Providing RPG Web Services on IBM i

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"A computer once beat me at chess, but it was no match for me at kick boxing." — Emo Philips

Our Agenda

Agenda for this session:

1. Introduction
   • What's a web service?
   • Why web services?
   • Types (REST/soap/XML/JSON)

2. SOAP web service with IBM's IWS

3. REST web service with IBM's IWS

4. Writing your own from the ground-up with Apache.

5. Discussion/wrap-up
I am a Web Service. What Am I?

A routine that can be called over a TCP/IP network.

- A callable routine. (Program? Subprocedure?)
- Callable over a TCP/IP Network. (LAN? Intranet? Internet?)
  ....can also be called from the same computer.
- Using the HTTP (or HTTPS) network protocol

Despite the name, not necessarily "web"

- different from a "web site" or "web application"
- input and output are via "parameters" (of sorts) and are for programs to use. No user interface -- not even a browser.
- can be used from a web application (just as an API or program could)
  either from JavaScript in the browser, or from a server-side programming language like RPG, PHP, .NET or Java
- but is just as likely to be called from other environments... even 5250!

Write Once, Call From Anywhere

In other words... Services Oriented Architecture (SOA).

- Your business logic (business rules) are implemented as a set of "services" to any caller that needs them.
- Web services are only one of many ways to implement SOA. Don't believe the hype!

Callable from anywhere

- Any other program, written in (just about) any language.
- From the same computer, or from another one.
- From the same office (data center), or from another one.
- From folks in the same company, or (if desired) any of your business partners. Even the public, if you want!

RPG can function as either a provider (server) or a consumer (client)

...this session focuses on providing.
What is a Web Service?

A “program call” (or subprocedure call) that works over the Web.

• Very similar in concept to the CALL command.
  
  ```call
  call pgm(exchrate) parm('us' 'euro' &dollars &euros)
  ```

• Runs over the Web, so can be called from programs on other computers anywhere in the world.

• Maybe a web front-end?
  
  • (Java, .NET, PHP, JavaScript framework, even another RPG.)

• Maybe a thick-client program (windows program, mobile app, etc.)

To be called from a program

Designed to be called from other programs, instead of interfacing directly with the user.

• Web services do not display a screen, or prompt a user

• All input comes from “parameter” data.

• All output is sent via “parameter” data

• Often referred to as an “API”
How Do They Work?

HTTP starts with a request for the server
- Can include a document (XML, JSON, etc)
- Document can contain "input parameters"

HTTP then runs server-side program
- input document is given to program
- HTTP waits til program completes.
- program outputs a new document (XML, JSON, etc)
- document contains "output parameters"
- document is returned to calling program.

REST vs SOAP

SOAP: "Simple Object Access Protocol"
The "old" way. Not as common anymore, but has some advantages.
- URL identifies the web services server
- Input/output documents are always XML in SOAP format
- The "verb" (or action to perform) is given in a separate "soap-action" keyword.
- An accompanying WSDL document describes the SOAP details, including networking details and schema
- Much more complex than REST, but…
- Many more tools are available (vs REST) which can make SOAP easier to code than REST.

REST: "REpresentative State Transfer"
The "new" way. Most new web services use this method.
- URL identifies a “resource” to work with.
- Input/output documents may be in any format. (Most commonly XML or JSON)
- Often, all input is within the URL
- Technically, the HTTP method should be the “verb” (type of action to take), but many web services do not use this approach, and still refer to themselves as REST
- Much simpler/runs faster than SOAP.
**XML vs. JSON**

Both XML and JSON are widely used in web services:
- Self-describing
- Can make changes without breaking compatibility
- Available for all popular languages / systems

XML:
- Has schemas, namespaces, transformations, etc.
- Has been around longer.
- Only format supported in SOAP

JSON:
- Natively supported by all web browsers
- Results in smaller documents (means faster network transfers)
- Parses faster.

**JSON is "Taking Over"**

In a 2013 study done by the ProgrammableWeb (web service directory and community), we can see JSON growing while XML is declining.

As a percentage of the overall directory (left) XML is higher, but it's close.

For new APIs, JSON is much higher
Without Adding Spacing for Humans

In this simple "textbook" example, that's a 35% size reduction.

50 bytes doesn't matter, but sometimes these documents can be megabytes long – so a 35% reduction can be important.

...and programs process JSON faster, too!
IBM's Integrated Web Services Server

IBM provides a Web Services tool with IBM i at no extra charge!

The tool takes care of all of the HTTP and XML work for you!

It's called the Integrated Web Services tool.

http://www.ibm.com/systems/i/software/iws/

- Can be used to provide web services
- Can also be used to consume them -- but requires in-depth knowledge of C and pointers -- I won't cover IBM's consumer tool today.

Requirements:
- IBM i operating system, version 5.4 or newer.
- 57xx-SS1, opt 30: QShell
- 57xx-SS1, opt 33: PASE
- 57xx-JV1, opt 8: J2SE 5.0 32-bit (Java)
- 57xx-DG1 -- the HTTP server (powered by Apache)

Make sure you have the latest cum & HTTP Sever group PTFs installed.

Let's Get Started!

The HTTP server administration tool runs in a special HTTP server called *ADMIN, and you use it from your browser.

- If this isn't already started, you can start it with:
  STRTCPSVR SERVER(*HTTP) HTTPSVR(*ADMIN)
- Point browser at:
  http://your-system:2001/
- Sign-in
- Click “Internet Configurations” (if IBM i 6.1 or higher)
- Click “IBM Web Administration for i”
IBM Navigator for i

Welcome to the IBM Navigator for i

IBM Navigator for i provides an easy-to-use interface for the web-enabled IBM i management tasks, including all previous IBM i Navigator tasks on the web, and 2001 port tasks.

To see the previous version of the 2001 port tasks and where they are located now, click below:

IBM Navigator for i

Click “Internet Configurations”

Internet Configurations

IBM Web Administration for i

IBM i Internet Configurations allows you to perform internet configuration tasks.

IBM Web Administration for i

Allows you to manage and configure HTTP servers and application servers.

Digital Certificate Manager

Allows you to create, distribute, and manage Digital Certificates.

IBM i IPP Server for i

Allows you to configure the IBM IPP Server.

Internet Setup Wizard

Allows you to use the internet setup wizard to configure your internet environment.
Web Administration for i

The IWS is under “Create New Web Services Server”

The same link is up here as well – and is available throughout the tool from this link.

Create IWS Server (1 of 4)

Version 2.6 has both REST and SOAP support.

Version 1.5 is here for backward compatibility if you already have made older SOAP services. (It doesn’t support REST.)
Create IWS Server (2 of 4)

Server name is used to generate stuff like object names, so must be a valid IBM i object name (10 chars or less.)

Description can be whatever you want... should explain what the server is to be used for.

Create IWS Server (3 of 4)

Here you choose the userid that the web services server (but not necessarily your RPG application) will run under.

The default will be the IBM-supplied profile QWSERVICE.

But you can specify a different one if you want. This user will own all of the objects needed to run a server that sits and waits for web service requests.
Create IWS Server (4 of 4)

This last step shows a summary of your settings. It's worth making a note of the Server URL and the Context Root that it has chosen.

We Now Have a Server!

It takes a few seconds to build, but soon you'll have a server, and see this screen. To get back here at a later date, click on the "Manage" tab, then the "Application Servers" sub-tab, and select your server from the "server" drop-down list.
**Now What?**

Now that we have a web services server, we can add (or "deploy" is the official term) web services... i.e. programs/subprocedures that can be called as web services.

- One server can handle many services (programs/procedures)
- The same server can handle both REST and SOAP services (version 2.6+)
- IBM provides a "ConvertTemp" service as an example.

The "manage deployed services" button can be used to stop/start individual services as well as add/remove them.

**SOAP Web Services**

- Always XML (you could have a different "payload", but it'd be embedded in XML under the covers)
- SOAP is the XML format for the "parameters" when making a call
- URL and SoapAction HTTP header define the program to call.
- WSDL document describes the details (contains network info as well as an XML schema)

To understand Web Services Description Language (WSDL), think "how would you tell the world"?

- Documentation? (Word Doc, PDF, etc?)
- Sample programs?
- Or... info that can be used to generate programs?
**WSDL Skeleton**

```xml
<definitions>
    <types>
        definition of types ........
    </types>

    <message>
        definition of a message....
    </message>

    <portType>
        definition of a port........
    </portType>

    <binding>
        definition of a binding....
    </binding>

    <service>
        a logical grouping of ports...
    </service>

</definitions>
```

**SOAP**

SOAP = Simple Object Access Protocol

SOAP is an XML language that describes the parameters that you pass to the programs that you call. When calling a Web service, there are two SOAP documents -- an input document that you send to the program you're calling, and an output document that gets sent back to you.

"Simple" is perhaps a misnomer!

- Not as simple as RPG parameter lists.
- Not as simple as REST
Here's the skeleton of a SOAP message:

```xml
<soap:Envelope xmlns:soap="http://www.w3.org/2001/12/soap-envelope"
    soap:encodingStyle="http://www.w3.org/2001/12/soap-encoding">
  <soap:Header>
    (optional) contains header info, like payment info or authentication info
    (crypto key, userid/password, etc)
  </soap:Header>
  <soap:Body>
    ... Contains the parameter info. (Varies by application.) ...
  </soap:Body>
  <soap:Fault>
    (optional) error info.
  </soap:Fault>
</soap:Envelope>
```

Sample SOAP Documents

Some details removed for brevity....

Input Message:

```xml
<soapenv:Envelope>
  <soapenv:Body>
    <xsd:getcust>
      <xsd:args0>
        <xsd:CUSTNO>495</xsd:CUSTNO>
      </xsd:args0>
    </xsd:getcust>
  </soapenv:Body>
</soapenv:Envelope>
```

Output Message:

```xml
<soapenv:Envelope>
  <soapenv:Body>
    <ns:getcustResponse>
      <ns:return>
        <ns:CITY>POMANO BEACH</ns:CITY>
        <ns:NAME>ACME INC</ns:NAME>
        <ns:POSTAL>33064-2121</ns:POSTAL>
        <ns:STATE>FL</ns:STATE>
        <ns:STREET>123 MAIN STREET</ns:STREET>
      </ns:return>
    </ns:getcustResponse>
  </soapenv:Body>
</soapenv:Envelope>
```
### GETCUST RPG Program (1 of 2)

```
H DFTACTGRP(*NO) ACTGRP('SOAP') PGMINFO(*PCML: *MODULE)
FCUSTFILE IF E K DISK PREFIX('CUST.')
D CUST E DS qualified
deextname(CUSTFILE)
D GETCUST PR ExtPgm('GETCUST')
D CustNo like(Cust.CustNo)
D Name like(Cust.Name)
D Street like(Cust.Street)
D City like(Cust.City)
D State like(Cust.State)
D Postal like(Cust.Postal)
D GETCUST PI
D CustNo like(Cust.CustNo)
D Name like(Cust.Name)
D Street like(Cust.Street)
D City like(Cust.City)
D State like(Cust.State)
D Postal like(Cust.Postal)
```

- **PCML with parameter info will be embedded in the module and program objects.**
- **This PREFIX causes the file to be read into the CUST data struct.**
- **When there's no P-spec, the PR/PI acts the same as *ENTRY PLIST.**

### GETCUST RPG Program (2 of 2)

```
/free
chain CustNo CUSTFILE;
if not %found;
    msgdta = 'Customer not found.';
QMHNSDPM( 'CPF9897': 'QCPFMGS *LIBL'
    : msgdta: %len(msgdta): '*ESCAPE'
    : '*PGMBDY': 1: MsgKey: err );
else;
    Custno = Cust.Custno;
    Name = Cust.name;
    Street = Cust.Street;
    City = Cust.City;
    State = Cust.State;
    Postal = Cust.Postal;
endif;
*inlr = *on;
/end-free
```

- **This API is equivalent to the CL SNDPMMMSG command, and causes my program to end with an exception ("halt")**
- **When there are no errors, I simply return my output via the parameter list. IWS takes care of the XML for me!**
PCML so IWS Knows Our Parameters

Our GETCUST example gets input and output as normal parameters. To use these with IWS, we need to tell IWS what these parameters are. This is done with yet another XML document.

**PCML = Program Call Markup Language**

- A flavor of XML that describes a program’s (or *SRVPGM's) parameters.
- Can be generated for you by the RPG compiler, and stored in the IFS:

```
CRTBNDRPG PGM(xyz) SRCFILE(QRPGLESRC)
PGMINFO(*PCML)
INFOSTMF('/path/to/myfile.pcml')
```

- Or can be embedded into the module/program objects themselves, with an H-spec:

```
H PGMINFO(*PCML:*MODULE)
```

GETCUST as SOAP Service

To add a program (such as our ‘Get Customer’ example) click "Deploy New Service"
We'll do SOAP first, so select SOAP from the choices here.

Remember the PGMINFO('PCML:' MODULE)?

When the PCML is inside the module, you can just point the web service server to the ILE program or service program object.

If the PCML was saved to the IFS, however, choose the "Browse" option, and provide the IFS path name instead.
The service name must be a valid IBM i object name. It will be used to store details about this service on disk.

Description can be whatever you like.

It knows the parameters from the PCML. But, I need to tell it which ones are input, and which are output.
Here you can specify the userid that your program will run under.

If you choose "Use Server's UserID" it will use the one we specified earlier when we created the server, but you can choose anything that makes sense for your application.

It will automatically switch to this userid when running your program.

---

Here you can control the library list that will be set when your program is run. You can add and remove any libraries you like.
If you check the box here, IWS will set an environment variable containing the consumer’s IP address.

- If you need that – go ahead and check the box.
- Otherwise, just take the default.

Here you can control some of the finer details of the WSDL it will generate.

Most SOAP web services use SOAP 1.1, as SOAP 1.2 never became popular. (But, 1.2 is a choice here if needed.)

I like to change the “namespace” to my own namespace. I think that looks more professional – but the default IBM-generated one will work just fine.
SoapUI Example (9 of 9)

This shows a summary of what you've chosen. Click "Finish" and the IWS will generate Java programs that will (under the covers) handle all of the SOAP/WSDL generation for you, and call your RPG program as needed.

Testing SOAP with SoapUI (1 of 4)

Step 1: Click File -> New Project (some versions say "WSDL project", others say "SoapUI project. They're the same.)

Step 2: Paste in URL to WSDL (from the "View Service Definition" link) into the Initial WSDL blank.
Step 3: Expand tree till you find the 'Request 1'. Double click it to see SOAP request.

Step 4: Enter the customer number into the SOAP message for the input parms.

Step 5: Click the small green triangle -- SoapUI will send the request over HTTP to the IWS server!
After SOAP, I Need a REST

Remember that REST (sometimes called 'RESTful') web services differ from SOAP in that:
- the URL points to a "noun" (or "resource")
- the HTTP method specifies a "verb" like GET, POST, PUT or DELETE. (Similar to a database Create, Read, Update, Delete...)
- REST sounds nicer than CRUD, haha.

IWS structures the URL like this:

```
http://address:port/context-root/root-resource/path-template
```

- **context-root** = Distinguishes from other servers. The default context-root is /web/services, but you can change this in the server properties.
- **root-resource** = identifies the type of resource (or "noun") we're working with. In our example, we'll use "/cust" to identify a customer. The IWS will also use this to determine which program to run.
- **path-template** = identifies the variables/parameters that distinguish this noun from others. In our example, it'll be the customer number.
Example REST Input

For our example, we will use this URL:

**http://address:port/web/services/cust/495**

Our URL will represent a customer record. Then we can:

- GET <url> the customer to see the address.
- potentially POST <url> the customer to create a new customer record
- potentially PUT <url> the customer to update an existing customer record
- potentially DELETE <url> to remove the customer record.

Though, in this particular example, our requirements are only to retrieve customer details, so we won't do all four possible verbs, we'll only do GET.

That means in IWS terminology:

- /web/services is the context root.
- /cust is the root resource (and will point to our GETCUST program)
- /495 (or any other customer number) is the path template.

With that in mind, we're off to see the wizard… the wonderful wizard of REST.

---

REST Wizard (1 of 9)

Now I'd like to do the same web service as REST instead of SOAP. (The IWS also supports REST in the latest versions.)

To do that, I'll click 'Deploy New Service' again, this time choosing REST.
As with the SOAP example, PCML will be used to learn about the program’s parameters.

REST Wizard (2 of 9)

resource name is 'cust', because we want /cust/ in the URL.

description can be whatever you want.

PATH template deserves it's own slide 😊
Path Templates

You can make your URL as sophisticated as you like with a REST service. For example:

- Maybe there are multiple path variables separated by slashes
- Maybe they allow only numeric values
- Maybe they allow only letters, or only uppercase letters, or only lowercase, or both letters and numbers
- Maybe they have to have certain punctuation, like slashes in a date, or dashes in a phone number.

Path templates are how you configure all of that. They have a syntax like:

\{ identifier : regular expression \}

- The identifier will be used later to map the variable into a program's parameter.
- The regular expression is used to tell IWS what is allowed in the parameter

Path Template Examples

For our example, we want /495 (or any other customer number) in the URL, so we do:

\{custno:\d+\}  \(identifier=\text{custno}, \text{ and regular expression } \backslash d+ \text{ means } \backslash d = \text{ any digit, + = one or more}\)

As a more sophisticated example, consider a web service that returns inventory in a particular warehouse location. The path template might identify a warehouse location in this syntax

\(/\text{Milwaukee/202/Freezer1/B/12/C}\)

These identify City, Building, Room, Aisle, Slot and Shelf. The path template might be

\(/\text{city:w+/bldg: \text{\d+}/room: w+/aisle: [A-Z]/slot: d/d/\text{shelf: [A-E]} \})\)

\(\backslash w+ = \text{ one or more of A-Z, a-z or 0-9 characters.} \)

Aisle is only one letter, but can be A-Z (capital)

Slot is always a two-digit number, from 00-99, \(\backslash d/d\) means two numeric digits

Shelf is always capital letters A,B,C,D or E.

IWS uses Java regular expression syntax. A tutorial can be found here: [https://docs.oracle.com/javase/tutorial/essential/regex/](https://docs.oracle.com/javase/tutorial/essential/regex/)
Like SOAP, we have to identify which parameters are input or output.

Here we tell it we want to use GET, and JSON as the data format.

We also have to tell it where to get the input parameters. Do they come from the URL? An uploaded JSON document? Somewhere else?

In this case, CUSTNO comes from the URL which IWS calls "PATH_PARAM". We map the CUSTNO parameter from the 'custno' identifier in the path template.
REST Wizard (steps 6 to 9)

These steps are the same as the SOAP version

STEP 6 = UserID to run the program under

STEP 7 = Library List to run under

STEP 8 = consumer's IP address or any other HTTP meta data

STEP 9 = Summary screen where you click "Finish" to create the service.

Test REST By Doing a REST Test

When you put a URL into the "location" box in your web browser, the browser does a GET HTTP request. Therefore, a web browser is an easy way to test REST web services that use the GET method.

That way, you can make sure your service works before opening it up to other people who may be using a web service consumer.
SOAPUI REST Testing (1 of 2)

Since it's hard to test other methods (besides GET) in a browser, it's good to have other alternatives. Recent versions of SoapUI have nice tools for testing REST services as well.

Choose File / New REST Project, and type the URL, then click OK

SOAPUI REST Testing (2 of 2)

Here you can change the method and the resource ("noun") easily, and click the green "play" button to try it.

It can also help make XML, JSON or HTML output "prettier" by formatting it for you.
**Do It Yourself**

IWS is a neat tool, but:

- Maximum of 7 params
- Can't nest arrays inside arrays
- Supports only XML or JSON
- Very limited options for security
- doesn't always perform well

Writing your own:

- Gives you complete control
- Performs as fast as your RPG code can go.
- Requires more knowledge/work of web service technologies such as XML and JSON
- You can accept/return data in any format you like. (CSV? PDF? Excel? No problem.)
- Write your own security. UserId/Password? Crypto? do whatever you want.
- The only limitation is your imagination.

**Create an HTTP Server**

Click "Setup" to create a new web server.

Do not create a web services server at this time. That is for IBM's Integrated Web Services tool.

Instead, create a "normal" HTTP server.
The “Server Name”

The “Server Name” controls:
- The job name of the server jobs
- The IFS directory where config is stored
- The server name you select when editing configs
- The server name you select when starting/stopping the server.

Server Root

The “server root” is the spot in the IFS where all the files for this server should go.

By convention, it's always `/www/server name`. 
Document Root

The "document root" is the default location of files, programs, images, etc. Anything in here is accessible over a network from your HTTP server. By convention, it’s always specified as /www/ + server name + /htdocs

Set Port Number

This is where you specify the port number that we determined on the "Manage / All Servers" screen.
An "access log" will log all accesses made to the HTTP server. Useful to track server activity.

Over time, access logs can get quite large. The HTTP server can automatically delete data over a certain age. I like to keep mine for about a week.
URL Tells Apache What To Call

To get started with REST, let's tell Apache how to call our program. You'll want to make a library just for web services, anything in this library will be callable from a web service consumer. I called mine SKWEBSRV

- `ScriptAliasMatch /rest/([a-z0-9]+)/.* /qsys.lib/skwebsrv.lib/$1.pgm`
- `<Directory /qsys.lib/skwebsrv.lib>
  Require all granted
</Directory>`

- add the preceding code to the bottom of an Apache instance on IBM i.
- `ScriptAliasMatch` tells Apache that you want to run a program.
- `/rest/` is our "context root" Apache will `CALL PGM(SKWEBSRV/XXX)`
- `[a-z0-9]+` is a regular expression allowing all letters/numbers
- Parenthesis store the value in variable `$1`, used as "root resource"
- The `./.*` allows any trailing characters, we'll use that as our "path template", and work it out in our RPG program.
- Our REST web service can be run from any IP address (Require all granted).

http://your-ibmi:8500/rest/custinfo/495 (CALL SKWEBSRV/CUSTINFO)
Apache 2.4 Update

Starting with IBM i 7.2, we have Apache 2.4. They recommend using "require" instead of "Order"

Newer IBM i 7.2 syntax:

```xml
<Directory /qsys.lib/skwebsrv.lib>
  Require all granted
</Directory>
```

For older releases, replace the above with:

```xml
<Directory /qsys.lib/skwebsrv.lib>
  Order allow,deny
  Allow from all
</Directory>
```

Edit Configuration File

Scroll down to the "Tools" section.

Use "edit configuration file" to enter Apache directives.

Tip: You can use "Display configuration file" to check for errors in the Apache configuration.
Add Custom Directives

Scroll down to the bottom of the file.

Type the directives (as shown) and click “Apply” to save your changes.

Start New Apache Server

Before starting, click “Display Configuration File” and make sure it does not show any errors.

Then, click the green “start” button at the top to start your new server.

You can also start from 5250 with:

```
STRTCPSVR *HTTP HTTPSVR(MYDEMO)
```
DIY REST Example

Our web service takes a customer number as input, and returns that customer’s address.

**Input**

```bash
GET http://your-ibmi:8500/rest/custinfo/495
```

**Output**

```xml
<result>
  <cust id="495">
    <name>ANCO FOODS</name>
    <street>1100 N.W. 33RD STREET</street>
    <city>POMPANO BEACH</city>
    <state>FL</state>
    <postal>33064-2121</postal>
  </cust>
</result>
```

---

This is CGI -- But It's Not HTML

Web servers (HTTP servers) have a standard way of calling a program on the local system. It’s know as Common Gateway Interface (CGI)

- The URL you were called from is available via the REQUEST_URI envvar
- The verb GET is available from the REQUEST_METHOD envvar
- If any data is uploaded to your program you can retrieve it from "standard input".
- To write data back from your program to Apache (and ultimately the web service consumer) you write your data to "standard output".

To accomplish this, I’m going to use 3 different APIs (all provided by IBM)
- `getenv` ← retrieves an environment variable.
- `QtmhRdStin` ← reads standard input
- `QtmhWrStout` ← writes data to standard output.
DIY REST Example (2 of 3)

```plaintext
uri = %str( getenv('REQUEST_URI') );
monitor;
    pos = %scan(ID1: uri) + %len(ID1);
    custno = %int(%subst(uri:pos));
on-error;
    data = 'Status: 500 Invalid URI' + CRLF
        + 'Content-type: text/xml' + CRLF
        + CRLF
        + '<error>Invalid URI</error>' + CRLF;
    QtmhWrStout(data: %len(%trimr(data)): err);
return;
endmon;

chain custno CUSTFILE;
if not %found;
    data = 'Status: 500 Unknown Customer' + CRLF
        + 'Content-type: text/xml' + CRLF
        + CRLF
        + '<error>Unknown Customer Number</error>' + CRLF;
    QtmhWrStout(data: %len(%trimr(data)): err);
return;
endif;
```

REQUEST_URI will contain http://x.com/cust/495

Custno is everything after /cust/ in the URL

If an error occurs, I set the status to 500, so the consumer knows there was an error. We also provide a message in XML, in case the consumer wants to show the user.
DIY REST Example (3 of 3)

```plaintext
data = 'Status: 200 OK' + CRLF + 'Content-type: text/xml' + CRLF + 'CRLF' + '<result>' + '<cust id="' + %char(custno) + '">' + '<name>' + xml(name) + '</name>' + '<street>' + xml(street) + '</street>' + '<city>' + xml(city) + '</city>' + '<state>' + xml(state) + '</state>' + '<postal>' + xml(postal) + '</postal>' + '</cust>' + '</result>' + CRLF;

QtmhWrStout(data: %len(%trimr(data)): err);
```

Status 200 means that all was well.

Here I send the XML Response.

The `xml()` subprocedure is just a little tool to escape any special characters that might be in the database fields.

I won't include the code for that in this talk, but you can download the complete program from my web site (see link at end of handout.)

Testing and More Examples

- There's nothing special about testing our DIY example. You call it the same as any other REST web service – just use SoapUI or the browser, just as we did with the IWS example.

- There are additional examples of REST and SOAP in the handout. These are for your benefit – due to time concerns, Scott will skip over these in a standard 75 minute presentation.
Although the previous slide had only one parameter, REST can have multiple parameters -- but they must all fit on the same URL.

This web service is designed to return a list of invoices for a given customer number, within a given date range.

- 495 = customer number
- 20100901 = start date (in year, month, date format)
- 20100930 = end date (in year, month, date format)

The web service will scan for the slashes, get the parameter info from the URL, and build a JSON document that matches the criteria.

For our next example, we'll create a report of all invoices for a customer.

If there's no error, we'll output data in JSON format, as a big array of data structures.

If an error occurs, we'll output a JSON document like this.

```json
{
  "success": false,
  "errmsg": "Put Error Message Here"
}
```

```json
{
  "success": true,
  "errmsg": 
  "list": [{
    "invno": "xyz",
    "date": "2012-01-23",
    "name": "Acme Industries, Inc.",
    "amount": 123.45,
    "weight": 123.45,
  },
  { same fields again },
  { same fields again },
  { etc }
}]
```

There's no limit to how many rows of data you can place in a JSON document.
**DIY JSON, RPG Code (2 of 5)**

```rpg
/free:
exec SQL set option naming=*SYS;
  *inlr = *on;
  uri = %str(getenv('REQUEST_URI'));
  monitor:
    custpos = %scan('/invoice/': uri) + %len('/invoice/');
    sdatepos = %scan('/', uri: custpos) + 1;
    edatepos = %scan('/', uri: sdatepos) + 1;
    cust = %int(%subst(uri: custpos: (sdatepos-custpos-1)));  
    sdate = %int(%subst(uri: sdatepos: (edatepos-sdatepos-1)));  
    edate = %int(%subst(uri: edatepos));
  on-error;
    data = 'Status: 500 Invalid URI' + CRLF
       + 'Content-type: text/json' + CRLF
      + CRLF
       + %char(LBRACE) + CRLF
       + '"success": false,' + CRLF
       + '"errmsg": "An unknown URI format was given"' + CRLF
      + %char(RBRACE) + CRLF;
    QtmhWrStout(data: %len(data): err);
    return;
endmon;
```
• Each time I call `QtmhWrStout()`, it adds more data on to the end of what I’ve already sent.
• This part is just the start of the JSON document.
• Subsequent calls will write rows of data, and they will be added on to the end.
• Finally, we’ll call `QtmhWrStout` one last time to end the JSON document.
DIY JSON, RPG Code (5 of 5)

dow %subst(sqlstt:1:2)='00' or %subst(sqlstt:1:2)='01';
  jsonName = %scanrpl( '"': '"': row.name);
  jsonDate = %char( %date( row.date: *iso ): *iso );
  data = %char(LBRACE) + CRLF
      + ' "invno": "' + row.inv           + ',"' + CRLF
      + ' "date": "' + jsonDate          + ',"' + CRLF
      + ' "name": "' + %trim(jsonName)   + ',"' + CRLF
      + ' "weight": "' + %char(row.weight) + '"' + CRLF
  + %char(RBRACE);
QtmhWrStout(data: %len(data): err);

exec SQL fetch next from C1 into :row;
if %subst(sqlstt:1:2)='00' or %subst(sqlstt:1:2)='01';
  data = ',' + CRLF;
else;
  data = CRLF;
endif;
QtmhWrStout(data: %len(data): err);
enddo;

data = %char(RSQB) + %char(RBRACE) + CRLF;
QtmhWrStout(data: %len(data): err);

JSON Output in Browser

You can test this one with SoapUI's testing tool, too.
A SOAP Service With a List

The GETCUST service only returns one "record" so to speak. Can I do something like the "Invoice List" (the DIY example) using SOAP?

- **Q:** How do I do that if I don't code the XML in the program?
- **A:** With an array!

- **Q:** How do make an array that returns a list of "records" (more than one field per array element)?
- **A:** Use an array of data structures.

- **Q:** What if the number of returned elements (i.e. the number of invoices in the list) varies? How can I specify the number of returned array elements?
- **A:** If you code a "10i 0" parameter in your parameter list, IWS will let you use it to control the array size.

SOAPINV (invoice list) (1 of 2)

<table>
<thead>
<tr>
<th>D</th>
<th>OPTION(*SRCSTMT: *NODEBUGIO) PGMINFO(*PCML:*MODULE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>row ds qualified inz</td>
</tr>
<tr>
<td>D</td>
<td>inv 5a</td>
</tr>
<tr>
<td>D</td>
<td>date 8s 0</td>
</tr>
<tr>
<td>D</td>
<td>name 25a</td>
</tr>
<tr>
<td>D</td>
<td>amount 9p 2</td>
</tr>
<tr>
<td>D</td>
<td>weight 9p 1</td>
</tr>
<tr>
<td>D</td>
<td>SOAPINV PR</td>
</tr>
<tr>
<td>D</td>
<td>CustNo 4p 0 const</td>
</tr>
<tr>
<td>D</td>
<td>strDate 8p 0 const</td>
</tr>
<tr>
<td>D</td>
<td>endDate 8p 0 const</td>
</tr>
<tr>
<td>D</td>
<td>rtnCount 10i 0</td>
</tr>
<tr>
<td>D</td>
<td>rtnList</td>
</tr>
</tbody>
</table>

This is what needs to be returned for each invoice in the list

rtncount will tell IWS how many invoices are returned. (to a 999 maximum)

rtnList is the returned array. Notice: LIKEDS!
rtncount = 0;
exec SQL declare C1 cursor for
    select aiOrdn, aiIDat, aiSNme, aiDamt, aiLbs
    from ARSHIST
    where aiCust = :CustNo
        and aiIDat between :strDate
            and :endDate;
exec SQL open C1;
exec SQL fetch next from C1 into :row;
dow sqlstt='00000' or %subst(sqlstt:1:2)='01';
    rtncount = rtncount + 1;
    rtnlist(rtncount) = row;
enddo;
exec SQL fetch next from C1 into :row;
exec SQL close C1;

For each record found, rtncount is updated, and rtnList() array contains a row.

CustNo, strDate and endDate are all input parameters passed by IWS.

The other screens will be the same as they were for GETCUST.

Except, that on the parameter screen, I have to tell IWS about the returned parameter count.
By default, the count for RTNLIST is 999, just like the DIM(999) in my RPG code. But I can change it to "RTNCOUNT" because RTNCOUNT happens to be a 10i 0 field, IWS knows it can be used to specify the array size. Unfortunately, there's no way to stop IWS from sending RTNCOUNT to the consumer, as well. (But if the consumer doesn't need it, it can ignore it.)

Discussion / Wrap Up

SOAP is heavily standardized, works best with tools
REST is simpler, more versatile, runs faster

- Use SOAP when making a service to be called my "the masses" (customers, vendors, anything where there are a lot of consumers) because they can use tools, so you don't have to help them.

- Use REST for everything else.

- Use DIY when you need to go beyond what IWS can do, or when performance is paramount
More Information / Resources

Gaining a basic understanding of HTTP:

What Is HTTP, Really? (Scott Klement)
http://iprodeveloper.com/application-development/what-http-really

What’s the Difference Between a URI, URL, and Domain Name? (Scott Klement)

Gaining a basic understanding of Web Services & Terminology:

Web Services: The Next Big Thing  (Scott N. Gerard)
http://iprodeveloper.com/rpg-programming/web-services-next-big-thing

SOAP, WDSL, HTTP, XSD? What? (Aaron Bartell)

More Information / Resources

w3schools.com -- free (and great!) site for learning web technology
XML: http://www.w3schools.com/xml/default.asp
Web Services: http://www.w3schools.com/webservices/default.asp
WSDL: http://www.w3schools.com/wsdl/default.asp
SOAP: http://www.w3schools.com/soap/default.asp

IBM’s web site for the Integrated Web Services (IWS) tool:
http://www.ibm.com/systems/i/software/iws/

SoapUI home page
http://www.soapui.org

WSDL2RPG Home Page
http://www.tools400.de/English/Freeware/WSDL2RPG/wsdl2rpg.html

Call a Web Service with WSDL2RPG (Thomas Raddatz)
http://iprodeveloper.com/rpg-programming/call-web-service-wdsl2rpg
**More Information / Resources**

**How-To Articles About Consuming/Providing Web Services:**

- RPG Consumes the REST (Scott Klement)

- RPG Consuming Web Services with HTTPAPI and SoapUI (Scott Klement)

- IBM's Integrated Web Services (Scott Klement)

- Consume Web Services with IBM's IWS (Scott Klement)

- Serving RESTful Web Services in RPG

- Serve JSON Web Services with RPG and YAJL

**Sites that offer web service directories**

- WebServiceX.net
- XMethods.net
- BindingPoint.com
- RemoteMethods.com

**RPG’s XML Opcodes & BIFs:**

- "Real World" Example of XML-INTO (Scott Klement)
  [http://iprodeveloper.com/rpg-programming/real-world-example-xml](http://iprodeveloper.com/rpg-programming/real-world-example-xml)

- RPG’s XML-SAX Opcode

- PTFs for Version 6.1 Enhance RPG’s XML-INTO

- XML-INTO: Maximum Length

- XML-INTO: Read XML Data Larger Than 65535

- XML-INTO: Output to Array Larger than 16 MB
This Presentation

You can download a PDF copy of this presentation from:
http://www.scottklement.com/presentations/

The Sample Web Service Providers in this article are also available at the preceding link.

Thank you!