Pieces of the puzzle

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Pieces of the puzzle so far

- Google AppEngine/GWTJ: a platform for cloud computing.
- Map/Reduce: a core technology of cloud computing.
  - Google Map/Reduce
    - closed system
    - real-time queries
    - Can specify custom map operations (slowly).
    - Only one kind of reduce (collect).
  - Hadoop Map/Reduce
    - Open system
    - Specify map/combine/reduce operations.
    - Not real-time.
    - Requires another piece to expose data.

Some missing pieces

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Some missing pieces

- From Hadoop to applications.
  - How to store massive M/R computations.
  - The concept of a service.
- The hidden role of business logic.
  - Why clouds are important.

A rather important missing piece.

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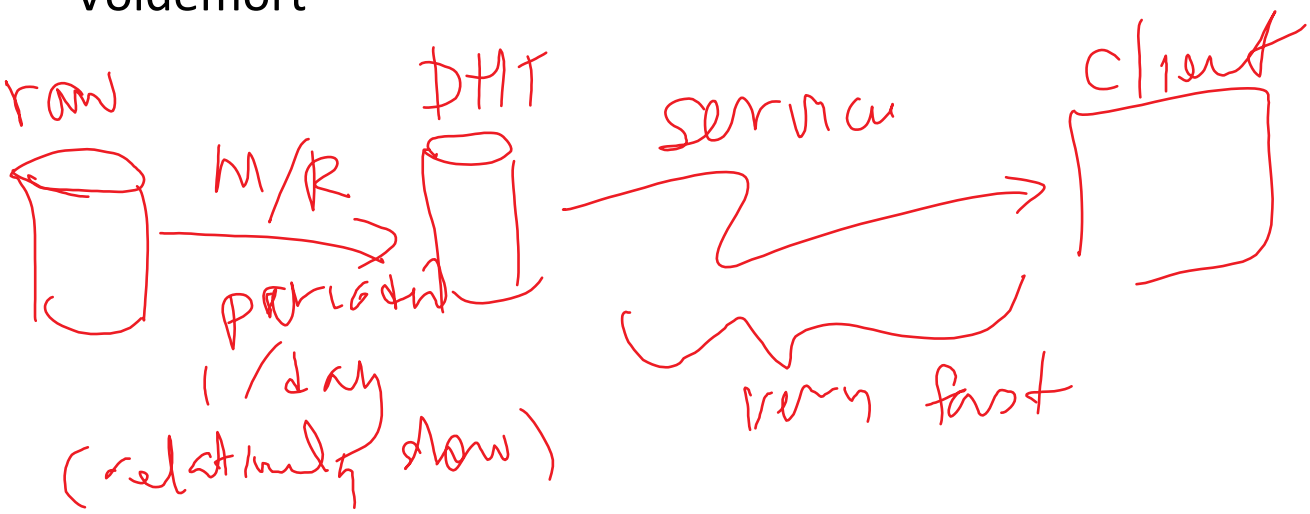
A rather important missing piece

- Hadoop Map/Reduce is not a real-time technology.
- Instead, we feed Map/Reduce output into an object store.
- This is typically a Distributed Hash Table (DHT).
  - Dynamo
  - Voldemort



Thinking cloudily

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You might expect that in thinking about clouds, you would have a cloudy perspective!

- Clouds are about **closing boxes** and **keeping them closed.**
- Cloud abstractions allow us **not** to know things.
- Skill of doing this relies upon a new way of approaching programming.

How this lecture came about

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I was all set to bury you in details of SOAP.
I quickly decided that everything I wanted to tell you was **irrelevant**, **useless**, and **peripheral**!
I had to function at a completely **new level of abstraction.**

The real truth about clouds:

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The old-style programmer can't program the cloud. My generation has difficulty.
The new-style programmer approaches the cloud differently, by being able to close boxes and keep them closed.
The next-generation programmer is not going to be concerned with boxes, but instead, with patterns, best practices, and "technological shamanism".

Patterns and rituals

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A good example is not a pattern

- A pattern contains detail about limits and scope.
- An example is a "ritual": do this, get that.

Abstraction botches

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Abstraction botches

An **abstraction botch** occurs when the choice of level of abstraction is so wrong that it limits either functionality or further development.

The worst abstraction botch…

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The worst abstraction botch…

… is to write code that only works for one vendor/platform/configuration.

… so you're trapped into using them, forever!

The "wrong" way to implement JDO:

write it to write and read directly from Oracle10g, mysql, etc. Oracle would **really** like you to do this!

The "right" way to implement JDO:

use an **abstraction layer** that can run it on top of any grid-enabled datastore, regardless of who wrote it!

There is a business case for appropriate layering of abstraction… because you aren't locked into one vendor.

Don't pay any attention…

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Don't pay any attention to that man behind the curtain!

- (Wizard of OZ)
- Cloud programming is about **using strategic abstraction to hide details.**
- There is danger in even looking behind the curtain:
  - It isn't empowering.
  - It is hopelessly confusing.
- Cloud programming requires a different way of thinking.

Two schools of programming...

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Two schools of programming...

- The **old school** of programming: you **must know** exactly what your program is doing, or "you'll be sorry".
  - Avoid abstractions.
  - Use operational semantics (what something does is defined through **exactly how it does it**).
- The **cloud school** of programming: you **don't need to know** exactly what is happening; only that at some level, your program's **behavior is predictable.**
  - Embrace abstractions.
  - Use axiomatic semantics and/or contracts (what something does is defined through **external invariants** of its behavior).

Implementing a service

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Implementing a service

- Figure out what it is supposed to do.
- Implement basic code that does it.
- Embed this inside a web server, somehow.

Example: location awareness:

- what it should do: take in IP address, output <lat,long>
- how it should do it: look up IP address in a datastore.
- how to embed this inside a web server?

Service Architecture

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Service Architecture

- Two parts to a service
  - How it's implemented, e.g., via a datastore back-end.
  - How it's requested and responds.
- Key to service programming
  - I specify how it's implemented.
  - Interface to the outside world is generated.

SOAP

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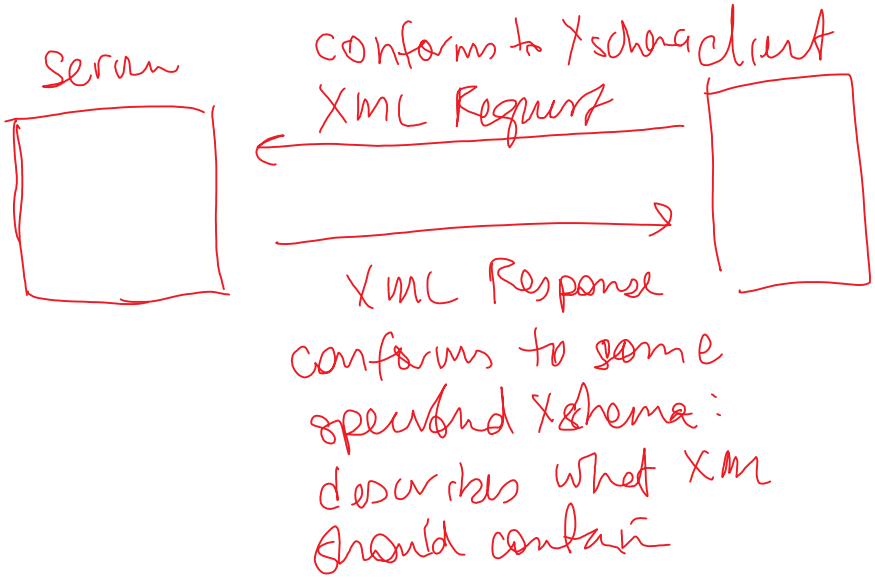

SOAP:

- checks that input schema is correct
- calls some server
- checks that output is correct

Slightly more detailed model

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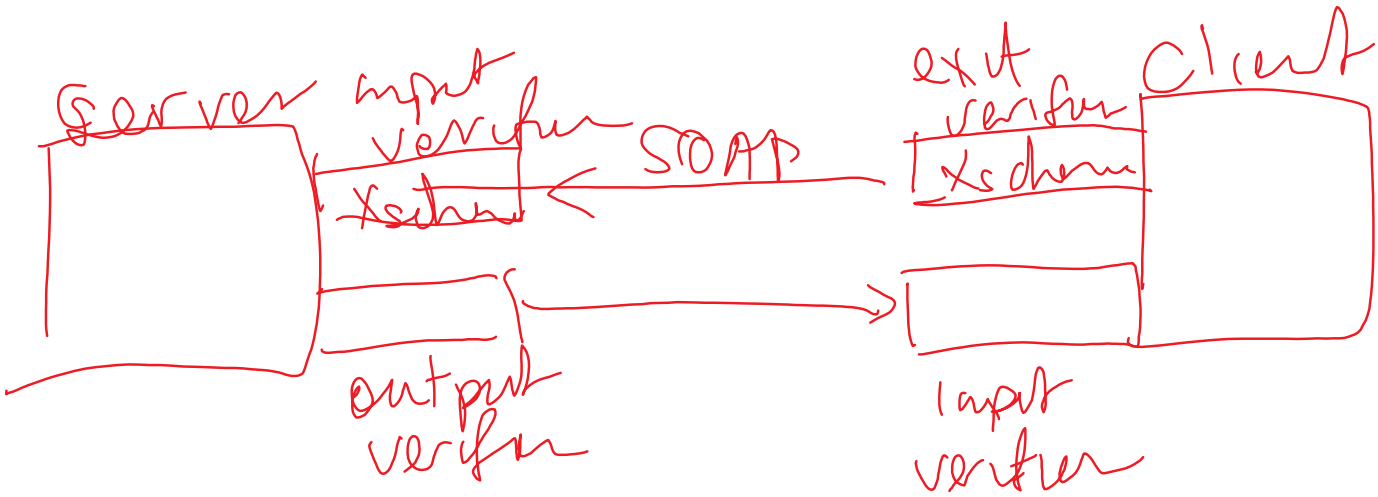

A SOAP request is described as a series of verifications,
a HUGE amount of plug-and-chug programming.

Three kinds of "services"

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Three kinds of "services"

- Remote procedure call.
- SOAP/REST (web) service.
- Servlets

Remote Procedure Calls

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Remote Procedure Calls

- Client requests data from server.
- Server replies to client.
- Utilizes a **portable data format** that is assured to mean the same thing on client and server.
- Most common format: XML-RPC.

Other interesting formats

- Native RPC
- Google protocol buffers.

SOAP and REST

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SOAP: Simple object access protocol

- Client sends XML "request" to server.
- Server responds with XML to client.
- XML Schemas determine legal inputs and outputs.

REST: Representative State Transfer

- Client sends a request to a specific URL with embedded CGI data.
- Server responds with XML or plaintext.
- Service is invoked via a regular webserver URL.
  - www.customer.com/invoice/54/paid=true

Choosing the format of a service

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Choosing the format of a service

Servlets: most suitable for services that output end-user data.

REST: most suitable for services whose input is simple and whose output is used by other parts of an application.

SOAP: best for complex inputs and outputs.

SOAP and Axis

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SOAP and Axis

- Basic SOA building block: Simple Object Access Protocol (SOAP)
- Apache Axis: builds SOAP services from Java code.
- You specify a plain-old-java class.
- Axis translates this into a web service.

(End of lecture on 3/9/2011)

What SOAP does

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SOAP is:

- A request/response protocol.
- Request and response are coded as XML, validated through XML schemas.

Components of a SOAP request:

- An XML schema for valid input.
- XML input conforming to the schema.

Components of a SOAP response:

- An XML schema for valid output.
- XML output conforming to the schema.

A SOAP service

- Receives requests conforming to the input schema.
- Generates responses conforming to the output schema.

Developing SOAP the old way

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Developing SOAP the old way: "top-down"

- Define input schema.
- Define output schema.
- Define request handler for the schema, that generates appropriate output for each input.
- Define client that calls the request handler and encodes data according to the schema.
- Zzzz...

Bottom-up service development

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The new world order: **bottom-up service development**

- Start by defining Plain Old Java Objects (POJOs) that you want to turn into web services, e.g., that read Hadoop HDFS files.
- **Generate** XML Schemas, service stubs, etc using a **service deployment framework**, e.g., Apache Axis 2.
- **Don't even learn** XML or Schemas! The framework handles all of that!

Service deployment frameworks

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Service deployment frameworks

- Manage "deployment" of a service.
- Require only minimal input from you.
  - Java Code to deploy.
  - Some configuration options.
- Result: a running service.

Deployment and code generation

- A deployment framework is not a code generator.
- The XML schemas for your service aren't even stored.
- Instead, they are generated from Java code through inspection when they are needed.

Apache Axis 2

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Apache Axis 2

- Built on top of the Apache Tomcat Java Servlet Engine.
- Supported in native Eclipse J2EE edition
  - (without plugins, but you do have to download local copies of Apache Tomcat and Axis and get them running and bound into Eclipse).
- Takes plain old java objects (POJOs) as input.
- Generates service and client code that treats POJOs as services!

Using Axis

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Using Axis

Define a simple service as a java class.
Tell Axis it should become a service.
"Package" the service.
"Deploy" the service.
Reference: http://wso2.org/library/95

Defining a service

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```
/**
* The service implementation class
*/
public class SimpleService {
    public String echo(String value) {
        return value;
    }
}
```

Pasted from <http://wso2.org/library/95>

Informing Axis of the service

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Informing Axis of the service: services.xml

```
<service>
    <parameter name="ServiceClass"
        locked="false">SimpleService</parameter>
    <operation name="echo">
        <messageReceiver
        class="org.apache.axis2.rpc.receivers.RPCMessageReceiver"/>
    </operation>
</service>
```

Pasted from <http://wso2.org/library/95>

Packaging the service

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Packaging the service

Axis expects service files to be found in a specific directory hierarchy.

Creating the hierarchy:

```
mkdir temp
javac SimpleService.java -d temp/
mkdir temp/META.INF
cp services.xml temp/META.INF/
cd temp
jar -cvf SimpleService.aar *
```

Deploying the service

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Deploying the service

Choose a web server platform (e.g., Apache Tomcat+Axis2 or SimpleHTTPserver + Axis2) (Instructions differ.)

Simplest deployment: SimpleHTTPserver included with Axis2.

Using SimpleHTTPServer

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Using SimpleHTTPServer

- Create a "repository" axis2-repo containing
  - `conf` subdirectory containing `axis2.xml`
  - empty `modules` subdirectory (contains jars that your code might need).
  - `services` directory containing `SimpleService.aar`
- Run the SimpleHTTPserver:

```
sh http-server.sh /path/to/axis2-repo
```

Now things get interesting…

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Now things get interesting…

Axis2 Services are **reflective**, i.e., they are self-describing on the web.

If one runs the SimpleHTTPserver and browses to
http://localhost:8080/services/SimpleService
one gets a description of the service and even how to use it.

Weird: one has to have the service **running** before one can **build a client** to it.

Creating a client

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Creating a client

Client code is generated by querying the reflection interface for a **running service**! (It doesn't matter how you wrote the service)

```
sh WSDL2Java.sh -uri \\
   http://localhost:8080/axis2/services/SimpleService?wsdl \\
   -o /path/to/my/client/code/
```

This generates code in the Axis2 hierarchy that calls the service.

It can be run on a **different host** than the host on which the service was developed!

It can be written in a different language.

Querying via generated code

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```
// SimpleServer.echo corresponds to
// SimpleServiceStub.EchoResponse
// in generated code.

package org.apache.axis2;

import org.apache.axis2.SimpleServiceStub.EchoResponse;

public class Client {
   public static void main(String[] args) throws Exception {
      SimpleServiceStub stub = new SimpleServiceStub();

      //Create the request
      SimpleServiceStub.Echo request = new SimpleServiceStub.Echo();
      request.setParam0("Hello world");

      //Invoke the service
      EchoResponse response = stub.echo(request);
      System.out.println("Response : " + response.get_return());
   }
}
```

class SimpleServer

public echo()

real call

Pasted from <http://wso2.org/library/95>

So, what have we done?

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So, what have we done?

On our server:

- We provided a Plain Old Java Object (POJO).
- Server-side Axis implemented a web service based upon it.

Meanwhile, halfway around the world (or on Mars):

- Client-side Axis implemented a client stub class that calls it.
- We wrote a client that calls the stub.

Neither side cares even **whether the other is using Axis!**

WSDL and WSAPI

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But wait, there's more! (how much would you pay?)

- Axis provides for free:
  - WSDL: a definition of your service in a standard form.
  - WSAPI: a standard for inspecting a service.
- But these represent a dream that never happened!

The dream of Service Oriented Architectures

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The dream of Service-Oriented Architectures

- There will be a "**service marketplace**".
- Companies will **compete** to provide services.
- We'll **dynamically bind to services** based upon price;
  - ("if it's Tuesday, we'll use google maps, but on Thu, we'll use MapQuest!")
- Application programs will intelligently choose between services dynamically.
- Not.

Problems with the dream

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Problems with the dream:

- Trust: can we trust the vendor to be honest?
- Ontology: can we trust the vendor to even use the same language as us?

The problem of trust

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The problem of trust

- Can you trust your service provider to be honest?
- Can you trust your service provider to keep providing?
  - Case law: no, you can't.
- What guarantees do you get from the provider?
  - Case law: don't believe them.

The problem of ontology

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The problem of ontology

- Vendors describe the same things with different words

Location service 1:

- Input: **ADDRESS**
- Output: **Lat, Long**

Location service 2:

- Input: **IP**
- Output: **Latitude, Longitude**

How do we know these are the same?

This problem really comes into its own when one is trying to communicate business-critical, legal, or medical concepts!

What is an ontology?

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What is an ontology?

A taxonomy is a mapping from names to things.

Each web service has its own taxonomy, as expressed by its API (WSDL).

An **ontology** is a **mapping between taxonomies**.

E.g., to solve the problem on the previous page:

"IP" is an address in one taxonomy.

"ADDRESS" is an address in the other.

An ontology must relate "IP" <-> "ADDRESS"

Beyond WSAPI

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Beyond the service marketplace:

- One buys a "service stack" consisting of a set of interoperating services.
- One vendor, explicit contract.
- No dynamic switching.