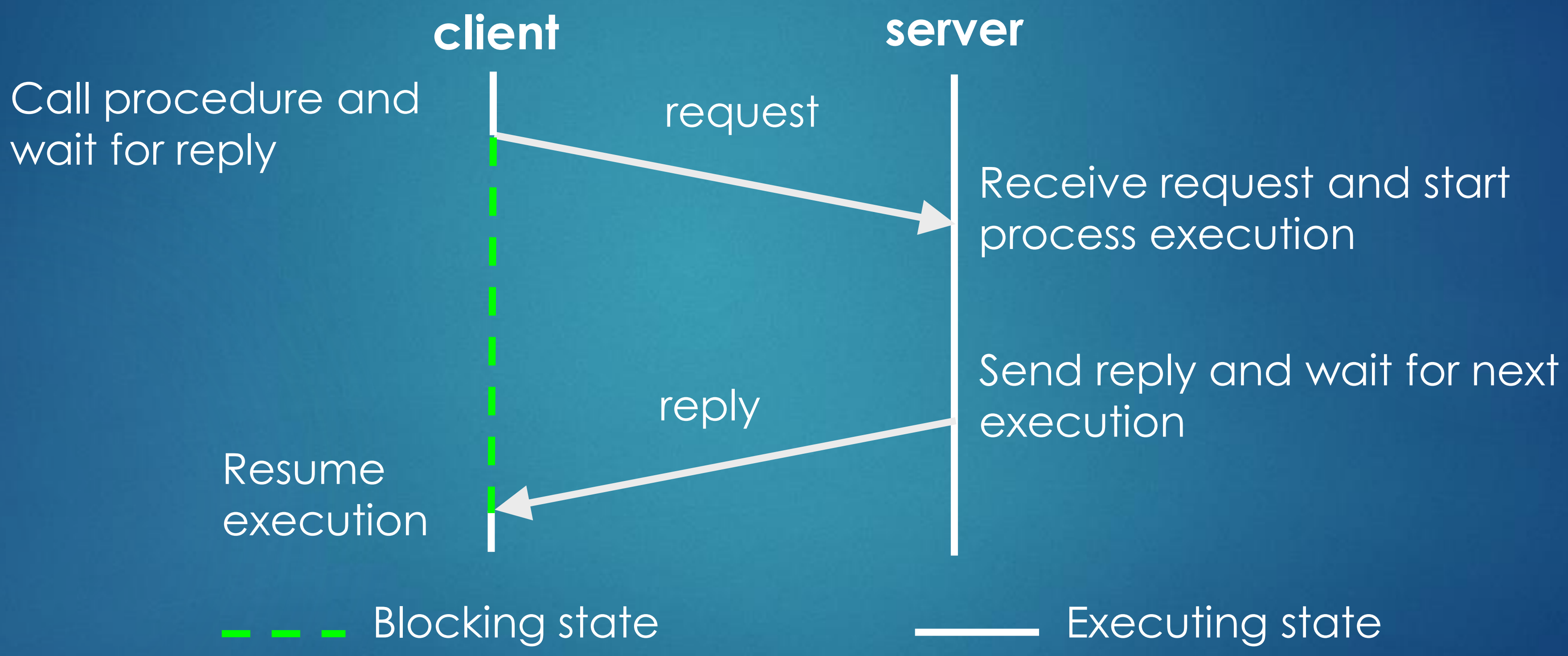
#06
RPC & REST

CLIENT/SERVER COMPUTING AND WEB TECHNOLOGIES

Introduction

- Remote Procedure Call (RPC) is a high-level model for client-sever communication.
- It provides the programmers with a familiar mechanism for building distributed systems.
- Examples: File service, Authentication service.

RPC Model


client
server
Call procedure and wait for reply
request
Receive request and start process execution
Send reply and wait for next execution
reply
Resume execution
Blocking state
Executing state

Characteristics

- The called procedure is in another process which may reside in another machine.
- The processes do not share address space.
  - Passing of parameters by reference and passing pointer values are not allowed.
  - Parameters are passed by values.
- The called remote procedure executes within the environment of the server process.
  - The called procedure does not have access to the calling procedure's environment.
- No message passing or I/O at all is visible to the programmer.

Features

- Simple call syntax
- Familiar semantics
- Well defined interface
- Ease of use
- Efficient
- Can communicate between processes on the same machine or different machines

Limitations

- Parameters passed by values only and pointer values are not allowed.
- Speed: remote procedure calling (and return) time (i.e., overheads) can be significantly (1 - 3 orders of magnitude) slower than that for local procedure.
- Failure: RPC is more vulnerable to failure (since it involves communication system, another machine and another process).
  - The programmer should be aware of the call semantics, i.e. programs that make use of RPC must have the capability of handling errors that cannot occur in local procedure calls.

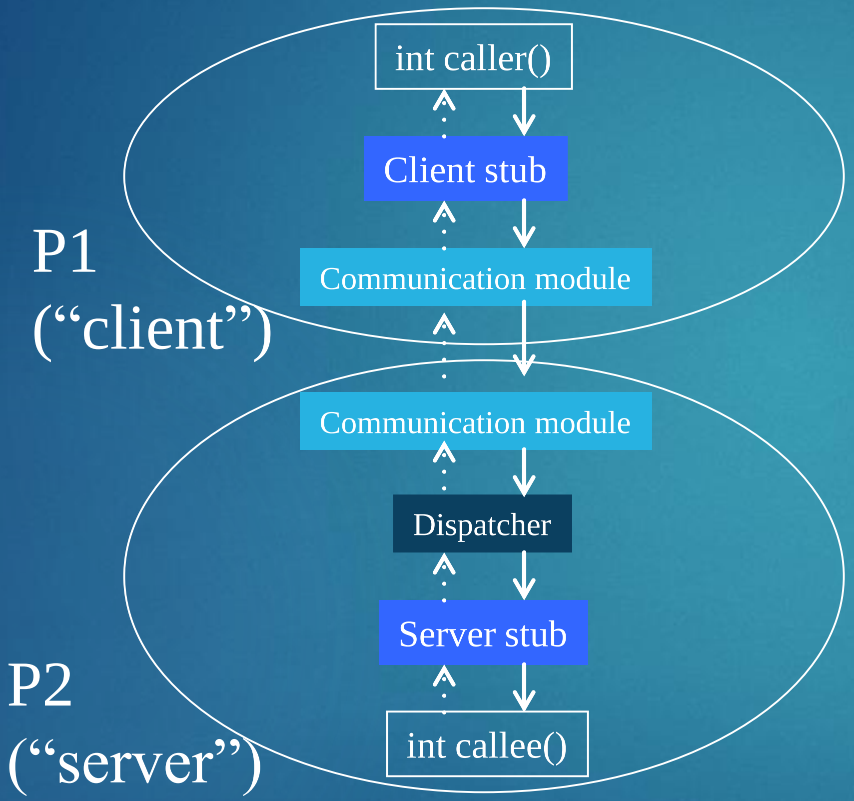
Design Issues

- Exception handling
  - Necessary because of possibility of network and nodes failures;
  - RPC uses return value to indicate errors;
- Transparency
  - Syntactic → achievable, exactly the same syntax as a local procedure call;
  - Semantic → impossible because of RPC limitation: failure (similar but not exactly the same);

Design Issues

- Delivery guarantees
  - Retry request message: whether to retransmit the request message until either a reply or the server is assumed to have failed;
  - Duplicate filtering : when retransmission are used, whether to filter out duplicates at the server;
  - Retransmission of replies: whether to keep a history of reply messages to enable lost replies to be retransmitted without re-executing the server operations.

RPC Components



Client

- **Client stub**: has same function signature as callee()
  - Allows same caller() code to be used for LPC and RPC
- **Communication Module**: Forwards requests and replies to appropriate hosts

Server

- **Dispatcher**: Selects which server stub to forward request to
- **Server stub**: calls callee(), allows it to return a value

Generating Code

- Programmer only writes code for caller function and callee function
- Code for remaining components all generated automatically from function signatures (or object interfaces in Object-based languages)
  - E.g., Sun RPC system: Sun XDR interface representation fed into rpcgen compiler
- These components together part of a Middleware system
  - E.g., CORBA (Common Object Request Brokerage Architecture)
  - E.g., Sun RPC
  - E.g., Java RMI

Marshalling

- Different architectures use different ways of representing data
- Caller (and callee) process uses its own platform-dependent way of storing data
- Middleware has a common data representation (CDR) which is platform-independent
- Caller process converts arguments into CDR format
  - Called “Marshalling”
- Callee process extracts arguments from message into its own platform-dependent format
  - Called “Unmarshalling”
- Return values are marshalled on callee process and unmarshalled at caller process

JSON-RPC

- Remote procedure call protocol encoded in JSON.
- It is a very simple protocol (and very similar to XML-RPC), defining only a handful of data types and commands.
- Allows for notifications (data sent to the server that does not require a response)
- Multiple calls to be sent to the server which may be answered out of order.
- Invoked by sending a request to a remote service using HTTP or a TCP/IP socket (starting with version 2.0).

Example: adding


```
var rpc = require('json-rpc2');
var server = rpc.Server.$create();

function add(args, opt, callback) {
    callback(null, args[0] + args[1]);
}

server.expose('add', add);
server.listen(8000, 'localhost');
```

>> npm install json-rpc2

```
var rpc = require('json-rpc2');
var client = rpc.Client.$create(8000,
   'localhost');

// Call add function on the server
client.call('add', [1, 2],
   function(err, result) {
      console.log('1 + 2 = ' + result);
   }
);
```

Reference: https://github.com/pocesar/node-jsonrpc2
https://github.com/justmoon/node-jsonrpc2

REST and HTTP

- The motivation for REST was to capture the characteristics of the Web which made the Web successful.
  - URI Addressable resources
  - HTTP Protocol
  - Make a Request – Receive Response – Display Response
- Exploits the use of the HTTP protocol beyond HTTP POST and HTTP GET
  - HTTP PUT, HTTP DELETE

Main Concepts

Nouns (Resources)
unconstrained
i.e., http://example.com/employees/12345

Verbs
constrained
i.e., GET

Representations
constrained
i.e., XML

Resources

REpresentative State Transfer

- The key abstraction of information in REST is a resource.
- A resource is a conceptual mapping to a set of entities
  - Any information that can be named can be a resource
    - a document or image
    - a temporal service (e.g. "today's weather in Los Angeles")
    - a collection of other resources
    - a non-virtual object (e.g. a person)
- Represented with a global identifier (URI in HTTP)
    - http://www.boeing.com/aircraft/747

Verbs

- Represent the actions to be performed on resources

- HTTP GET
- HTTP POST
- HTTP PUT
- HTTP DELETE

HTTP GET

- How clients ask for the information they seek.
- Issuing a GET request transfers the data from the server to the client in some representation

- GET http://localhost/books
  - Retrieve all books

- GET http://localhost/books/ISBN-0011021
  - Retrieve book identified with ISBN-0011021

- GET http://localhost/books/ISBN-0011021/authors
  - Retrieve authors for book identified with ISBN-0011021

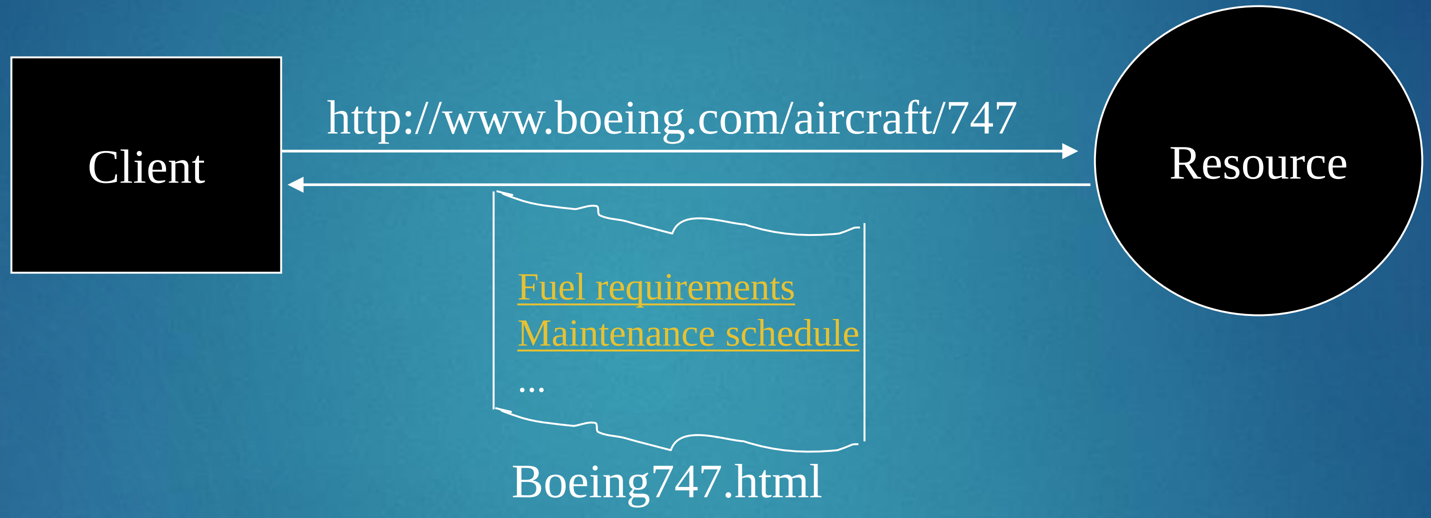
HTTP PUT, POST, DELETE

- POST http://localhost/books/
  - Content: {title, authors[], …}
  - Creates a new book with given properties
- PUT http://localhost/books/isbn-111
  - Content: {isbn, title, authors[], …}
  - Updates book identified by isbn-111 with submitted properties
- DELETE http://localhost/books/ISBN-0011
  - Delete book identified by ISBN-0011

Representations

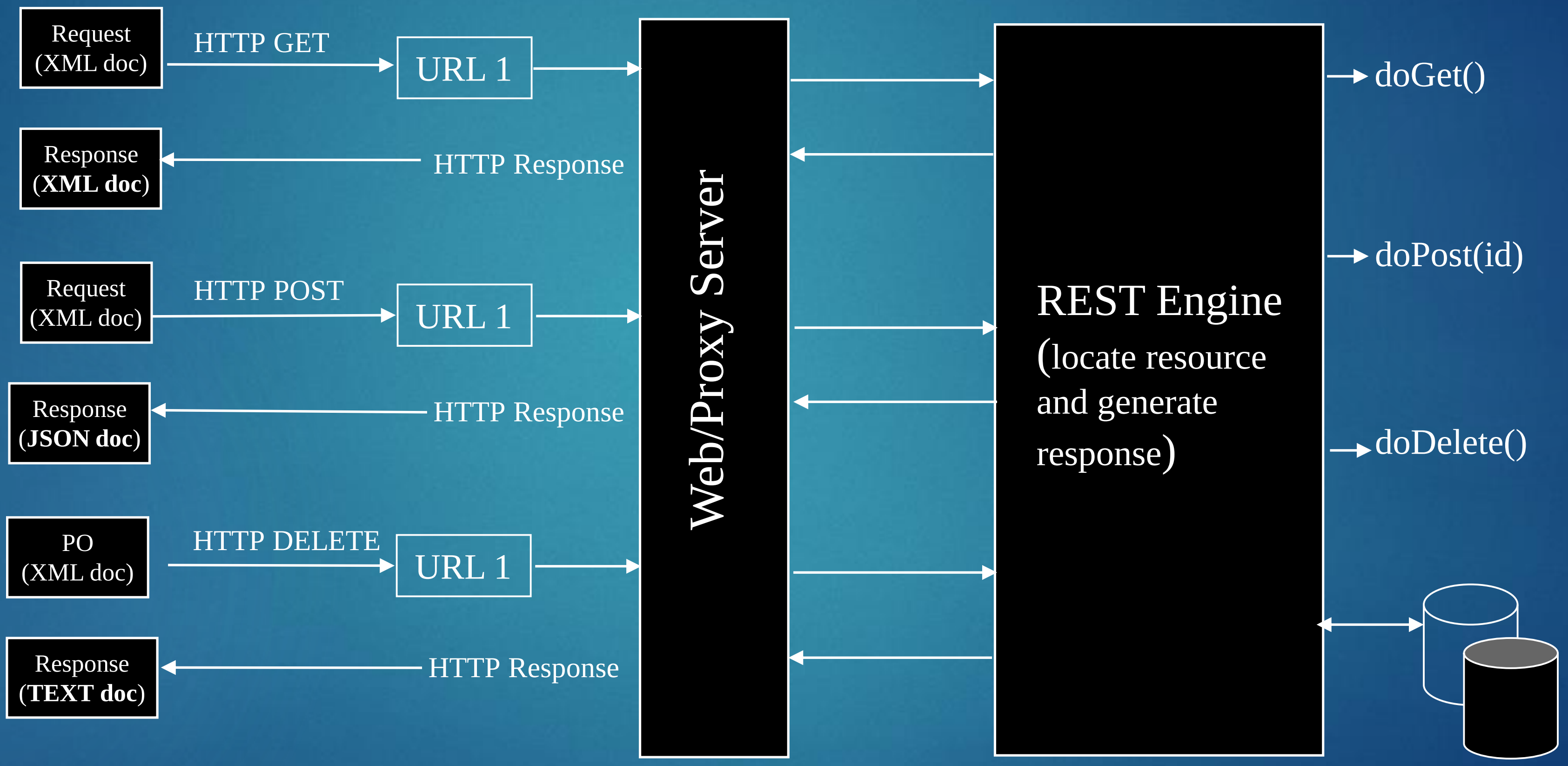
- How data is represented or returned to the client for presentation.
- Two main formats:
  - JavaScript Object Notation (JSON)
  - XML
- It is common to have multiple representations of the same data

Why is it called
"Representational State Transfer"?



The Client references a Web resource using a URL. A **representation** of the resource is returned (in this case as an HTML document).
The representation (e.g., Boeing747.html) places the client application in a **state**. The result of the client traversing a hyperlink in Boeing747.html is another resource accessed. The new representation places the client application into yet another state. Thus, the client application changes (**transfer**s) state with each resource representation --> Representation State Transfer!

Architecture Style



Example: REST for bears

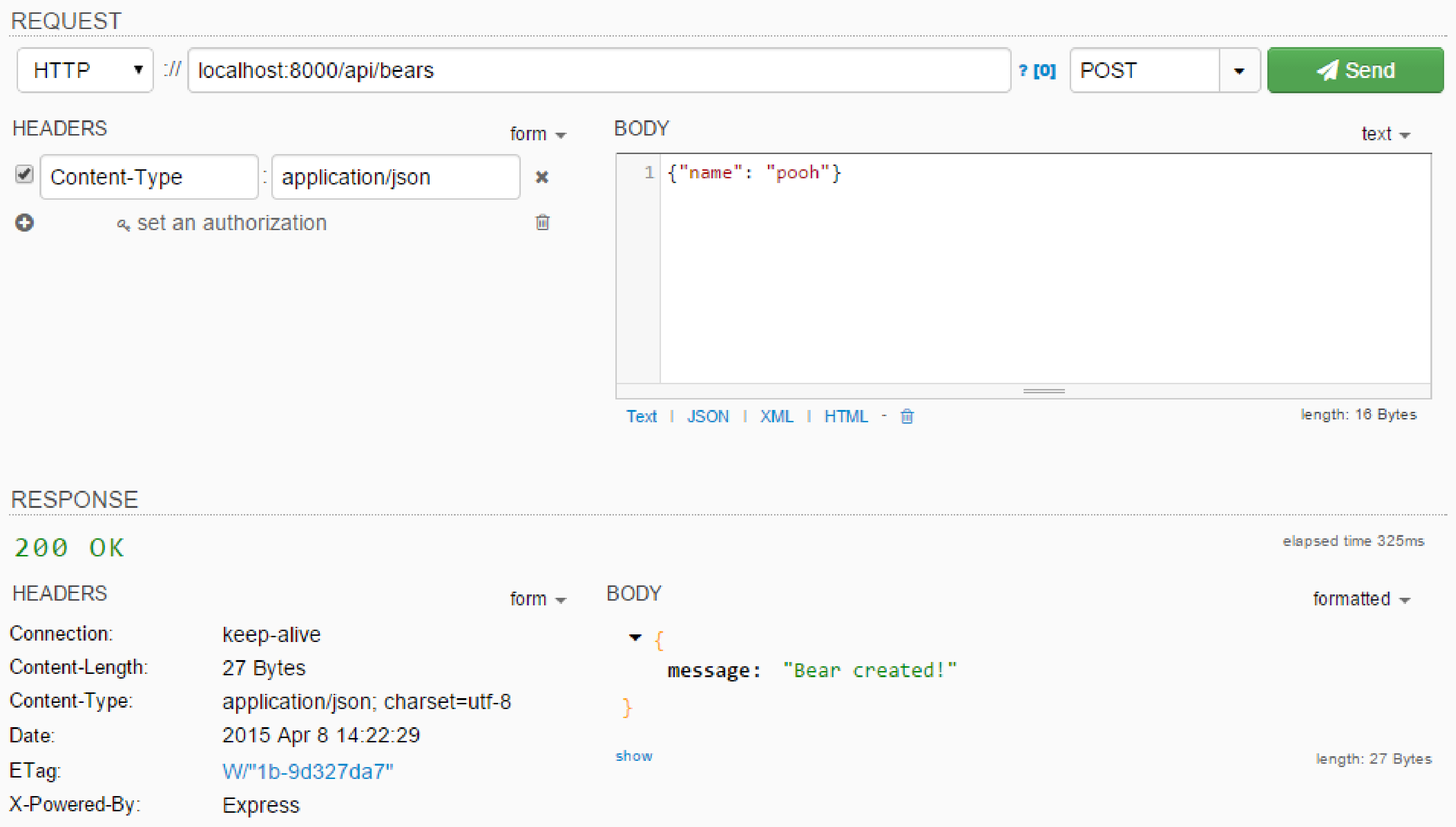
/api/bears	GET	Get all the bears.
/api/bears/:bear_id	GET	Get a single bear.
/api/bears/:bear_id	DELETE	Delete a bear.

Example: Create a bear


```
var express = require('express');
var app = express();
var router = express.Router();
var bodyParser = require('body-parser');

var bears = [];

router.route('/bears')
  .post(function(req, res) {
    var bear = {};
    bear.name = req.body.name;
    bears.push(bear);
    res.json({ message: 'Bear created!' });
  });

// all of our routes will be prefixed with /api
app.use('/api', bodyParser.json(), router);
app.listen(8000);
```

Try REST API

- Chrome plugins with REST clients functionality are available. e.g., Postman, DHC



Restful - React

Get all bears (1)


```
import React, { Component } from 'react';
import axios from 'axios';
import _ from 'lodash';

const URL = 'http://localhost/api/bears';

class Bear extends Component {
    constructor(props){
        super(props)
        this.state = {  data: {} }
    }

    componentDidMount() {
        axios.get(URL)
            .then(response => {
                    this.setState({data : response.data})
                    console.log(response.data)
                }
            )
    }

    ...
```

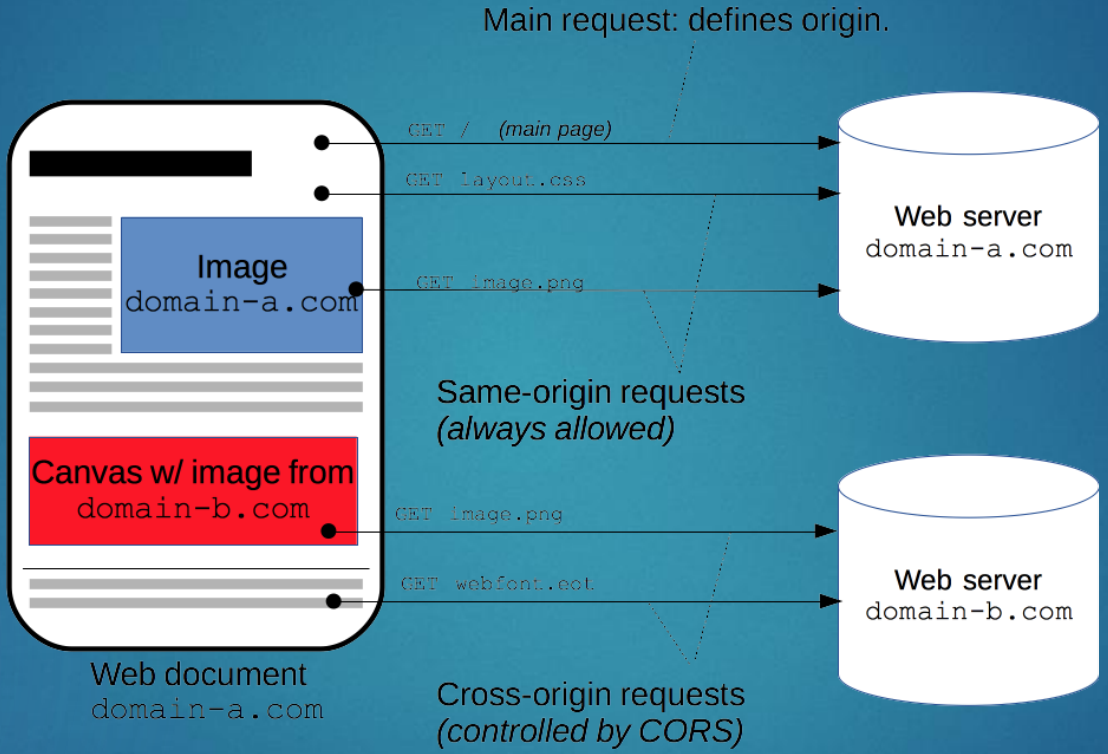
Get all bears (2)

from lodash

```
renderBears() {
        return _.map(this.state.data, bear => {
            return (
                <li className="list-group-item" key={bear.id}>
                    {bear.id+1}. {bear.name}, {bear.weight}
                </li>
            )
        })
    }

    render() {
        return (
            <div>
                <h2> Bear Profile</h2>
                <ul className="list-group">
                    {this.renderBears()}
                </ul>
            </div>
        );
    }

}
```

Cross-Origin Resource Sharing (CORS)

- Allow APIs to be called from different domains



- npm install cors

```
var cors = require('cors')
var app = express()
app.use(cors())
```

Axios: Post and Delete example


```
axios.post('http://localhost/api/bears', {
    name: 'Fred',
    weight: 123
})
.then( (response) => {
     console.log('Create a bear: ' + response);
})
.catch( (error) => {
     console.log(error);
});


axios.delete('http://localhost/api/bears/5')
    .then( (response) => {
         console.log('Delete:' + response)
 })
```

React - Redux - Router

Redux

- Redux is a predictable state container for JavaScript apps.
- Write applications that behave consistently, run in different environments (client, server, and native), and are easy to test.

- Redux divides a component into several types:
  - Components (View)
  - Actions (Event)
  - Reducers (Data)

Reference: https://en.wikipedia.org/wiki/Redux_(JavaScript_library)

Component

components/bear_index.js


```
class BearIndex extends Component {
    componentDidMount() {
        this.props.fetchBears()
    }

    renderBears() {
        return _.map(this.props.bears, bear => {
            return (
                <li className="list-group-item" key={bear.id}>
                    {bear.id+1}. {bear.name}, {bear.weight}
                </li>
            )
        })
    }

    render() {
        return (
            <div>
                <h2> Bear Profile</h2>
                <ul className="list-group">
                    {this.renderBears()}
                </ul>
            </div>
        );
    }
}

function mapStateToProps(state) {
    return { bears: state.bears};
}

export default connect(mapStateToProps, {fetchBears} )(BearIndex);
```

Actions

actions/index.js

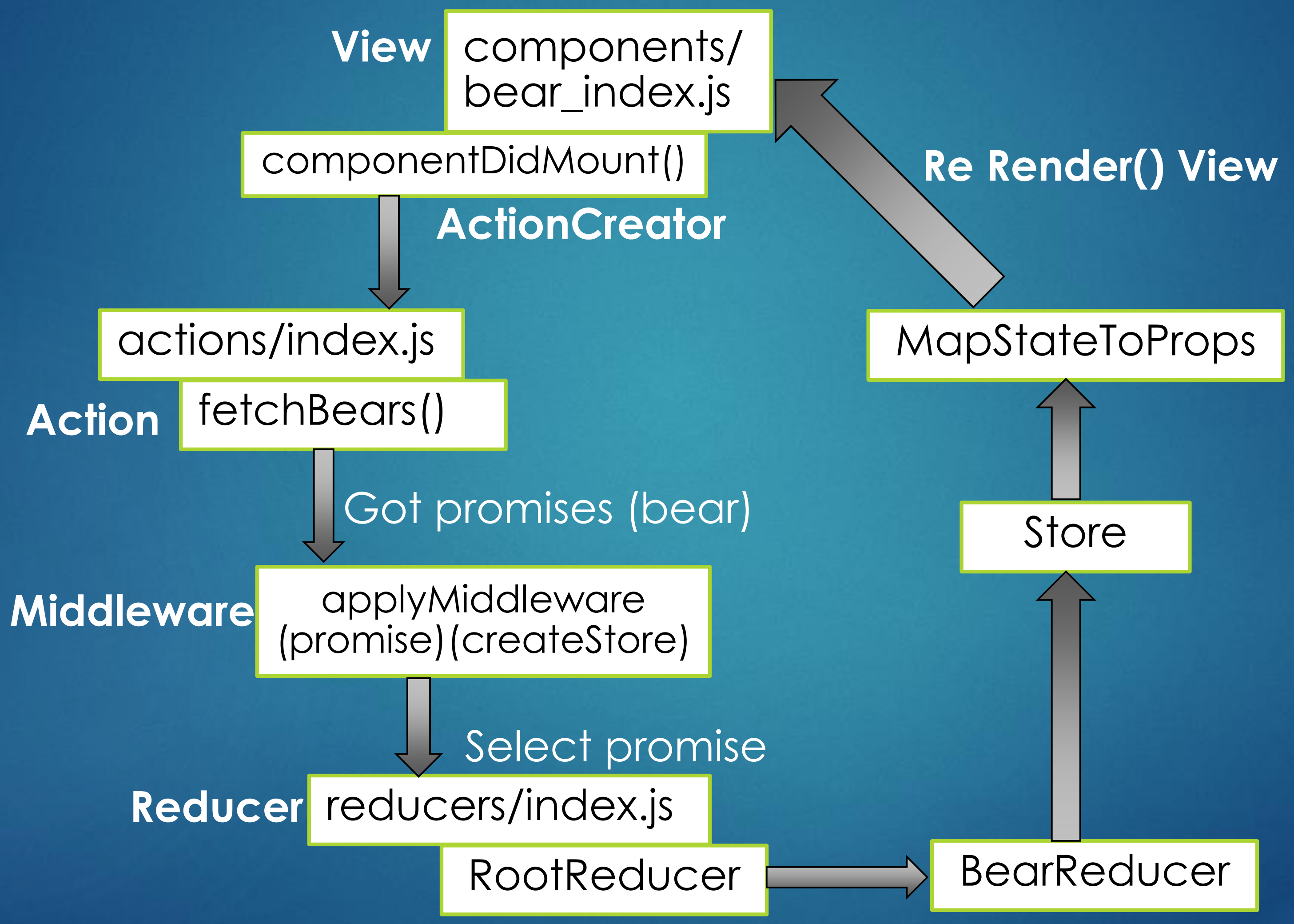
```
import axios from 'axios';

export const FETCH_BEARS = 'fetch_bears';
const ROOT_URL = 'http://localhost/api/bears';

export function fetchBears() {

    const request = axios.get(ROOT_URL);

    return {
        type: FETCH_BEARS,
        payload: request
    };
}
```

Reducers

reducers/index.js

```
import { combineReducers } from 'redux';
// import { reducer as formReducer } from 'redux-form';
import BearsReducer from './reducer_bears';

const rootReducer = combineReducers({
    bears: BearsReducer
});

export default rootReducer;
```

React-Redux


View
components/
bear_index.js
componentDidMount()
ActionCreator
Re Render() View
actions/index.js
MapStateToProps
Action
fetchBears()
Got promises (bear)
Store
Middleware
applyMiddleware
(promise)(createStore)
Select promise
Reducer
reducers/index.js
RootReducer
BearReducer

Reducer

reducers/bear_reducer.js

```
import _ from 'lodash';
import {FETCH_BEARS } from '../actions';

export default function (state = {}, action) {
    switch(action.type) {
        case FETCH_BEARS:
            return _.mapKeys(action.payload.data,'id');
        default:
            return state;
    }
}
```

Main page - Router


```
import React, { Component } from 'react';
import { Provider } from 'react-redux';
import { createStore, applyMiddleware } from 'redux';
import { BrowserRouter, Route, Switch } from 'react-router-dom'
import promise from 'redux-promise';

import reducers from './reducers';
import BearIndex from './components/bear_index';

const createStoreWithMiddleware = applyMiddleware(promise)(createStore);
```

Install more libraries

Main page - Router


```
class AppBear extends Component {

    render() {
        return (

            <Provider store={createStoreWithMiddleware(reducers)}>
                <BrowserRouter>
                    <div>
                        <Switch>
                            <Route path="/" component={BearIndex} />
                        </Switch>
                    </div>
                </BrowserRouter>
            </Provider>
        );
    }
}

export default AppBear;
```

Map path to a component

References

- "Advanced Operating Systems: RPC", Ajay Katangur
- "RPCs and Concurrency Control", Indranil Gupta, 2014
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- "Express Routing", http://expressjs.com/guide/routing.html