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Putting Java to REST

Bill Burke
Fellow, Red Hat
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Agenda

- What is REST?
- Why REST?
- Writing RESTFul Web Services in Java
  - JAX-RS

Speaker’s Qualifications

- RESTEasy project lead
  - Fully certified JAX-RS implementation
- JAX-RS JSR member
  - Also served on EE 5 and EJB 3.0 committees
- JBoss contributor since 2001
  - Clustering, EJB, AOP
- Published author
  - Books, articles

What are the goals of SOA?

SOA Goals

- Reusable
- Interoperable
- Evolvable
  - Versioning
- Governable
  - Standards
  - Architectural Guidelines and Constraints
  - Predictable
- Scalable
- Manageable

What system has these properties?

The Web!

What is REST?

- REpresentational State Transfer
  - PhD by Roy Fielding
- REST answers the questions of
  - Why is the Web so prevalent and ubiquitous?
  - What makes the Web scale?
  - How can I apply the architecture of the web to my applications?

What is REST?

- REST is a set of architectural principles
- REST isn’t protocol specific
    - But, usually REST == REST + HTTP
- A different way to look at writing Web Services
    - Many say it’s the anti-WS-*
    - In my experience, hard for CORBA or WS-* to accept/digest

What is REST?

- Addressable Resources
  - Every “thing” should have a URI
- Constrained interface
  - Use the standard methods of the protocol
  - HTTP: GET, POST, PUT, DELETE, etc.
- Representation Oriented
  - Different applications need different formats (AJAX + JSON
- Communicate statelessly
  - Stateless application scale

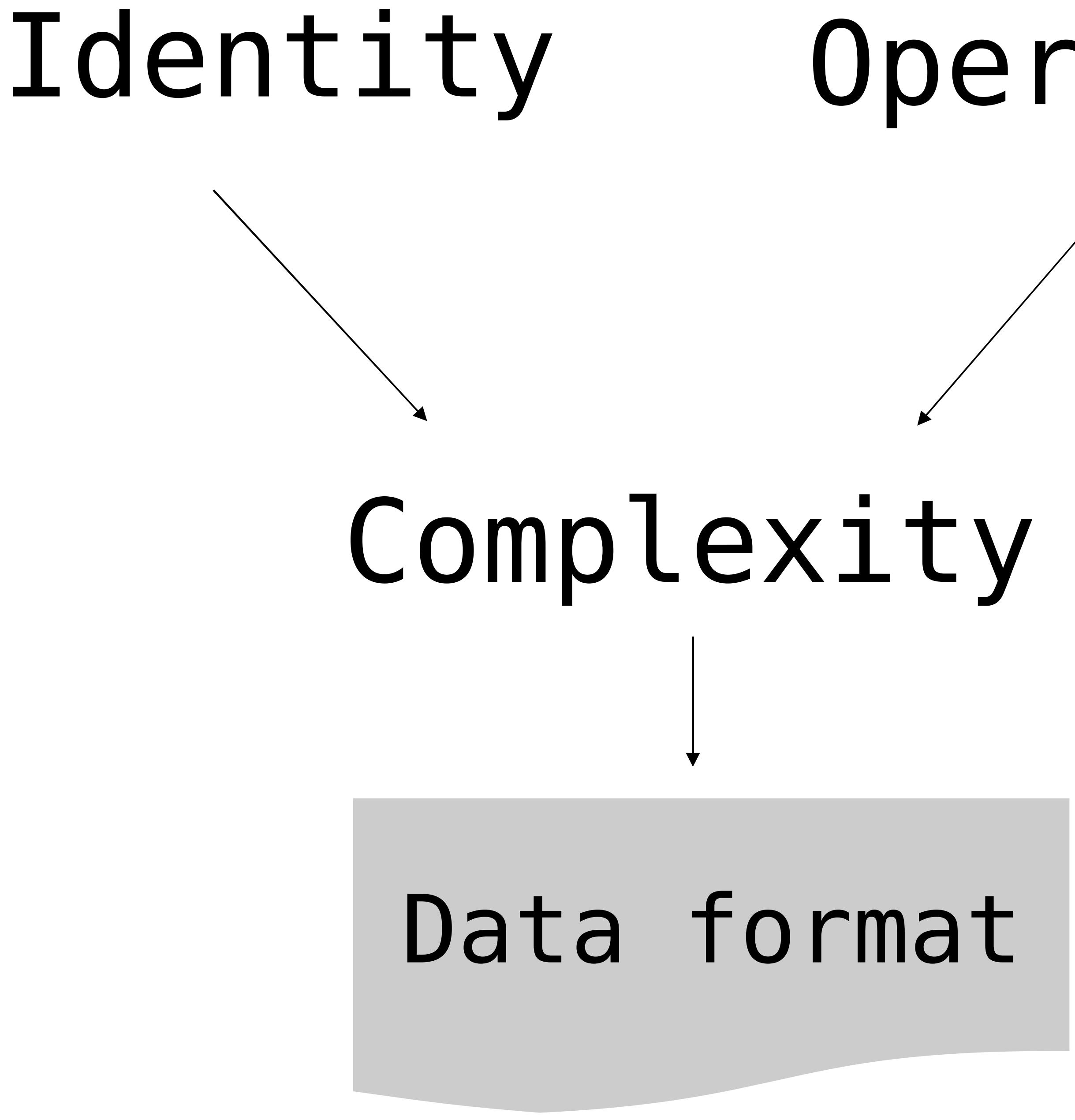
Addressability

- Use URIs
  - Every endpoint/thing has a URI
- Linkability
  - Resource representations have a standardized way of referencing other resource representations
  - Representations have a standardized way to compose themselves:

```
<order id=“111”>
  <customer>http://sales.com/customers/32133</customer>
  <order-entries>
     <order-entry>
        <quantity>5</quantity>
        <product>http://sales.com/products/111</product>
…
```

Constrained, Uniform Interface

- Hardest thing for those with CORBA and/or WS-* baggage to digest
- The idea is to have a well-defined, fixed, finite set of operations
  - Resources can only use these operations
  - Each operation has well-defined, explicit behavior
  - In HTTP land, these methods are GET, POST, PUT, DELETE
- How can we build applications with only 4+ methods?
  - SQL only has 4 operations: INSERT, UPDATE, SELECT, DELETE
  - JMS has a well-defined, fixed set of operations
  - Both are pretty powerful and useful APIs with constrained interfaces


Identity
Operations
Complexity
Data format

Implications of Uniform Interface

- Intuitive
  - You know what operations the resource will support
- Predictable behavior
  - GET - readonly and idempotent. Never changes the state of the resource
  - PUT - an idempotent insert or update of a resource. Idempotent because it is repeatable without side effects.
  - DELETE - resource removal and idempotent.
  - POST - non-idempotent, “anything goes” operation
- Clients, developers, admins, operations know what to expect
  - Much easier for admins to assign security roles
  - For idempotent messages, clients don’t have to worry about duplicate messages.

Implications of Uniform Interface

- Simplified
    - Nothing to install, maintain, upgrade
    - No stubs you have to generate distribute
    - No vendor you have to pay big bucks to
- Platform portability
    - HTTP is ubiquitous. Most popular languages have an HTTP client library
    - CORBA, WS-*, not as ubiquitous
    - (We'll talk later about multiple representations and HTTP content negotiation which also really helps with portability)
- Interoperability
    - HTTP a stable protocol
    - WS-*, again, is a moving target
    - Ask Xfire, Axis, and Metro how difficult Microsoft interoperability has been
    - Focus on interoperability between applications rather focusing on the interoperability between vendors.

Implications of Uniform Interface

- Familiarity
  - Operations and admins know how to secure, partition, route, and cache HTTP traffic
  - Leverage existing tools and infrastructure instead of creating new ones
- Easily debugged
  - How cool is it to be able to use your browser as a debugging tool!

Designing with Uniform Interface

```
public interface BankAccountService {
   Account getAccount(int id);
   void deleteAccount(int id);
   void updateAddress(int acct, Address address);
   void debit(double amount);
   void credit(double amount);

}
```

Designing with Uniform Interface

- /accounts/{acct-id}
  - GET - retrieve representation of account
  - DELETE - remove an account

- Actions become things
- Update Address
  - /accounts/{acct-id}/address
  - PUT new XML representation of address
- Debit/Credit
  - Define a “Account Transaction” XML document
  - /accounts/{acct-id}/transactions
  - POST new XML representation of a credit or debit

Representation Oriented

- URIs point to resources on the network
- Clients and servers exchange representations of a resource through the uniform interface
  - XML documents
  - JSON messages
- This is a familiar data exchange pattern for Java developers
  - Swing->RMI->Hibernate
  - Hibernate objects exchanged to and from client and server
  - Client modifies state, uses entities as DTOs, server merges changes
    - No different than how REST operates
  - No reason a RESTFul webservice and client can’t exchange Java objects!

HTTP Negotiation

- HTTP allows the client to specify the type of data it is sending and the type of data it would like to receive
- Depending on the environment, the client negotiates on the data exchanged
  - An AJAX application may want JSON
  - A Ruby application my want the XML representation of a resource

HTTP Negotiation

- HTTP Headers manage this negotiation
  - CONTENT-TYPE: specifies MIME type of message body
  - ACCEPT: comma delimited list of one or more MIME types the client would like to receive as a response
  - In the following example, the client is requesting a customer representation in either xml or json format

```
GET /customers/33323
Accept: application/xml,application/json
```

  - Preferences are supported and defined by HTTP specification

```
GET /customers/33323
Accept: text/html;q=1.0,
        application/json;q=0.7;application/xml;q=0.5
```

HTTP Negotiation

- Internationalization can be negotiated to
  - CONTENT-LANGUAGE: what language is the request body
  - ACCEPT-LANGUAGE: what language is desired by client

```
GET /customers/33323
ACCEPT: application/xml
ACCEPT-LANGUAGE: en_US
```

Implications of Representations

- Evolvable integration-friendly services
  - Common consistent location (URI)
  - Common consistent set of operations (uniform interface)
  - Slap on an exchange formats as needed
- Built-in service versioning
  - Add newer exchange format as an additional MIME type supported
  - application/vnd.myformat+xml
  - application/vnd.myformat-2+xml
- Internationalization becomes easy for clients
  - Most browsers can configure default ACCEPT-LANGUAGE

Statelessness

- A RESTFul web service does not maintain sessions/conversations on the server
- Doesn’t mean a web service can’t have state
- REST mandates
  - That state be converted to resource state
  - Conversational state be held on client and transferred with each request

Statelessness

- Sessions are not linkable
  - You can’t link a reference to a service that requires a session
- A stateless application scales
  - Sessions require replication
  - A simplified architecture is easier to debug
- Isolates client from changes on the server
  - Server topology could change during client interaction
  - DNS tables could be updated
  - Request could be rerouted to different machines

REST in Conclusion

- REST answers questions of
  - Why does the Web scale?
  - Why is the Web so ubiquitous?
  - How can I apply the architecture of the Web to my applications?
- REST is the Re-birth of HTTP
- Promises
  - Simplicity
  - Interoperability
  - Platform independence
  - Change resistance

JAX-RS

RESTFul Web Services in Java

JAX-RS

- JCP Specification
  - Lead by Sun, Marc Hadley
  - Finished in September 2008
- Annotation Framework
- Dispatch URI’s to specific classes and methods that can handle requests
- Allows you to map HTTP requests to method invocations
- IMO, a beautiful example of the power of parameter annotations
- Nice URI manipulation functionality

JAX-RS Annotations

- @Path
  - Defines URI mappings and templates
- @Produces, @Consumes
  - What MIME types does the resource produce and consume
- @GET, @POST, @DELETE, @PUT, @HEAD
  - Identifies which HTTP method the Java method is interested in

JAX-RS Parameter Annotations

- @PathParam
  - Allows you to extract URI parameters/named URI template segments
- @QueryParam
  - Access to specific parameter URI query string
- @HeaderParam
  - Access to a specific HTTP Header
- @CookieParam
  - Access to a specific cookie value
- Above annotations can automatically map HTTP request values to
  - String and primitive types
  - Class types with String constructor or a static valueOf(String val) method
  - List or Arrays of above types when there are multiple values
- @Context
  - Access to contextual information like the incoming URI

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

JAX-RS Resource Classes

- JAX-RS annotations are used on POJO classes
- The default component lifecycle is per-request
  - Same idea as @Stateless EJBs
  - Singletons supported too
  - EJB integration defined in EE 6
  - Most implementations have Spring integration
- Root resources identified via @Path annotation on class

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

Base URI path to resource

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @ProduceMime(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

Additional URI pattern
that getOrder() method maps to

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

Defines a URI path segment pattern

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

HTTP method Java getOrder() maps to

JAX-RS: GET /orders/3323

What’s the CONTENT-TYPE returned?

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

JAX-RS: GET /orders/3323

```
@Path("/orders")
public class OrderService {

   @Path("/{order-id}")
   @GET
   @Produces("application/xml")
   String getOrder(@PathParam("order-id") int id) {
    …
   }
}
```

Inject value of URI segment
into the *id* Java parameter

JAX-RS: GET /orders/3323

```
@Path(“/orders”)
public class OrderService {

   @Path(“/{order-id : \d+}”)
   @GET
   @Produces(“application/xml”)
   String getOrder(@PathParam(“order-id”) int id) {
    …
   }
}
```

Automatically convert URI string segment into an integer

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JAX-RS: POST /orders

```
@Path(“/orders”)
public class OrderService {

   @POST
   @Consumes(“application/xml”)
   void submitOrder(String orderXml) {
    …
   }
}
```

What CONTENT-TYPE is this method expecting from client?

JAX-RS: POST /orders

```
@Path(“/orders”)
public class OrderService {

   @POST
   @Consumes(“application/xml”)
   void submitOrder(Order orderXml) {
    …
   }
}
```

Un-annotated parameters assumed to be incoming message body. There can be only one!

MessageBodyReader/Writers

- JAX-RS can automatically (un)-marshall between HTTP message bodies and Java types
  - Method return value marshalled into HTTP response body
  - Un-annotated method parameter unmarshalled from HTTP message content
- JAX-RS has built-in MessageBodyReader/Writers
  - JAXB
  - String
  - StreamingOutput
  - byte[], java.io.InputStream, File, Reader
  - Form data
- Application can plug in custom MessageBodyReader/Writers

MessageBodyReader

```
public interface MessageBodyReader<T>
{
 boolean isReadable(Class<?> type,
                      Type genericType,
                      Annotation annotations[]);

 T readFrom(Class<T> type, Type genericType,
            Annotation annotations[],
            MediaType mediaType,
            MultivaluedMap<String, String> httpHeaders,
            InputStream entityStream)
               throws IOException,
                      WebApplicationException;

}
```

MessageBodyWriter

```
public interface MessageBodyWriter<T>
{
  boolean isWriteable(Class<?> type,
                      Type genericType,
                      Annotation annotations[]);

  long getSize(T t);

  void writeTo(T t, Class<?> type, Type genericType,
          Annotation annotations[],
          MediaType mediaType,
          MultivaluedMap<String, Object> httpHeaders,
          OutputStream entityStream)
     throws IOException, WebApplicationException;
}
```

Writing MessageBodyReader/Writer

- Must be annotated with @Provider
- MessageBodyReader must be annotated with @Consumes
  - To specify which MIME types it can convert to Java objects
- MessageBodyWriter must be annotated with @Produces
  - To specify which MIME types it can marshal Java objects to

Example MessageBodyReader

```
@Provider
@Consumes(“application/xml”)
public class JAXBProviderReader implements
                            MessageBodyReader
{
  boolean isReadable(Class<?> type,
                      Type genericType,
                      Annotation annotations[])
  {
      return type.isAnnotationPresent(
                      XmlRootElement.class);
  }

  …
}
```

Example MessageBodyReader

```
Object readFrom(Class<Object> type, Type genericType,
          Annotation annotations[], MediaType mediaType,
          MultivaluedMap<String, String> httpHeaders,
          InputStream entityStream)
    throws IOException, WebApplicationException   {
 try {
     JAXBContext jaxb = JAXBContext.newInstance(type);
     Object obj =
       jaxb.createUnmarshaller().unmarshal(inputStream);

       if (obj instanceof JAXBElement)
          obj = ((JAXBElement) obj).getValue();

       return obj;
    } catch (JAXBException e){
       throw new RuntimeException(e);
    }
 }
}
```

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Default Response Codes

- HTTP 1.1 specification defines response codes
- GET, DELETE and POST
  - 200 (OK) if content sent back with response
  - 204 (NO CONTENT) if no content sent back

Response Object

- JAX-RS has a Response and ResponseBuilder class
  - Customize response code
  - Specify specific response headers
  - Specify redirect URLs
  - Work with variants

```
@GET
Response getOrder() {
   ResponseBuilder builder =
        Response.status(200, order);
   builder.type(“text/xml”)
          .header(“custom-header”, “33333”);
   return builder.build();
}
```

JAX-RS Content Negotiation

- Matched up and chosen based on request ACCEPT header
  - Accept: application/json;q=1.0,application/xml;q=0.5

```
@GET
@Produces(“application/xml”)
String getXmlOrder() {…}

@GET
@Produces(“application/json”)
String getJsonOrder() {…}
```

ExceptionMappers

- Map application thrown exceptions to a Response object
  - Implementations annotated by @Provider

```
public interface ExceptionMapper<E>
{
   Response toResponse(E exception);
}
```

RESTFul Java Clients

RESTFul Java Clients

- java.net.URL
  - Ugly, buggy, clumsy
- Apache HTTP Client
  - Full featured
  - Verbose
  - Not JAX-RS aware (MessageBodyReaders/Writers)
- Jersey and RESTEasy APIs
  - Similar in idea to Apache HTTP Client except JAX-RS aware
- RESTEasy Client Proxy Framework
  - Define an interface, re-use JAX-RS annotations for sending requests

RESTEasy Client Proxy Framework

```
@Path(“/customers”)
public interface CustomerService {

   @GET
   @Path(“{id})
   @Produces(“application/xml”)
   public Customer getCustomer(
         @PathParam(“id”) String id);
}


CustomerService service =
        ProxyFactory(CustomerService.class,
                       “http://example.com”);

Customer cust = service.getCustomer(“3322”);
```

JAX-RS Example

Seeing it in action

RESTful JMS Facade

- Let’s define a simple RESTFul façade over a JMS queue
  - Store and forward asynch HTTP messages
- Work through REST resource design decisions
  - Introduce some new RESTful concepts
- Work through JAX-RS class design decisions
  - Introduce some other JAX-RS features

RESTFul Interface

- Sending a message to a queue
- Receiving a message from the queue

```
POST /queues/{queue-name}?persistent=true

GET /queues/{queue-name}
```

JAX-RS Implementation

```
@Path(“/queues/{name}”)
public interface QueueService {

   @POST
   public void send(
           @PathParam(“name”) destination,
           @QueryParam(“persistent”)
               @DefaultValue(“true”) boolean persistent
           @Context HttpHeaders headers,
           InputStream body);



   @GET
   public Response receive(
           @PathParam(“name”) destination);

}
```

JAX-RS Implementation

```
@Path(“/queues/{name}”)
public interface QueueService {

   @POST
   public void send(
           @PathParam(“name”) destination,
           @QueryParam(“persistent”)
               @DefaultValue(“true”) boolean persistent
           @Context HttpHeaders headers,
           InputStream body);



   @GET
   public Response receive(
           @PathParam(“name”) destination);

}
```

Default value for an optional URI query parameter

JAX-RS Implementation

```
@Path("/{division}/queues/{name}")
public interface QueueService {

   @POST
   public void send(
           @PathParam("division") String division,
           @PathParam("name") destination,
           @QueryParam("persistent")
               @DefaultValue("true") boolean persistent
           @Context HttpHeaders headers,
           InputStream body);



   @GET
   public Response receive(
           @PathParam("name") destination);
}
```

Access to all headers so we can forward them to receiver

Improvements to Send: Return created resource

- When creating with a POST common pattern is to redirect to the created resource
- Status code 201 (Created)
- Redirect to a resource representing the message
  - Location: /queues/myQueue/messages/3334422
  - Subresources of this URI could be used to find out status of message

Improvements to Send: Return created resource

```
@POST
public Response send(
           @PathParam(“name”) destination,
           @QueryParam(“persistent”)
               @DefaultValue(“true”) boolean persistent
           @Context HttpHeaders headers,
           @Context UriInfo uriInfo,
           InputStream body) {

      … create and post JMS message …

      URI messageUri = uriInfo.getAbsolutePathBuilder()
             .path(jmsMessage.getMessageID()).build();

      return Response.created(messageUri).build();
}
```

Improvements to Send: PUT instead of POST

- What happens if there is a network failure during a client send of a message?
  - Client doesn't know if message successfully posted or not
  - It may up sending a duplicate message
  - POST is not idempotent
- Lets use PUT
  - Client generates unique message id
  - PUT /queues/{name}/messages/{message-id}
  - If a failure during PUT, resend
  - If message of that ID already there, no worries

GET not Appropriate

- HTTP 1.1 specification says GET is idempotent
  - Receiving messages with GET is not idempotent
  - It is changing the state of the resource
  - It is reading a message, but also consuming the queue
- Use POST for receiving

GET not Appropriate

- Problem, we are already are using POST for this resource
- Overload it?
  - POST /queues/{name}?action=[send|receive]
  - Ugly, it’s a mini RPC
  - Doesn’t map well to JAX-RS anyways
- When in doubt, create a resource
  - POST /queues/{name}/receiver

One JAX-RS class not good design

- Finding JMS ConnectionFactory and Destination not portable
- Separate finding the Destination from sending/receiving
- JAX-RS allows this through Subresources and Subresource Locators
  - One object processes part of the request
  - Another object finishes the request

JAX-RS Implementation

```
@Path(“/queues”)
public class JBossDestinationLocator {

   @Path(“/{name}”)
   public QueueService findDestination(
              @PathParam(“name”) String name) {
       Destination destination = … find it …;
       return new QueueService(destination);
   }
}
public class QueueService {
   public QueueService(Destination dest) {…}

   @POST
   public void send(…) {}

   @Post
   @Path(“/receiving”)
   public Response receive(…) {…}
}
```

Why is this cool?

- Platform independence
  - Can a Python client post messages?
  - Can a Ruby client receive messages?
  - Can a Java client post messages to a C++ receiver?
- Lightweight
  - Clients only need an HTTP library to use the queue

JAX-RS Implementations

- JBoss RESTEasy
  - http://jboss.org/resteasy
  - Embeddable
  - Spring and EJB integration
  - Client Framework
  - Asynchronous HTTP abstractions
- Jersey
  - Sun reference implementation
  - WADL support
- Apache CXF
- RESTLet

References

- Links
  - http://jsr311.dev.java.net/
  - http://jboss.org/resteasy
  - http://rest.blueoxen.net/
  - http://java.dzone.com/articles/intro-rest
  - http://architects.dzone.com/articles/putting-java-rest
- Books
  - Coming this fall “RESTFul Java” by me
  - O’Reilly’s “RESTful Web Services”
  - http://oreilly.com/catalog/9780596529260/

QUESTIONS?

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