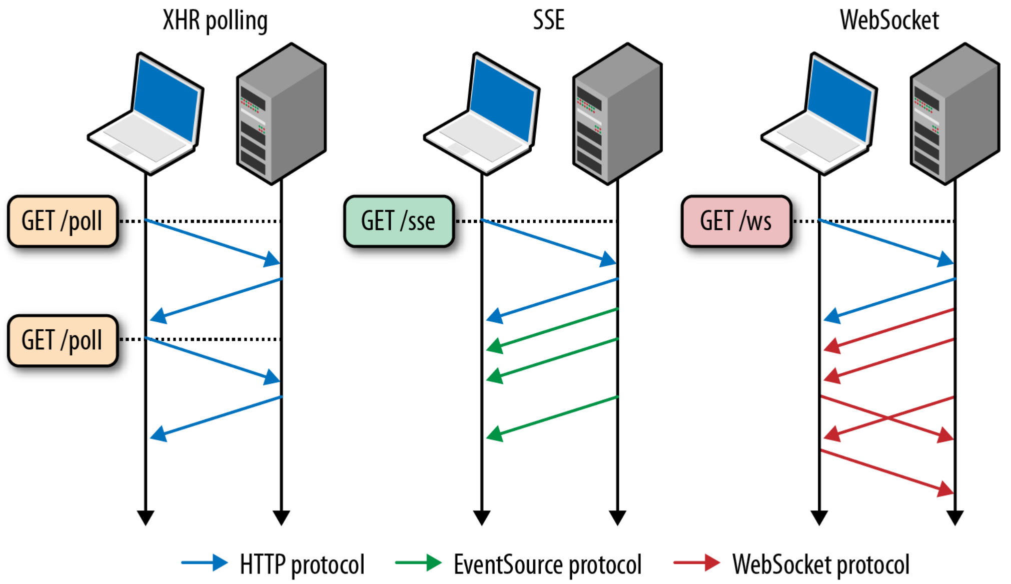
- Request comes in
  - JavaScript code creates database query based on parameters
  - Starts query and registers continuation
- When query completes (done asynchronously)
  - Template parameters computed from database result.
  - Template file is opened and a new continuation is provided
- When file is ready to read (done asynchronously)
  - A stream from the file to the client is established
  - The file is templated and output is output asynchronously

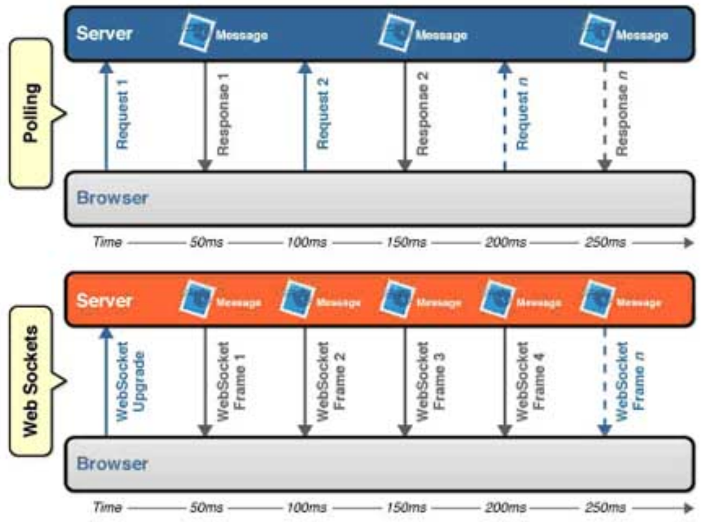
Asynchronous Operations

- Node.JS libraries define asynchronous operations
  - File open, read
  - Network read
  - Database queries and updates
  - Web sockets
- Common combined operations also defin
  - Streams: copy from one place to another
    - From the file system to the network
    - All handled in background

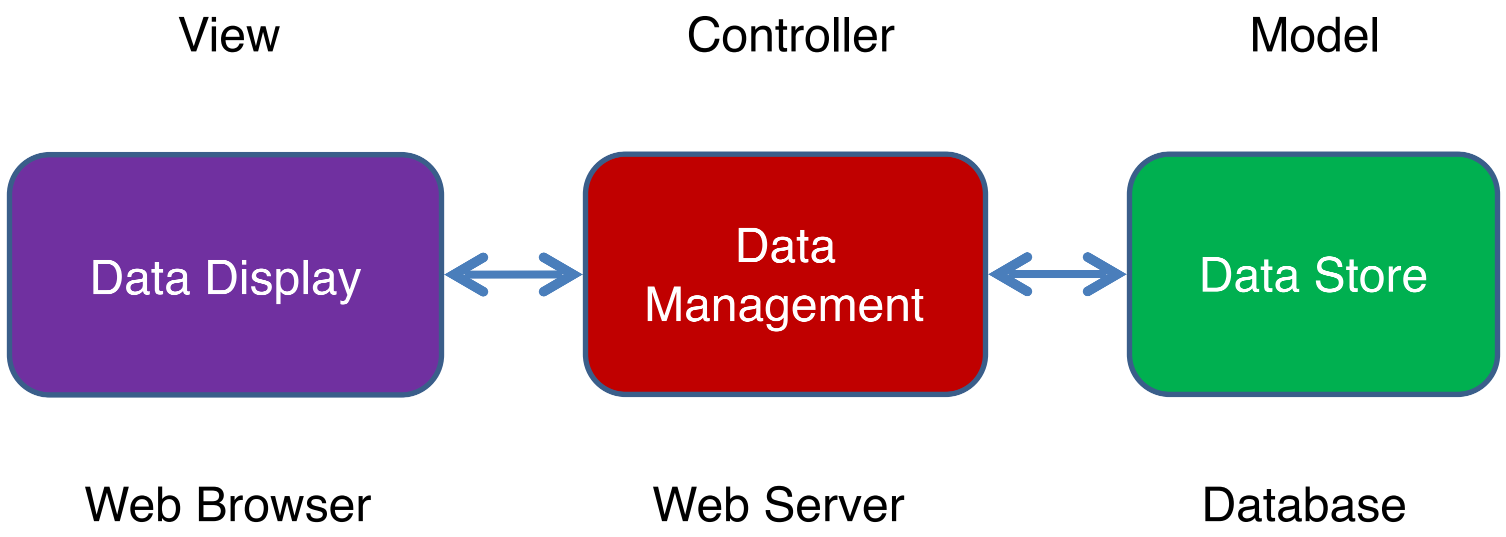

1 Node apps pass async tasks to the event loop, along with a callback
2 The event loop efficiently manages a thread pool and executes tasks efficiently...
(function, callback)
Node.js app
Node.js Event Loop
Thread 1
Thread 2
...
Thread n
Task 1
Task 2
Task 3
Return 1
Task 4
Callback1()
3 ...and executes each callback as tasks complete

Web Sockets


XHR polling
SSE
WebSocket
GET /poll
GET /poll
GET /sse
GET /ws
HTTP protocol
EventSource protocol
WebSocket protocol

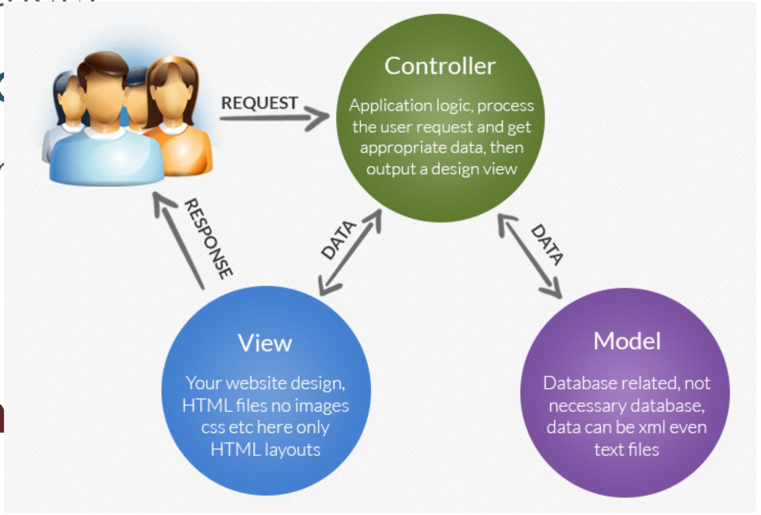

Server
Message
Polling
Request 1
Response 1
Request 2
Response 2
Request n
Response n
Browser
Time
50ms
100ms
150ms
200ms
250ms
Web Sockets
WebSocket Upgrade
WebSocket Frame 1
WebSocket Frame 2
WebSocket Frame 3
WebSocket Frame 4
WebSocket Frame n

Model-View-Controller



Model-View-Controller

- Basic idea is to separate the display, the data, and the logic
  - Each can be change independent of the others
- Exactly how this is done various fr
  - Some do it with a common data abstractior
  - Some do it with callbacks
  - All call themselves MVC
- Different people mean different th

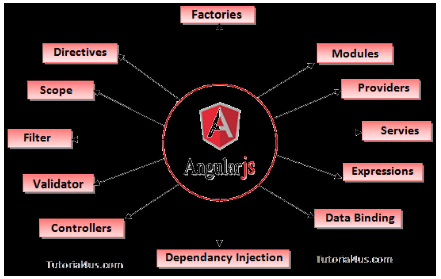

REQUEST
Controller
Application logic, process the user request and get appropriate data, then output a design view
RESPONSE
DATA
DATA
View
Your website design, HTML files no images css etc here only HTML layouts
Model
Database related, not necessary database, data can be xml even text files

React-JS

React

- Templates mixed with JavaScript code
  - Expressed as functions
  - With HTML
  - And embedded code
- Can be done either server side or client side
  - Use for templating in the server

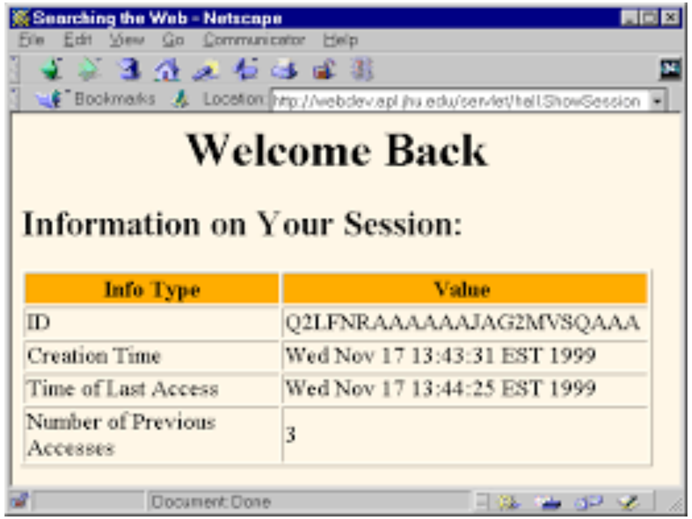
AngularJS and VueJS



- Templates that are executed at run time
- Automatically update the page as values change
- MVC (Model-View-Controller)
  - Model = the data structures
  - View = the template
  - Control = commands that modify the data
- Combine this with Object-Relational Modeling
  - Make a simple, consistent web application

What Information is Preserved

- Between pages
  - Authentication information
  - Current state (shopping cart, nearest store, …
  - History (videos watched, …)
- Between runs (between browsers)
  - User information
  - History
  - Is this session based?


Searching the Web - Netscape
File Edit View Go Communicator Help
Bookmarks
Location: http://webdev.apl.jhu.edu/servlet/hall.ShowSession
Document: Done

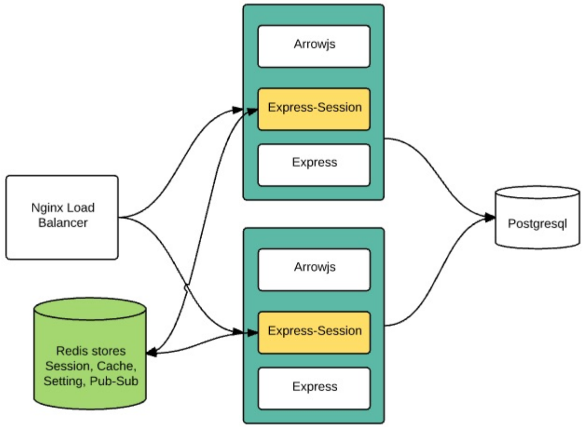
Welcome Back

Information on Your Session:

Info Type	Value
ID	Q2LFNRAAAAAAJAG2MVSQAAA
Creation Time	Wed Nov 17 13:43:31 EST 1999
Time of Last Access	Wed Nov 17 13:44:25 EST 1999
Number of Previous Accesses	3

Cookies, Sessions and Express

```
var session = require('express-session');
var cookieparser = require('cookie-parser');
…
app.use(cookieparser("KEY"));
app.use(session { secret : "KEY", store: new RedisStore(), …}));
app.use(sessionManager);
…
function sessionManager(req,res,next) {
        if (req.session.uuid == null) {
                req.session.uuid = <unique id>
                req.session.save();
        }
        next()
}
…
req.session.<field>
```


Arrowjs
Express-Session
Express
Nginx Load Balancer
Postgresql
Arrowjs
Express-Session
Express
Redis stores Session, Cache, Setting, Pub-Sub