

Working with JSON in RPG



(YAJL Open Source JSON Tool)

Presented by

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

The Agenda



Agenda for this session:



1. What is JSON?
 - Why use JSON?
 - Syntax Overview
2. The YAJL JSON reader/writer
 - Why YAJL?
 - Scott's RPG interface
3. Generating JSON in RPG Code
 - Example
4. Reading JSON in RPG Code
 - Example

Ugggh, Another Thing to Learn!



This is pretty much how I felt about JSON at first!

- ugggh, I just learned XML. Do I need to learn something new?!
- But, as I learned more, I started to love it.
- Now I much prefer JSON over XML.

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Much Like XML



JSON is a format for encapsulating data as it's sent over networks

Much Like XML.

JSON is self-describing (field names are in the data itself) and human-readable.

Much Like XML

Very popular in Web Services and AJAX

Much Like XML

Can be used by all major programming languages

Much Like XML

So why is it better than XML.....?



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Much Different Than XML



JSON is simpler:

- only supports UTF-8, whereas XML supports a variety of encodings.
- doesn't support schemas, transformations.
- doesn't support namespaces
- method of "escaping" data is much simpler.

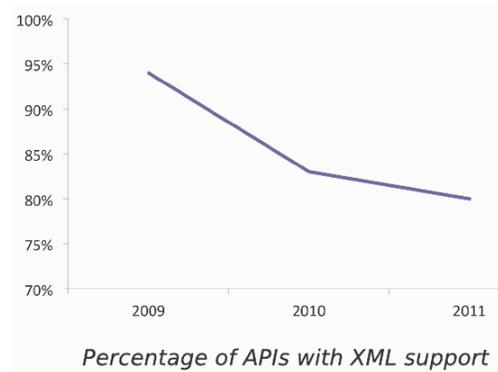
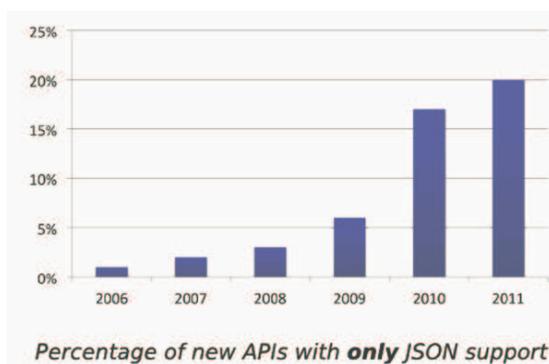
JSON is faster

- more terse (less verbose). About 70% of XML's size on average
- simpler means faster to parse
- dead simple to use in JavaScript



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JSON is Quickly Becoming Important



Over 70% of all APIs in ProgrammableWeb's API directory are RESTful, increasingly at the expense of SOAP. More than 55% of those same APIs support JSON output, with 20% opting not to offer XML at all.

Source: 1 in 5 APIs Say "Bye XML", Adam DuVander, May 25, 2011

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JSON Evolved from JavaScript



Originally JSON was the language used to describe "initializers" for JavaScript objects.

- Used to set the initial values of JavaScript Objects (data structures), and arrays. Even for arrays nested in data structures or vice-versa.
- Conceptually similar to "CTDATA" in RPG, except supports nested data as well.
- Unlike JavaScript, however, JSON does not support "methods" (executable routines in the object) so it's objects are equivalent to RPG data structures.

```
var DaysOfWeek = [ "Sunday",  
                  "Monday",  
                  "Tuesday",  
                  "Wednesday",  
                  "Thursday",  
                  "Friday",  
                  "Saturday" ];
```

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JSON Syntax Summary



Arrays start/end with square brackets

```
[ "Monday", "Tuesday", "Wednesday", "Thursday", "Friday" ]
```

Objects (data structures in RPG) start/end with curly braces { x, x, x, x }

```
{ "first": "Scott", "last": "Klement", "sex": "male" }
```

Strings are in double-quotes. Quotes and control characters are escaped with backslashes. Numbers and true/false are not quoted.

```
{ "name": "Henry \"Hank\" Aaron", "home_runs": 755, "retired": true }
```

Names are separated from values with a colon (as above)

Successive elements (array elements or fields in an object) are separated by commas. (as above)

Data can be nested (arrays inside objects and/or objects inside arrays).

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JSON and XML to Represent a DS



```
D list          ds          qualified
D              ds          dim(2)
D  custno      4p 0
D  name        25a
```

For example, this is an array of a data structure in RPG.

```
[
  {
    "custno": 1000,
    "name": "ACME, Inc"
  },
  {
    "custno": 2000,
    "name": "Industrial Supply Limited"
  }
]
```

This is how the same array might be represented (with data inside) in a JSON document.

```
<list>
  <cust>
    <custno>1000</custno>
    <name>Acme, Inc</name>
  </cust>
  <cust>
    <custno>2000</custno>
    <name>Industrial Supply Limited</name>
  </cust>
</list>
```

And it's approximately the same as this XML document.

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The YAJL Open Source Tool



YAJL = Yet Another JSON Library

- Created by Lloyd Hilaiel (who works for Mozilla)
- completely Open Source (very permissive ISC license)
- Extremely fast. (Fastest one we benchmarked)
- Written in C.
- Bindings available for Ruby, Python, Perl, Lua, Node.js and others

Ported to IBM i (ILE C) by Scott Klement & David Russo.

- Available at <http://www.scottklement.com/yajl>
- V5R4 or higher.
- Works entirely in UTF-8 Unicode

YAJLR4 = Scott's ILE RPG language bindings

- Simplifies calling YAJL from ILE RPG
- Replaces C macros with RPG subprocedures
- Handles UTF-8/EBCDIC translation for you

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YAJL Provides



YAJL provides sets of routines for:

- Generating JSON data
- Parsing JSON data in an event-driven (SAX-like) manner
- Parsing JSON in a tree (DOM-like) manner

I have found the tree-style routines to be easier to work with, so will use them in my examples.

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Example of Writing JSON



For an example, an RPG program that lists invoices in a date range in JSON format, like this:

```
{
  "success": true,
  "errmsg": "",
  "list": [
    {
      "invoice": "70689",
      "date": "03/01/2014",
      "name": "SCOTT KLEMENT",
      "amount": 14.80,
      "weight": 3.5
    },
    { another invoice },
    { another invoice },
    ...etc...
  ]
}
```

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Example of Writing JSON



Or if an error occurs, it'd return an abbreviated document like this:

```
{
  "success": false,
  "errmsg": "Error Message Here",
  "list": [ ]
}
```

To keep it simple, we'll just have it write the result to an IFS file.

Though, you can also use this in a web service, if desired (code download from ScottKlement.com will have an example of this)

RPG Writing JSON -- Definitions



```
H DFACTGRP(*NO) ACTGRP('KLEMENT') OPTION(*SRCSTMT)
H BNDDIR('YAJL') DECEDIT('0.')
/include yajl_h

D row          ds
D  inv         5a
D  date        8s 0
D  name        25a
D  amount      9p 2
D  weight      9p 1

D cust         s          4s 0 inz(4997)
D sdate        s          8s 0 inz(20100901)
D edate        s          8s 0 inz(20100930)
D dateUSA      s          10a  varying

D success      s          1n
D errMsg       s          500a  varying
```

Numbers in JSON must start a digit (not the decimal point)

The BNDDIR and copy book are needed to access YAJL's routines

To keep example simple, query criteria is hard-coded.

RPG Writing JSON -- Mainline



```
exec SQL declare C1 cursor for
  select aiOrdN, aiIDat, aiSNme, aiDamt, ailbs
  from ARSHIST
  where aiCust=:cust
  and aiIDat between :sdate and :edate;

exec SQL open C1;
exec SQL fetch next from C1 into :row;

exsr JSON_Start;

dow sqlstt='00000' or %subst(sqlstt:1:2)='01';
  exsr JSON_AddRow;
  exec SQL fetch next from C1 into :row;
enddo;

exec SQL close C1;

exsr JSON_Finish;
exsr JSON_Save;
*inlr = *on;
```

Using SQL to get list of invoices from sales history file

At the start of the list, output JSON start (subroutine)

For each invoice found, add the 'row' data structure to JSON document

At the end of the list, call subroutines to finish the JSON data & save it.

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YAJL Routines Used



To generate the JSON data we'll use the following YAJL procedures:

`yajl_genOpen()` / `yajl_genClose()` = Open/Close JSON generator.

The genOpen routine has a parm of *ON or *OFF tells whether JSON is "pretty" or "compact"

`yajl_beginObj()` / `yajl_endObj()` = start or end JSON object (data struct)

`yajl_beginArray()` / `yajl_endArray()` = start or end JSON array

`yajl_addBool()` = add a boolean (true/false) value to JSON

`yajl_addChar()` = add a character string to JSON

`yajl_addNum()` = add a numeric value to JSON

`yajl_saveBuf()` = write JSON document to IFS

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JSON_Start Routine



```
begsr JSON_Start;

    yajl_genOpen(*ON); // use *ON for easier to read JSON
                       //      *OFF for more compact JSON

    yajl_beginObj();
    yajl_addBool('success': success );
    yajl_addChar('errmsg': errMsg );
    yajl_beginArray('list');

endsr;
```

```
{
  "success": false,
  "errmsg": "Error Message Here",
  "list": [
```

← yajl_beginObj
← yajl_addBool
← yajl_addChar
← yajl_beginArray

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JSON_addRow Routine



```
begsr JSON_addRow;

    dateUsa = %char( %date(row.date:*iso) : *usa );

    yajl_beginObj();
    yajl_addChar('invoice': row.inv );
    yajl_addChar('date': dateUsa );
    yajl_addChar('name': %trim(row.name));
    yajl_addNum('amount': %char(row.amount));
    yajl_addNum('weight': %char(row.weight));
    yajl_endObj();

endsr;
```

```
{
  "invoice": "XYX",
  "date": "12/31/2013",
  "name": "John Doe",
  "amount": 123.45,
  "weight": 100.5
}
```

Each time this runs, it adds a new JSON element to the end of the document.
Since we have not yet called JSON_endArray(), each object is a new element in the array that was started in the JSON_start subroutine.

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JSON_Finish & JSON_Save



```
begsr JSON_Finish;  
    yajl_endArray();  
    yajl_endObj();  
endsr;
```

Finish off the array and the object that began in JSON_start.

```
begsr JSON_Save;
```

```
    yajl_saveBuf('/tmp/example.json': errMsg);  
    if errMsg <> '';  
        // handle error  
    endif;
```

Save result to IFS file

```
    yajl_genClose();
```

Close JSON generator (frees up memory)

```
endsr;
```

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RPG Writing JSON – "Pretty" Output



```
{  
  "success": true,  
  "errmsg": "",  
  "list": [  
    {  
      "invoice": "70689",  
      "date": "09/01/2010",  
      "name": "JIM JOHNSON",  
      "amount": 14.80,  
      "weight": 3.5  
    },  
    {  
      "invoice": "70695",  
      "date": "09/01/2010",  
      "name": "BILL VIERS",  
      "amount": 9.80,  
      "weight": 3.2  
    }  
  ]  
}
```

Result with yajl_genOpen("ON")
("pretty" JSON data)

Includes line breaks and indenting to make it easy as possible for humans to read.

This extra formatting isn't needed for computer programs to read it, however.

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RPG Writing JSON – "Compact" output



Result with `yajl_genOpen(*OFF)`

("compact" JSON data)

No line breaks or indenting. Makes file size smaller, so it transmits over the network a little bit faster.

But, is the exact same document.

```
{"success":true,"errmsg":"","list":[{"invoice":"70689","date":"09/01/2010","name":"JIM JOHNSON","amount":14.80,"weight":3.5},{"invoice":"70695","date":"09/01/2010","name":"BILL VIERS","amount":9.80,"weight":3.2}]}
```

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What if I Wanted a Web Service?



Although there isn't time to go into detail about how to code RESTful web services in this presentation, the gist would be:

- Get input parameters from the URL.
- Create the JSON document in exactly the same way.
- Use `JSON_copyBuf()` instead of `JSON_saveBuf()`

`JSON_copyBuf()` copies the JSON data into a memory buffer or program variable instead of writing it to the IFS. You could then return it from your web service.

An example of this is provided in the sample code on Scott's web site, here:

<http://www.scottklement.com/yajl>

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Reading JSON Data With YAJL



YAJL provides two ways of reading JSON data:

- event-based (like SAX in XML) APIs
- tree-based (like DOM in XML) APIs

This talk will discuss the tree-based method, since I have found it much easier to use.

A tree is the JSON data loaded into memory and organized in a hierarchical fashion.

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Populating the YAJL tree



To load JSON data from IFS into the tree parser, call `yajl_stmf_load_tree()`, as follows:

```
docNode = yajl_stmf_load_tree( '/tmp/example.json' : errMsg );
```

There is also `yajl_buf_load_tree()` if you prefer to load from a buffer or RPG variable.

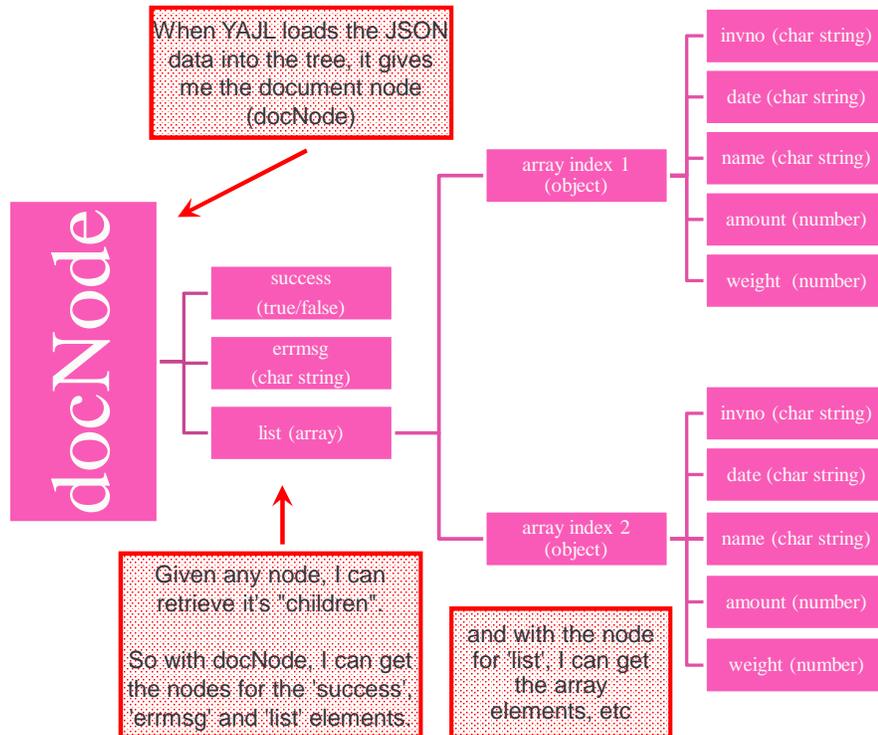
The return value is a YAJL 'node' that represents the outermost element of the JSON document. (the tree's "trunk")

A 'node' represents data at one level of the document, and can be used to retrieve 'child nodes' that are within the current 'node'.

(To understand better, see the diagram on the next slide.)

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Diagram of a JSON Tree



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Retrieving A "Child Node"



`yajl_object_find()` will get a child node by field name.

`yajl_is_true()` returns whether a true/false value is true.

`yajl_is_false()` returns whether a true/false value is false.

```
// { "success": true }  
succNode = yajl_object_find( docNode : 'success' );  
if yajl_is_true( succNode );  
    // success!  
else;  
    // failure  
endif;
```

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Get a String Value From a Node



`yajl_get_string()` = returns a string value from a node

```
// { "success": false, "errmsg": "invalid start date" }
succNode = yajl_object_find( docNode : 'success' );

if yajl_is_false( succNode );
    errMsgNode = yajl_object_find( docNode: 'errmsg' );
    msg = yajl_get_string(errMsgNode);
    // msg now contains "invalid start date"
endif;
```

For numeric values, there's also `yajl_get_number()`

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Processing an Array



`yajl_array_loop()` = loops through all elements in a JSON array

```
// { "list": [ invoice1, invoice2, invoice 3 ] }
list = yajl_object_find( docNode : 'list' );

i = 0;
dow YAJL_ARRAY_LOOP( list: i: node );

    // code here is repeated for each array element.
    // each time through, node and i are updated
    // to point to reflect the current array element.

enddo;
```

`yajl_array_elem()` (not demonstrated here) can be used if you prefer to get each element by it's array index number.

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Processing an Object (DS)



`yajl_object_loop()` = loops through all sub-fields in an object, and returns the field name ("key"), child node ("val") and index for each.

This is, equivalent to calling `yajl_object_find()` separately for each field name.

```
// { "invoice": 123, "name": "Scott Klement", "amount": 100.00 }  
  
i = 0;  
dow YAJL_OBJECT_LOOP( docNode: i: key: val );  
  
    // code here is repeated for each field in the object  
    // each time through, key, val and i are updated  
    // to point to reflect the current field  
  
enddo;
```

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Freeing Up Resources (When Done)



When `yajl_stmf_load_tree()` ran, all of the JSON details were loaded into memory. To free up that memory, you must call `yajl_tree_free()`

```
yajl_tree_free( docNode );
```

You must pass the document node into `yajl_tree_free()`, so be sure to save it when you call `yajl_xxxx_load_tree()`.

`yajl_tree_free()` will free up all of the child nodes as well as the document node. So be sure that you do not refer to any of the nodes after calling it.

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Reading JSON – RPG Example



To put together all of the YAJL tree concepts shown in the preceding slides, I have provided an RPG example.

- Reads the same JSON file (from IFS) that we created earlier
- Loads the JSON data into an RPG data structure.
- After all is loaded, loops through and prints the data (just to demonstrate reading)

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RPG Reading JSON (1 of 6)



```
H DFTACTGRP(*NO) ACTGRP('KLEMENT') OPTION(*SRCSTMT)
H BNDDIR('YAJL')
```

```
/include yajl_h
```

```
D list_t          ds          qualified
D                 ds          template
D inv             5a
D date           8s 0
D name           25a
D amount         9p 2
D weight         9p 1

D result         ds          qualified
D success        1n
D errmsg         500a varying
D list           likeds(list_t) dim(999)

D i              s           10i 0
D j              s           10i 0
D dateUSA        s           10a
D errMsg         s           500a varying inz('')
```

The 'result' data structure will be populated from the JSON data

RPG Reading JSON (2 of 6)



```
D docNode      s           like(yajl_val)
D list         s           like(yajl_val)
D node         s           like(yajl_val)
D val          s           like(yajl_val)
D key          s           50a  varying
```

Variables that represent JSON nodes are defined as 'yajl_val'

Technically, under the covers, these are pointers to the data structures that YAJL uses internally.

However, there's no need for the RPG program to be concerned with how it works, and it's not necessary to do any sort of pointer logic on these fields. They are just placeholders for the JSON nodes.

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RPG Reading JSON (3 of 6)



```
// load the example.json document into a tree.

docNode = yajl_stmf_load_tree( '/tmp/example.json' : errMsg );
if errMsg <> '';
  // handle error
endif;

// get the 'success' field into 'result' DS
// result.success is an RPG named indicator, and will be
// *ON if success=true, *OFF if success=false

node = YAJL_object_find(docNode: 'success');
result.success = YAJL_is_true(node);

// get the 'errmsg' field into 'result' DS

node = YAJL_object_find(docNode: 'errmsg');
result.errmsg = YAJL_get_string(node);
```

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RPG Reading JSON (4 of 6)



```
list = YAJL_object_find(docNode: 'list');
```

```
i = 0;
```

```
dow YAJL_ARRAY_LOOP( list: i: node );
```

```
  j = 0;
```

```
  dow YAJL_OBJECT_LOOP( node: j: key: val);
```

```
    // when 'load_subfield' is run, "key" will contain  
    // the JSON field name, and "val" will contain  
    // a YAJL node from which the value can be extracted
```

```
    exsr load_subfield;
```

```
  enddo;
```

```
enddo;
```

'node' contains the array element that represents an invoice object in the list.

yajl_object_loop is called for each array 'node' to get it's subfields.

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RPG Reading JSON (5 of 6)



```
begsr load_subfield;
```

```
  select;
```

```
  when key = 'invoice';
```

```
    result.list(i).inv = yajl_get_string(val);
```

```
  when key = 'date';
```

```
    dateUSA = yajl_get_string(val);
```

```
    result.list(i).date = %dec(%date(dateUSA:*usa):*iso);
```

```
  when key = 'name';
```

```
    result.list(i).name = yajl_get_string(val);
```

```
  when key = 'amount';
```

```
    result.list(i).amount = yajl_get_number(val);
```

```
  when key = 'weight';
```

```
    result.list(i).weight = yajl_get_number(val);
```

```
  endsl;
```

```
endsr;
```

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RPG Reading JSON (6 of 6)



Just for the sake of having some output, here's a quick & dirty routine to print the invoice list (with O-specs)

```
D prt          ds          likeds(list_t)
.
.
for i = 1 to YAjl_ARRAY_SIZE(list);
  prt = result.list(i);
  except print;
endfor;
.
.
OQSYSPRT  E          PRINT
O          PRT.INV          5
O          PRT.DATE        17 ' - - '
O          PRT.NAME        44
O          PRT.AMOUNT      L  56
O          PRT.WEIGHT      L  67
```

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RPG Reading JSON -- Output



The output of the program would look as follows:

70689	2010-09-01	JIM JOHNSON	14.80	3.5
70695	2010-09-01	BILL VIERS	9.80	3.2
70700	2010-09-01	JOSE MENDOZA	6.00	3.0
70703	2010-09-01	RICHARD KERBEL	10.00	5.0
70715	2010-09-01	JACKIE OLSON	23.80	10.0
70736	2010-09-01	LISA XIONG	24.00	7.0
70748	2010-09-01	JOHN HANSON	11.80	5.0
70806	2010-09-01	JOHN ESSLINGER	7.50	5.0
70809	2010-09-01	LORI SKUZENSKI	20.00	1.0
70826	2010-09-02	KURT KADOW	11.25	7.0
70926	2010-09-02	PENNY STRAW	25.00	5.0
70979	2010-09-02	WOLSKI STEVE	12.75	.0
71021	2010-09-02	KENNETH HALE	21.25	5.9
71062	2010-09-02	ALEX AGULIERA	10.00	2.0
71081	2010-09-03	JIM JOHNSON	41.50	13.5
71270	2010-09-03	DAVE DRESEN	11.90	3.5

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This Presentation



You can download YAJL and the sample code presented in this session from:

<http://www.scottklement.com/yajl>

You can download a PDF copy of this presentation from:

<http://www.scottklement.com/presentations/>

Thank you!