Distribution and Integration Technologies

XML Web Services

- A web service is a set of methods, usually in a class, accessible and invoked using web technologies
  - Can be used in an intranet or in the internet
- Usually
  - Web methods are invoked using an OO language like C# or Java
  - The web technology used for invocations is SOAP (Simple Object Access Protocol) over HTTP
- Almost all development platforms support Web Services nowadays (both as servers as well as clients)

Involved Technologies

- Simple Object Access Protocol (SOAP)
  - A protocol for coding the invocation and response messages using an XML schema
- Web Services Description Language (WSDL)
  - A language for Web Services description and specification, also using XML
    - Methods, Types, Parameters, Responses, URLs
- Universal Description, Discovery and Integration (UDDI) server
  - Also called the Web Services yellow pages, implemented as a Web Service (optional and seldom used)

General Architecture

- UDDI
  - Services Directory
    - Supplies
      - (SOAP protocol)
    - Consults
      - (SOAP protocol)
  - Service Description
    - Uses for proxy building
    - Generates
    - Document WSDL
  - Service Consumer
    - Client
  - Service Supplier
    - Server
    - (SOAP over HTTP)
Web Services – Discovery and Use

The Web of Services (SOA)

Invocation and response

Description: WSDL

- Document using an XML format
  - Schema approved by the World Wide Web Consortium (W3C)
  - Followed by all the players in the Web Services communities
    - The Web Services containers generate this document
    - The proxy build tools read it
- Contains
  - Type descriptions for parameters and results
  - Invocation ports and addresses
  - Available methods
  - Format for invocation and response
Encoding: SOAP

- The SOAP protocol is used in invocations
  - Uses an XML format for parameters and result values
- The SOAP request/reply messages can be transported using:
  - HTTP
    - The most common transport protocol
  - SMTP or MSMQ
    - Can be used in less interactive applications
  - Other protocols
- Globally supported and implemented
  - Microsoft, IBM, Oracle, BEA, Iona, and many others ...
- Independent
  - From the operating system, languages, object models, etc
  - Supports synchronous and asynchronous calls

General Format of a SOAP Message

*Envelope*
*Headers*

*Body*
*Method*
*Parameters*

Headers are used in specifications that increase the basic Web Services functionalities. Some of those specifications (approved by W3C or other organizations) are implemented by several framework suppliers, that make efforts to make them interoperable.

Some of those specifications are:
- WS-Attachments
- WS-ReliableMessaging
- WS-Security
- WS-Addressing
- WS-Referral
- WS-Routing
- WS-AtomicTransaction
- WS-SecureConversation
- Other protocols

Globally supported and implemented
- Microsoft, IBM, Oracle, BEA, Iona, and many others ...
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SOAP Messages over HTTP

Request:

```
POST /AccountAccess HTTP/1.1
Host: www.qwickbank.com
Content-Type: text/xml; charset="utf-8"
Content-Length: 305

<SOAP-ENV:Envelope
  xmlns:SOAP-ENV = "http://schemas.xmlsoap.org/soap/envelope/"
  SOAP-ENV:encodingStyle = "http://schemas.xmlsoap.org/soap/encoding/">
  <SOAP-ENV:Body>
    <m:GetBalance
      xmlns:m="http://www.qwickbank.com/bank">
      <Account>729-1269-4785</Account>
    </m:GetBalance>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Reply:

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset="utf-8"
Content-Length: 304

<SOAP-ENV:Envelope
  xmlns:SOAP-ENV = "http://schemas.xmlsoap.org/soap/envelope/"
  SOAP-ENV:encodingStyle = "http://schemas.xmlsoap.org/soap/encoding/">
  <SOAP-ENV:Body>
    <m:GetBalanceResponse
      xmlns:m="http://www.qwickbank.com/bank">
      <Balance>3,822.55</Balance>
    </m:GetBalanceResponse>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

ASMX Web Services in .NET

```
class X {
    [WebMethod]
    public int Method1() {
        ...
    }
}
```
Client Proxy and Container Intervention

Client
Calc c = new Calc();
int sum = c.Add(2, 4);

Proxy
acmemath.com

Container

IIS

SOAP

ASMX

Handler

Calc

Client and Proxy

Command line tool for the generation of a proxy class: wsdl
> wsdl http://localhost/WS/Calc.asmx

class CalculatorWebService
string Url
int Timeout (default 100000 ms) (∞ = Timeout.Infinite)

csc /t:exe CalcClient.cs calc.cs

Web Services in IIS

IIS
directory - URL

bin
calc.dll
calc.asmx

<%@ WebService class="CalcWS.Calculator" %>

Presentation of a WS from IIS

Client and Proxy

using System;
using System.Web.Services;

namespace CalcWS {
    [WebService(Namespace="http://fe.up.pt/apm/webservices/",
        Name="Calculator Web Service",
        Description="Provides simple remote methods for several calculations")]
    public class Calculator {
        [WebMethod(Description="Returns the square root of a number")]
        public double Sqroot(double value) {
            double res = Math.Sqrt(value);
            return res;
        }

        [WebMethod(Description="Determines the maximum and minimum of an array of numbers")]
        public int Maxmin(double[] vals, ref double mx, ref double mn) {
            int k, len;
            mx = mn = 0;
            len = vals.Length;
            if (len > 0) {
                mx = mn = vals[0];
                for (k = 1; k < len; k++)
                    if (vals[k] > mx)
                        mx = vals[k];
                    else if (vals[k] < mn)
                        mn = vals[k];
            }
            return len;
        }
    }
}

using System;
using System;

namespace CalcWS {
    [WebService(Namespace="http://fe.up.pt/apm/webservices/",
        Name="Calculator Web Service",
        Description="Provides simple remote methods for several calculations")]
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                        mn = vals[k];
            }
            return len;
        }
    }
}
XML Web Services in Java EE

- Hosted in a web server capable of executing the web technologies defined in Java EE (web container)
- Created in a "web project" (.war), configured with a deployment descriptor and manifest (XML)
- Can be created and made available from
  - Java classes defined as resources of a web application, using 'annotations' (after version Java EE 5 and JAX-WS)
  - session EJBs
- From the WSDL document proxies can be created in
  - 'standalone' Java SE applications
  - Enterprise Clients
  - Web applications (these run inside an application server)
  - EJBs
- Available in Apache Tomcat
- Also available in any application server (Glassfish, JBoss, Websphere, Weblogic, etc)

Java Tools

- Netbeans
  - Has wizards aiding the creation of web services, methods, input parameters and return type
  - Facilities to deploy in a web container supported by the IDE
  - Contains Apache Tomcat e Glassfish Application Server test versions
  - Has a wizard for the proxy generation in applications
  - Has a wizard for generating the method calls in Web Services

Web Service and Invocation in Java

```java
@WebService()
public class WSAdder {

    /**
     * Web service operation
     */
    @WebMethod( operationName = "add" )
    public double add( @WebParam( name = "a" ) double a,
                      @WebParam( name = "b" ) double b ) {
        double c = a + b;
        return c;
    }
}
```

```java
try {
    ws.WSAdderService service = new ws.WSAdderService( );
    ws.WSAdder port = service.getWSAdderPort( );
    double a = 2.3d;
    double b = 5.5d;
    double result = port.add( a, b );
    System.out.println( "Result = " + result );
} catch ( Exception ex ) {
    ex.printStackTrace( );
}
```