CS 580 Client-Server Programming
Spring Semester, 2009
Doc 18 REST, Jar & Distributed Computing
23 Apr 2009

References

REST Comment, http://developers.slashdot.org/article.pl?sid=03/04/03/1942235&mode=nocomment&tid=185&tid=156

REST, http://en.wikipedia.org/wiki/Representational_State_Transfer

Architectural Styles and the Design of Network-based Software Architectures, Roy Fielding, http://www.ics.uci.edu/~fielding/pubs/dissertation/top.htm

Packaging Programs in JAR Files, http://java.sun.com/docs/books/tutorial/deployment/jar/

Distributed Computing, http://en.wikipedia.org/wiki/Distributed_computing

JSON - JavaScript Object Notation,

- Main JSON web site, http://www.json.org/
- JSON in Java, http://www.json.org/java/index.html

Java's Object Streams

- Java 6 API documentation, http://java.sun.com/javase/6/docs/api/
- Object Stream Spec, http://java.sun.com/javase/6/docs/platform/serialization/spec/protocol.html

REST

http://developers.slashdot.org/article.pl?sid=03/04/03/1942235&mode=nocomment&tid=185&tid=156

tadghin:

“I was recently talking with Jeff Barr, creator of syndic8 and now Amazon's chief web services evangelist. He let drop an interesting tidbit. Amazon has both SOAP and REST interfaces to their web services, and 85% of their usage is of the REST interface."

" Despite all of the corporate hype over the SOAP stack, this is pretty compelling evidence that developers like the simpler REST approach. “

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History

Roy Fielding

2000 Ph.D. Thesis

Architectural Styles and the Design of Network-based Software Architectures

What makes the Web scale?

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REST Principles

Application state and functionality are abstracted into resources

Every resource is uniquely addressable using a universal syntax for use in hypermedia links

All resources share a uniform interface for the transfer of state between client and resource, consisting of

- A constrained set of well-defined operations
- A constrained set of content types, optionally supporting code on demand

A protocol which is:

- Client-server
- Stateless
- Cacheable
- Layered

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Two Meanings of REST

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Fielding's definition

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Any simple interface which transmits domain-specific data over HTTP

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Jar Files

Zip compressed files

Optional MANIFEST file

http://java.sun.com/docs/books/tutorial/deployment/jar/

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Example

File: sdsu/Foo.class

Showing source rather than byte code

```
package sdsu;

public class Foo {

	public static void main(String[] args) {
		System.out.println(hello());
	}

	public static String hello() {
		return "Hello World";
	}
}
```

File: sampleManifest

```
Manifest-Version: 1.0
Class-Path: .
Main-Class: sdsu.Foo
```


MANIFEST files must end in new line or carriage return

Creating the Jar file

> jar -cmf sampleManifest sdsu

Running the jar file

> java -jar sample.jar

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Extracting contents of Jar

```
> jar -xvf sample.jar

 created: META-INF/
inflated: META-INF/MANIFEST.MF
 created: sdsu/
inflated: sdsu/Foo.class
```


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Note that the MANIFEST.IM always ends up in META-INF

META-INF Directory

MANIFEST.MF

Defines extension and package related data

INDEX.LIST

Used by class loaders to speed up class loading

x.SF

Signature file

x.DSA

Signature of the corresponding signature file

services/

Service provider configuration files

Some MANIFEST Attributes

Manifest-Version:
Created-By:
Signature-Version:
Class-Path:
Main-Class:

http://java.sun.com/javase/6/docs/technotes/guides/jar/jar.html

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Jars in Eclipse Projects

File: cs580/Bar.java

```
package cs580;

import sdsu.Foo;

public class Bar {

        public static void main(String[] args) {
                System.out.println("Here");
                System.out.println(Foo.hello());
        }
}
```


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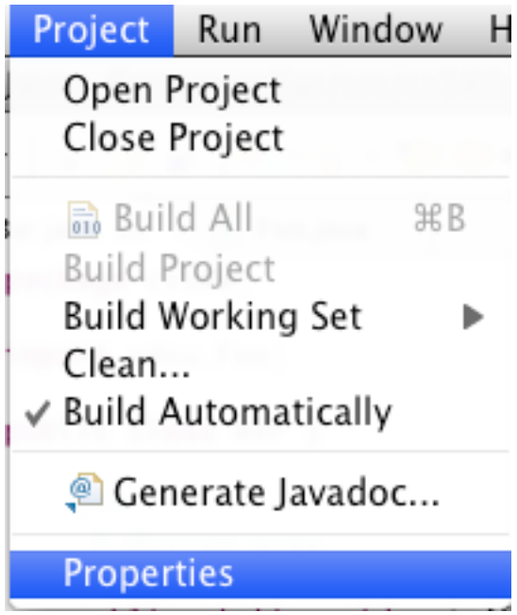
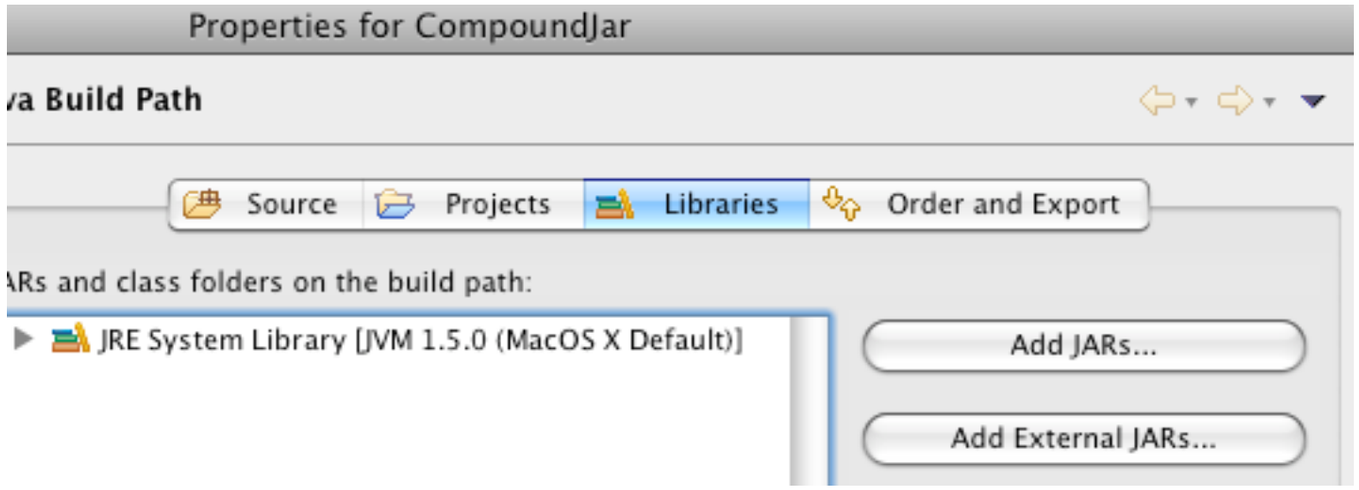
Adding Jar





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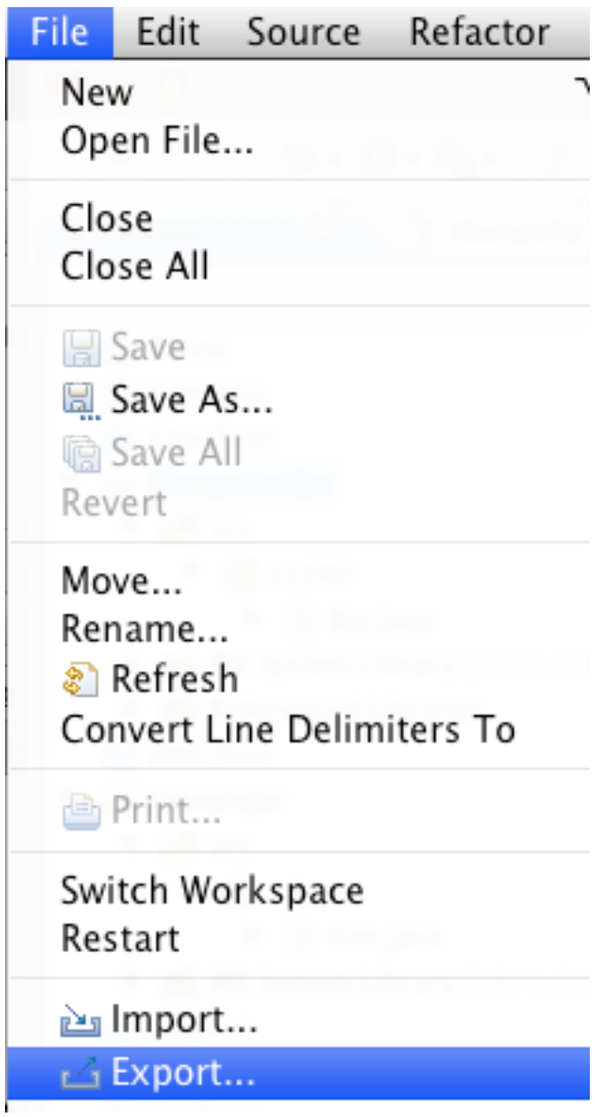
Now Create Jar from Project

1



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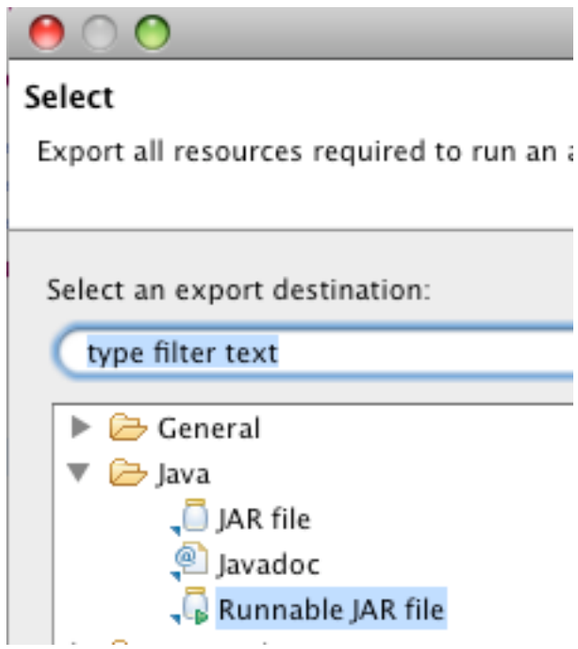

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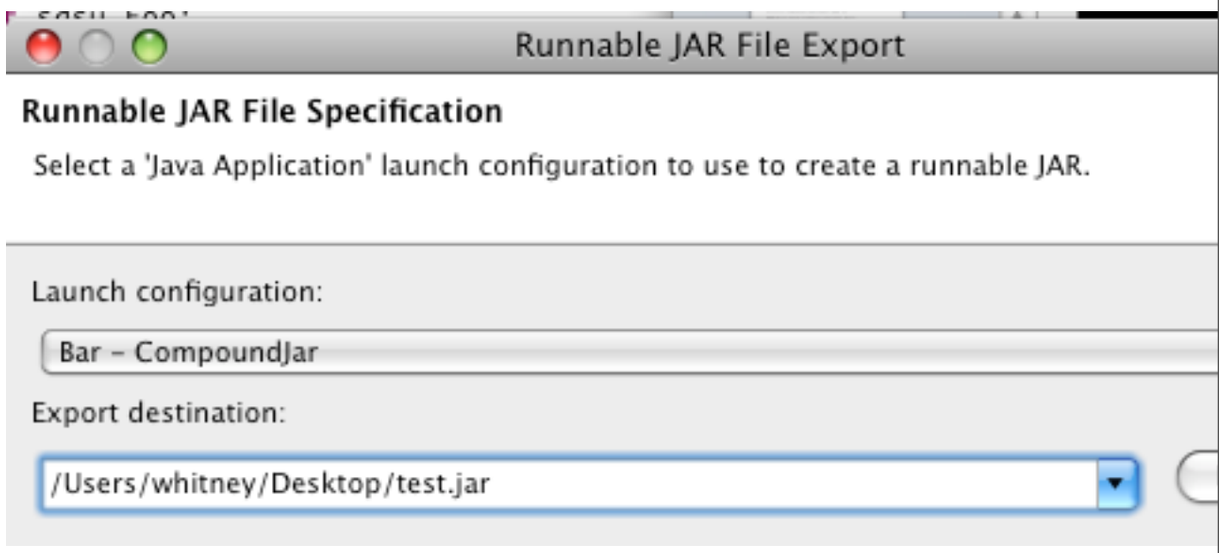

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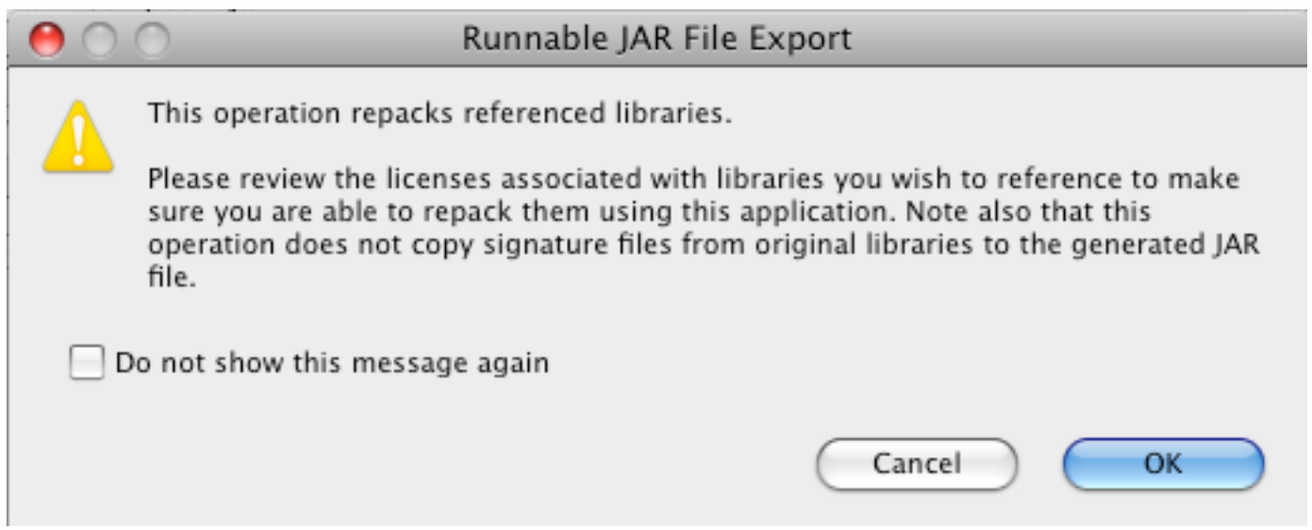

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New Jar File works

> 7java -jar test.jar
Here
Hello World

But No Jar inside the jar

> jar -tf test.jar
META-INF/MANIFEST.MF
cs580/Bar.class
sdsu/Foo.class

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Distributed Computing

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Jar's In Jars

You need to implement a class loader to load
a jar file that is inside a jar file

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Related Terms

Concurrent Computing

Simultaneous execution of multiple interacting computational tasks

Networking

Multiple computers interacting via network

Do not share single program

Distributed Computing

Different parts of a program run on multiple computers

Parts communicate via network

Parallel computing

Different parts of a program run on multiple processors in same computer

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Some Motivation

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Basic Communication Steps

Design protocol

Create domain objects

Extract protocol string from select domain objects

Convert protocol string to domain object

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Vote Example

```
public class Vote {
    static String CR = "\r";
    int id;
    String option;

    public Vote(int pollId, String optionVote) {
        id = pollId;
        option = optionVote;
    }

    public int id() {return id;}

    public String option() {return option;}

    public String toString() {
        StringBuffer protocol = new StringBuffer();
        protocol.append("command:VOTE");
        protocol.append(CR);
        protocol.append("poll-id:");
        protocol.append(id);
        protocol.append(CR);
        protocol.append("option:");
        protocol.append(option);
        protocol.append(CR);
        protocol.append(CR);
        return protocol.toString();
    }
}
```


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Vote Example - Converting

```
public static Vote fromString(String voteString) {
      String[] lines = voteString.split(CR);
      HashMap<String, String> data = new HashMap<String, String>();
      for (int k = 0; k < lines.length;k++) {
          String[] keyValue = lines[k].split(":");
          data.put(keyValue[0].toLowerCase(), keyValue[1]);
      }
      return fromMap(data);
   }

   public static Vote fromMap(Map<String,String> voteData ){
       String option = voteData.get("option");
       Integer id = Integer.valueOf(voteData.get("poll-id"));
       return new Vote(id.intValue(), option);
    }
}
```


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Repeat

Repeat for each Command

Repeat for each client-server project

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Some Ways to Automate the Work

JSON

ObjectStreams

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JSON

http://www.json.org/

JavaScript Object Notation

data-interchange format

rfc 4627

Maps to/from strings

- null
- true, false
- number
- string
- array
- objects

Implementations in

C, C++, C#, D, E, Java, Objective C
Cold Fusion, Delphi, Erlang, Haskell
JavaScript, Lisp, LotusScript, Perl,
PHP, Pike, Prolog, Python, Ruby, Smalltalk

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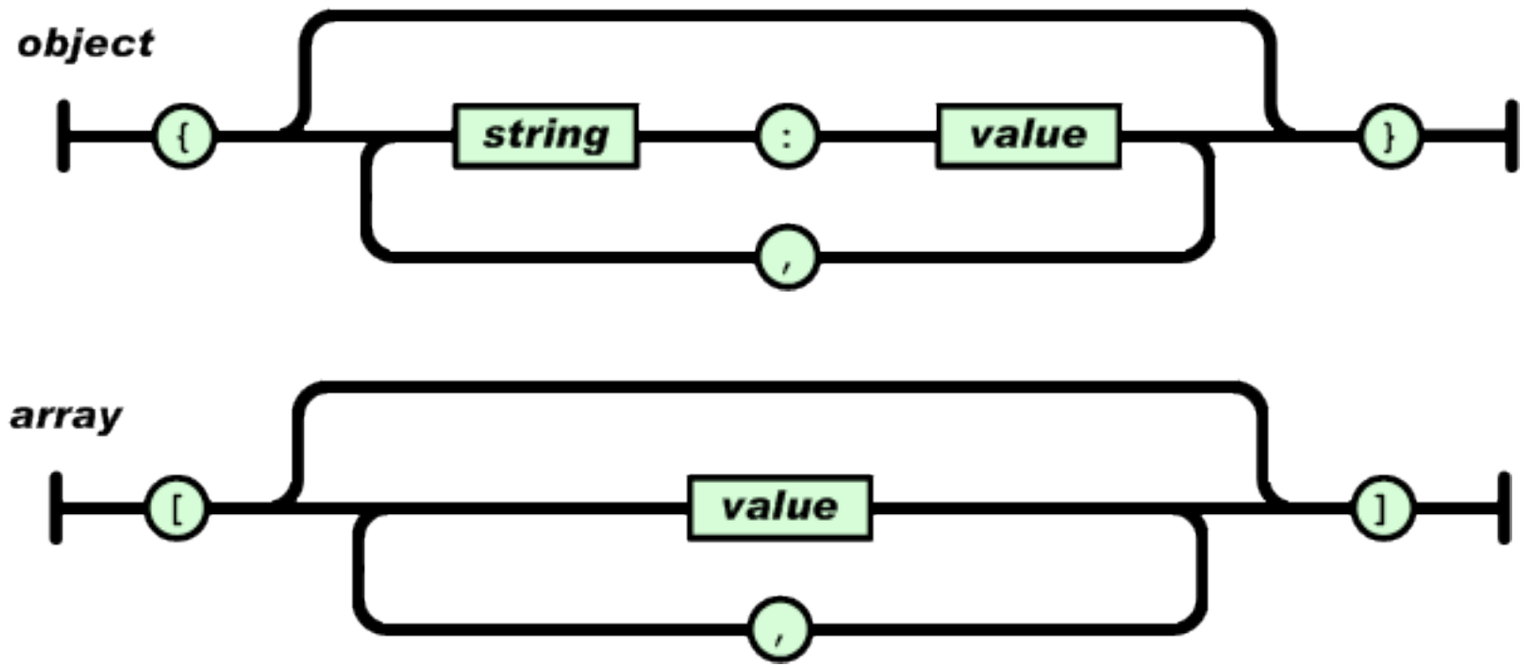
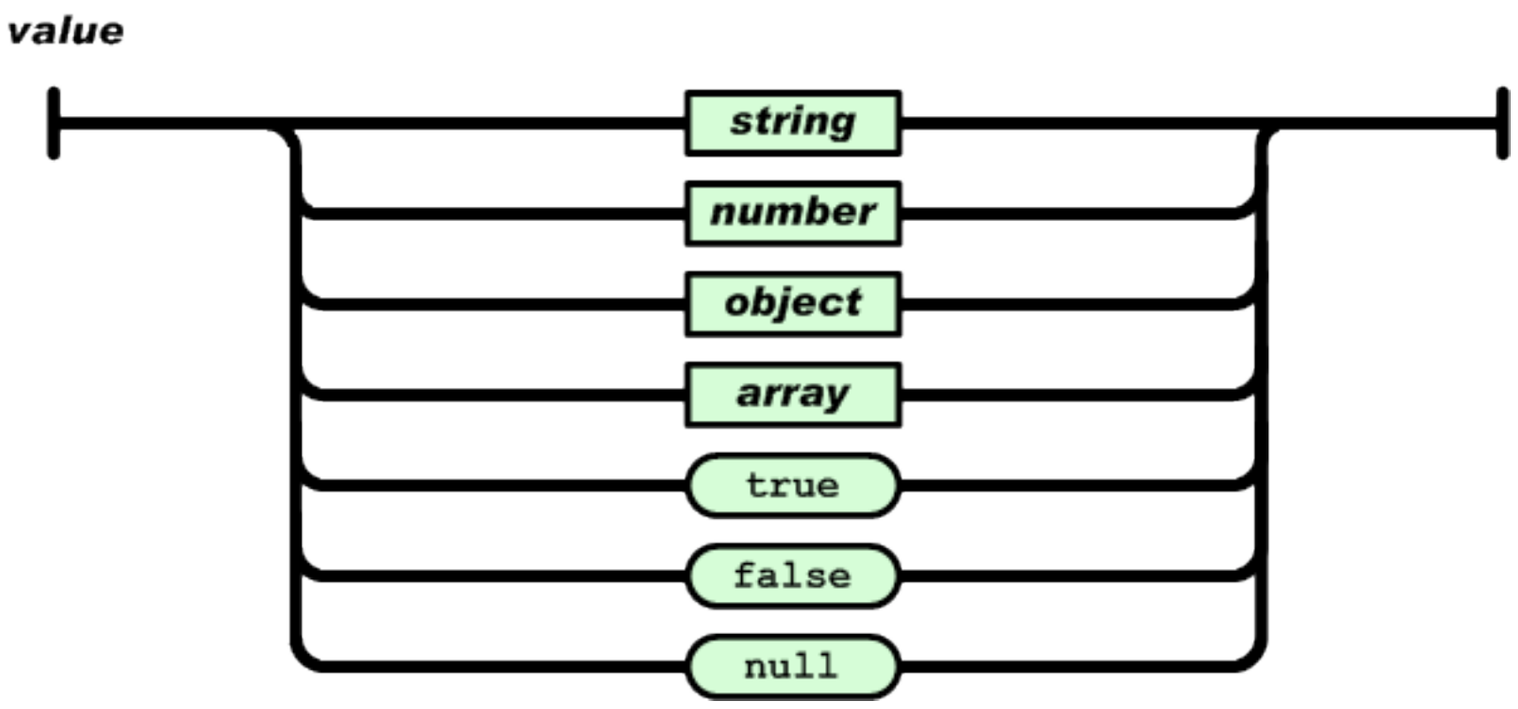
JSON Definition

Source: http://www.json.org/





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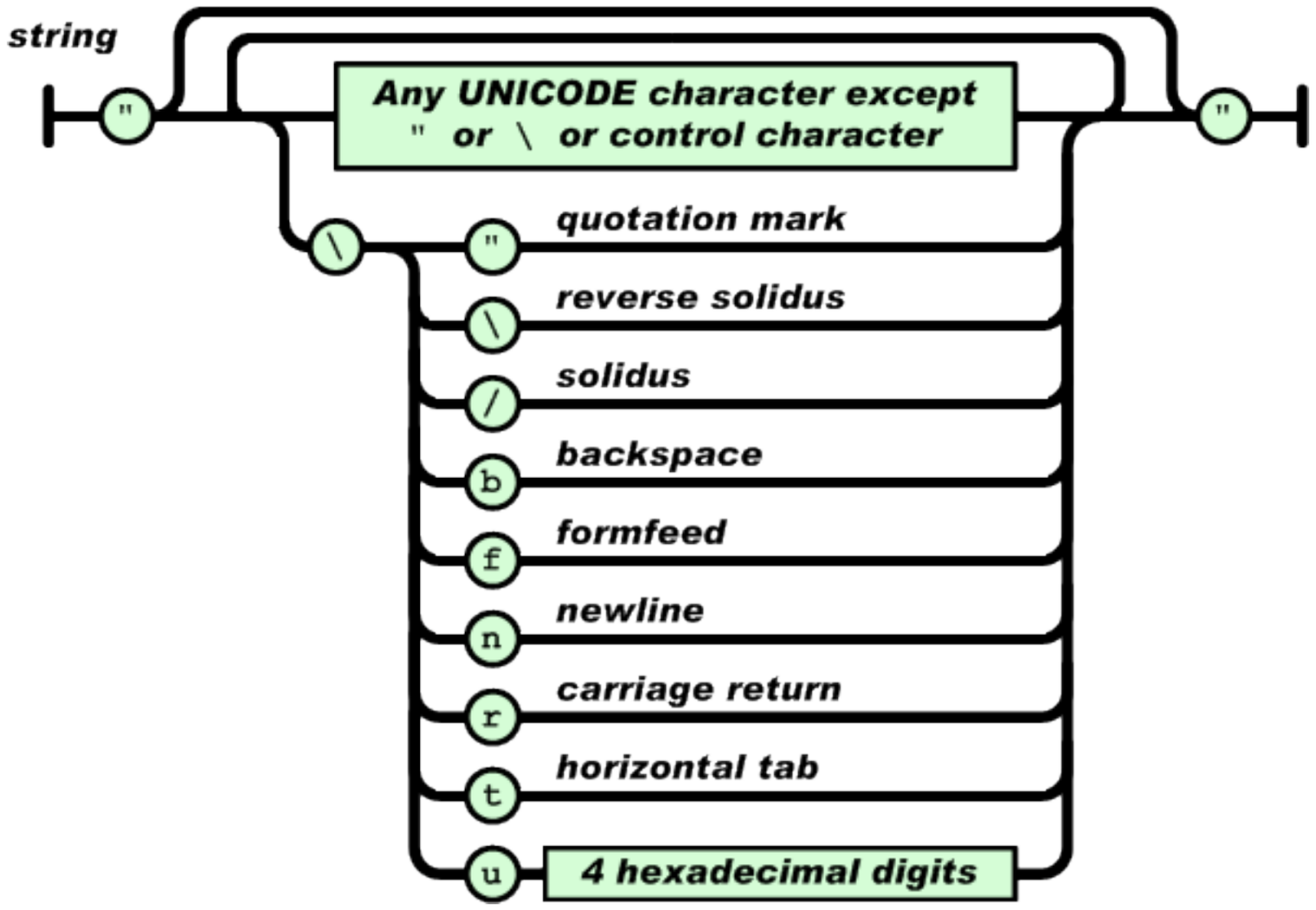
String


string
"
Any UNICODE character except
" or \ or control character
"
\
"
quotation mark
\
reverse solidus
/
solidus
b
backspace
f
formfeed
n
newline
r
carriage return
t
horizontal tab
u
4 hexadecimal digits

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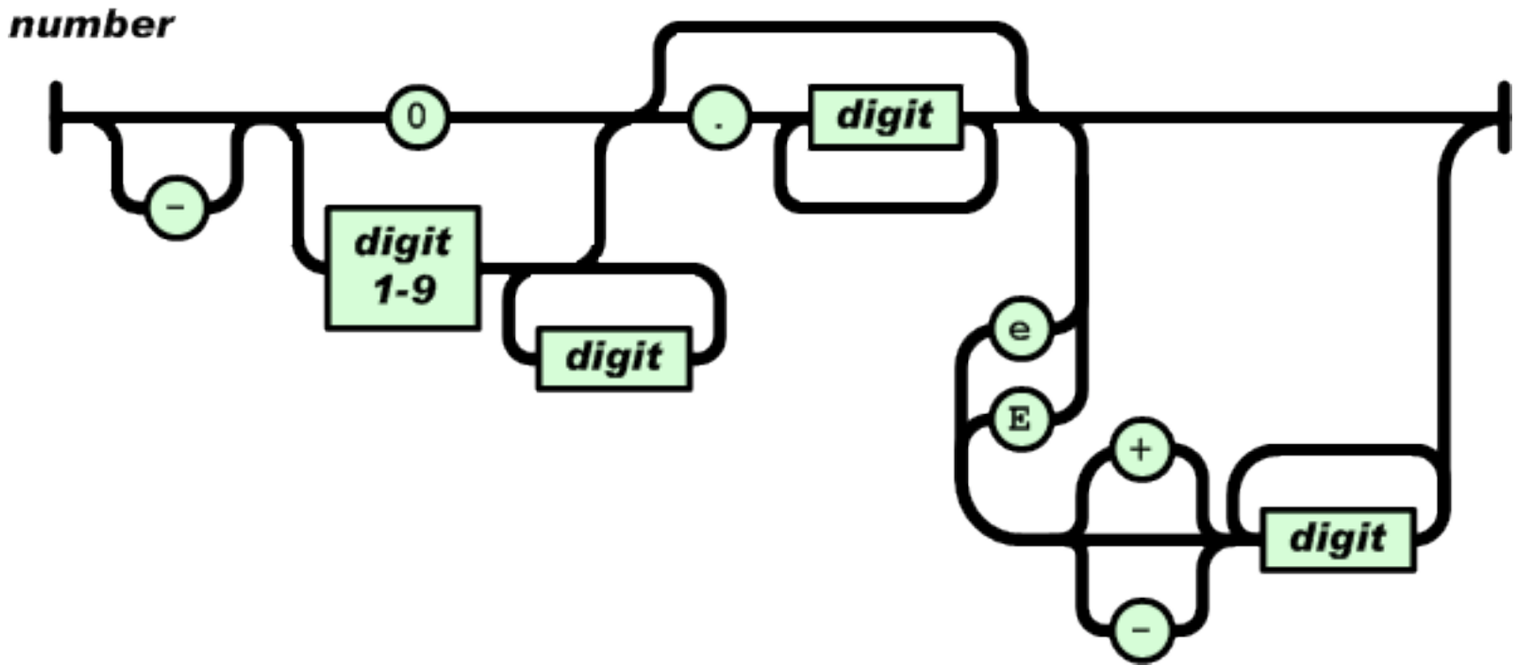
Number



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Examples

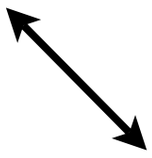
Java Structure

```
Vector array = new Vector();
array.append(new Integer(12));
array.append("Egypt");
array.append(new Boolean(false));
array.append(new Integer(-31));
```

JSON Representation

```
[12,"Egypt",false,-31]
```

```
HashMap<String,Integer> object = new HashMap<String,Integer>();
object.put("lowerBound", 18);
object.put("upperBound", 139);
```



```
{"lowerBound":18,"upperBound":139}
```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Possible Client-Server Usage

Use JSON as protocol syntax

Use JSON libraries to

Generate client-server messages

Parse messages from network

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JSON in Java

http://www.json.org/java/index.html

A Java JSON library

JSONObject

- Constructs JSON strings
- Parses JSON strings

```
JSONObject json = new JSONObject();
json.put("lowerBound", 18);
json.put("upperBound", 139);

String objectString = json.toString();       //"{"lowerBound":18,"upperBound":139}"

JSONObject newJson = new JSONObject(objectString);
int bound = newJson.getInt("lowerBound");       // 18
```


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Vote Example

```
import org.json.JSONObject;
import org.json.JSONException;

public class Vote implements Serializable {
    int id;
    String option;

    public Vote(int pollId, String optionVote) {
        id = pollId;
        option = optionVote;
    }

    public int id() {return id;}
    public String option() {return option;}

    public String toJson() throws JSONException {
        JSONObject json = new JSONObject();
        json.put("command", "VOTE");
        json.put("poll-id", id);
        json.put("option", option);
        return json.toString();
    }
```

```
    public static Vote fromJson(String jsonString)
                            throws JSONException {
        JSONObject json = new JSONObject(jsonString);
        int id = json.getInt("poll-id");
        String option = json.getString("option");
        return new Vote(id, option);
    }
}
```

Using Java JSON library from
http://www.json.org/java/index.html

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Using JSON Strings

```
Vote cat = new Vote(1,"cat{:}dog");
String json = cat.toJson();

System.out.println(json);  //{"command":"VOTE","option":"cat{:}dog","poll-id":1}
```

```
Vote jsonVote = Vote.fromJson(json);
assertEquals(jsonVote.id(), 1);
```


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Consequences

Benefits

Parsing and generation of protocol simplified

- No need to escape special characters

Define protocol in terms of

- maps (key-value pairs)
- arrays
- basic types (string, number, boolean)

Cross language support

Drawbacks

Nested { } and [] complicate parsing

No general end of message sequence

Limited support for primitive types

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Object Streams

ObjectOutputStream

- Serializes objects
- Converts objects to bytes

ObjectInputStream

- Deserializes objects
- Converts DataOutputStream byte back into objects

"Requires" writer and reader to be Java programs

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Possible Client-Server Usage

Create Message and Response classes

Send message objects to server

Message object

- Contains needed data
- Possibility executes methods on server

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Vote Example

```
import java.io.Serializable;

public class Vote implements Serializable, Message {
    int id;
    String option;

    public Vote(int pollId, String optionVote) {
        id = pollId;
        option = optionVote;
    }

    public int id() {return id;}

    public String option() {return option;}

        public Response execute(VoteServer aServer ) {
                boolean succeeded  = aServer.addVote(id, option);
                if (succeeded)
                        return new SuccessResponse();
                return new FailedResponse();
}
```


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Using ObjectStreams

Writing the Object

```
Vote cat = new Vote(1,"cat");
FileOutputStream catBytes = new FileOutputStream("cat");
ObjectOutputStream out = new ObjectOutputStream(catBytes);
out.writeObject(cat);
out.close();
```

Reading the Object

```
ObjectInputStream in = new ObjectInputStream(new FileInputStream("cat"));
Vote result = (Vote)in.readObject();
```

Output File

```
¨ÌsrVoteªI\€ä…áIidLoptiontLjava/lang/String;xptcat
```


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Sample Client Usage

```
Socket connection = new Socket(server, port);
OutputStream rawOut = connection.getOutputStream();
ObjectOutputStream out = new ObjectOutputStream(rawOut);
InputStream rawIn = connection.getInputStream();
ObjectInputStream in = new ObjectInputStream(rawIn);

Vote forCat = new Vote(1,"cat");
out.writeObject(forCat);
out.flush();
Response answer =(Response) in.readObject();

out.close();
in.close();
```


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Sample Server

```
ServerSocket input = new ServerSocket( port );
while (true) {
   Socket client = input.accept();

      OutputStream rawOut = client.getOutputStream();
      ObjectOutputStream out = new ObjectOutputStream(rawOut);
      InputStream rawIn = client.getInputStream();
      ObjectInputStream in = new ObjectInputStream(rawIn);

      Message request = (Message) in.readObject();
      Response answer = request.execute(this);
      out.writeObject(answer);
      out.flush();
 client.close();
}
```


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Consequences

Benefits

No need for a text protocol - just send objects

Protocol is just objects one can send

No need for parsing - just read objects

Drawbacks

Client and server need to be in Java

Client & server must have same classes

Modifications of a class can cause problems

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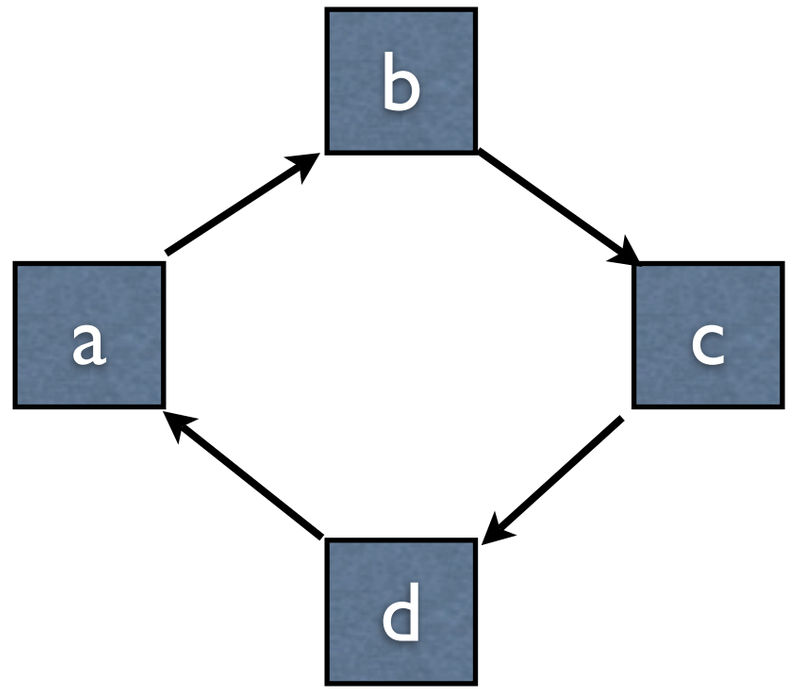
Circular References

Care is needed when serializing/deserializing objects with circular references

ObjectStream does it correctly



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Object Stream Protocol

The protocol used by Object Stream is documented at:

http://java.sun.com/javase/6/docs/platform/serialization/spec/protocol.html

At least one Lisp implementation of this protocol exists

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RPC - Remote Procedure Call

Client "directly" calls a function on the server

Issues

Cross platform

Marshalling/unmarshalling of parameters and results

How can one handle pointers as parameters?

Different contexts of client and server

Registering and finding servers

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XML-RPC

RPC using

HTTP as transport layer and

XML to encode request/response

Language and platform independent

Started by Userland (http://frontier.userland.com/) in 1998

Languages/Systems with XML-RPC implementations

Java, Perl, Python, Tcl, C, C++, Smalltalk

ASP, PHP, AppleScript, COM

Zope, WebCrossing

Led to the development of SOAP

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Example - Add Server

```
import org.apache.xmlrpc.*;

public class AddServer {
        public Integer addtwo(int x, int y)  {
        return new Integer( x + y);
     }

    public static void main( String[] args)  {
        try {
            System.out.println("Starting server on port 8080");
            WebServer addTwoServer = new WebServer(8080);
            addTwoServer.addHandler("examples", new AddServer());
            addTwoServer.start();
            System.out.println("server running");
        }
         catch (Exception webServerStartError) {
            System.err.println( "JavaServer " + webServerStartError.toString());
         }
    }
}
```

Client can access all public instance methods in AddServer

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Example - Client

```
import java.util.*;
import org.apache.xmlrpc.*;

public class XmlRpcExample {
        public static void main (String args[])  {
        try {
            XmlRpcClient xmlrpc =  new XmlRpcClientLite("http://127.0.0.1:8080/");
                    Vector parameters = new Vector ();
            parameters.addElement (new Integer(5) );
            parameters.addElement (new Integer(3) );

            Integer sum = (Integer) xmlrpc.execute("examples.addtwo", parameters);

            System.out.println( sum.intValue() );
        } catch (java.net.MalformedURLException badAddress) {
            badAddress.printStackTrace( System.out);
        } catch (java.io.IOException connectionProblem) {
            connectionProblem.printStackTrace( System.out);
        } catch (Exception serverProblem) {
            serverProblem.printStackTrace( System.out);
        }
    }
}
```


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Consequences

Benefits

Protocol = public methods
Handles the network communications
Handles generation/parsing of messages
Multiple language support
Platform independent
Simple

Drawbacks

Long messages
Limited support for objects

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