Creating Statistical Web Services Using ASP.NET

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Abstract

ASP .NET XML Web Services provide a useful mechanism for exposing statistical calculations and graphics to web application developers. Using this approach, the capabilities of statistical software packages can be tapped by developers without invoking the software's GUI. Data and instructions are passed to the package using XML files. Output (including graphics) is returned as HTML with imbedded images, while numerical results are made available to the calling program in XML files. The same scripts that control the web services can also be accessed by the software package's user interface to reproduce the same analyses, or the GUI can be used to help create the XML scripts. This talk examines some of the issues involved in implementing such an approach, using the STATGRAPHICS statistical software package as an example.

Introduction

Some commonly used statistical packages began as a command language, with a graphical user interface added at a later date. Others were developed from the outset using only menus and dialog boxes, with no underlying language. For the latter, exposing the capabilities of the package for use by other programs presents unique challenges. This paper describes an approach based on ASP.NET Web Services, using the STATGRAPHICS statistical software package as an example.

Access by External Applications

Programs such as STATGRAPHICS which were designed to run exclusively in an interactive environment are often somewhat awkward to control from an external process. For example, suppose a real-time SPC application wished to use the program to fit a distribution and perform a capability analysis. The external application would have to:

1. Place the desired data in a file that the program could read.
2. Instruct the program to read the data and perform the desired calculations.
3. Retrieve the results (both numerical and graphical) and display the output.

If the SPC application was web-based, the output would have to be in a format that could be displayed in a standard HTML page.

Solutions to this problem include:

> Method 1: **Interfacing with the program's GUI**. Using this method, a standard project would be created which reads a data file with a predefined structure, performs the requested analyses, and saves output in HTML format. This is the method used in current versions of STATGRAPHICS, where users may create and launch predefined StatFolios and use StatPublish to create HTML output. The disadvantage of such an approach is that the program's GUI must be launched on the client machine.
>
> Method 2: **Exposing the program's methods for direct access by the external program.** This enables the calculations to be performed invisibly in the background. Although this approach requires substantial development effort, it allows users to integrate the routines into their applications in a seamless manner.

Exposing Statistical Procedures Using JavaBeans

A previous approach taken to expose the statistical and graphical procedures in STATGRAPHICS was the creation of a library of Java Beans called STATBEANS. STATBEANS consists of three types of beans:

1. **DataSource StatBeans** - these beans maintain a rectangular data table which other StatBeans access to retrieve data for analysis. DataSource StatBeans are provided for reading data from local text files, for reading data over the Internet or local intranets, for accessing databases via JDBC, and for maintaining data generated by user programs.

2. **Calculation StatBeans** - these are non-visible beans which perform statistical calculations. They may be called by user programs to calculate statistics. They are also accessed by the tabular and graphical StatBeans.

3. **Tabular StatBeans** - these StatBeans perform statistical calculations and display them in the form of tables.

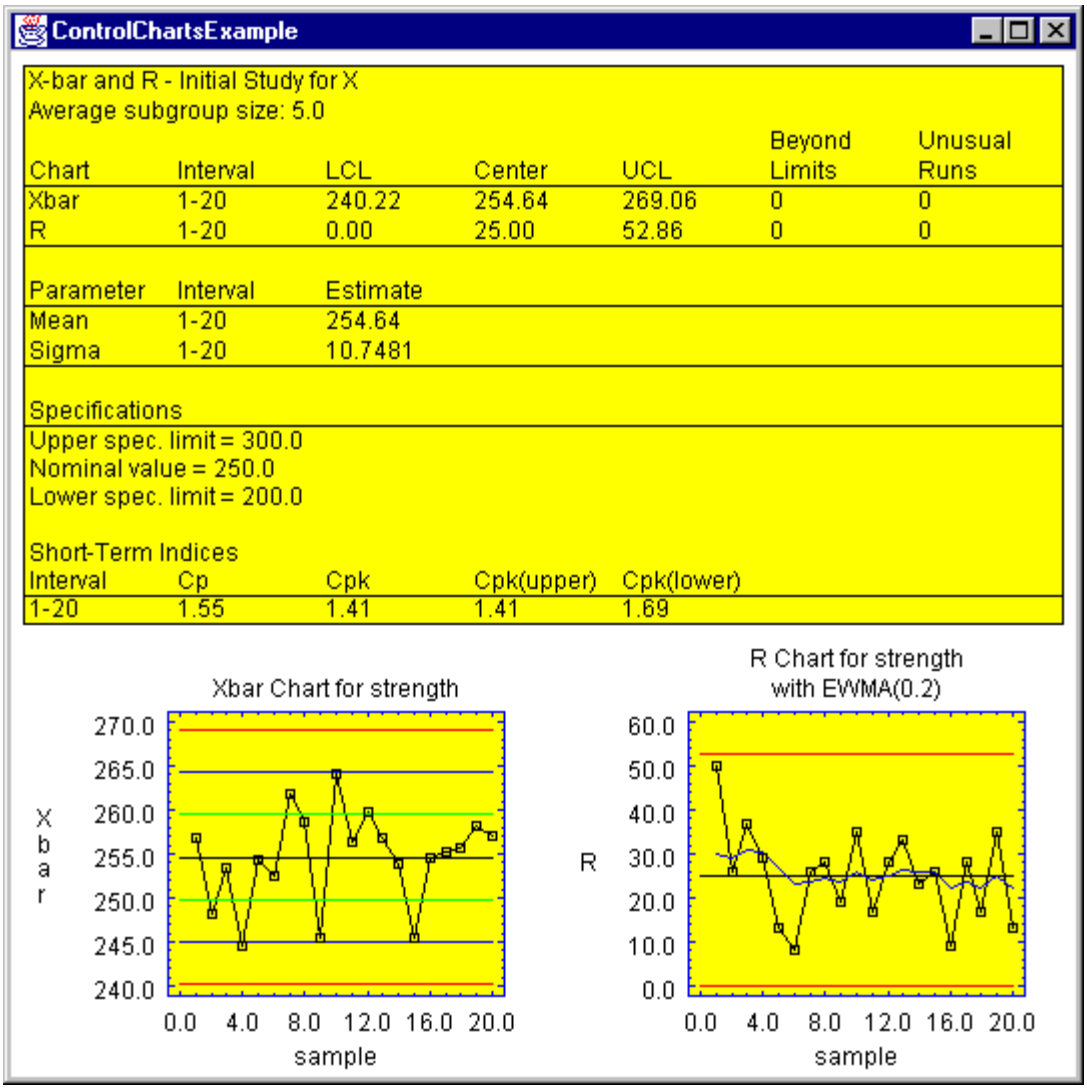
4. **Graphical StatBeans** - these StatBeans perform statistical calculations and display them in the form of graphs. Users create applications by first adding one or more datasource StatBeans to their project, and then linking the other StatBeans to the datasource.

StatBeans can be called by user applications on a server or by applets embedded in a web page. A typical program takes the following form:

```
//create a datasource bean
FileDataSource fileDataSource1 = new STATBEANS.FileDataSource();

//set the file name to be read
fileDataSource1.setFileName("c:\\statbeans\\samples\\spc.txt");

//create a calculation bean
ControlCharts controlCharts1 = new STATBEANS.ControlCharts();

//set the chart type
controlCharts1.setChartType("X-bar and R");

//set the name of the column containing the data
controlCharts1.setXVariableName("strength");

//set the subgroup size (if not 1)
controlCharts1.setSubgroupSize(5);

//set specification limits
controlCharts1.setUpperSpecificationLimit(300.0);
controlCharts1.setNominal(250.0);
controlCharts1.setLowerSpecificationLimit(200.0);

//create a table bean with 19 rows
ControlChartsTable controlChartsTable1 = new STATBEANS.ControlChartsTable();
controlChartsTable1.setNumberOfRowsInDisplay(19);

//set the number of decimal places for displaying the limits
controlChartsTable1.setDecimalPlaces(2);
```

```
//create 2 plot beans
ControlChartsPlot controlChartsPlot1 = new STATBEANS.ControlChartsPlot();
ControlChartsPlot controlChartsPlot2 = new STATBEANS.ControlChartsPlot();

//turn off the legends
controlChartsPlot1.setDisplayLimitValues(false);
controlChartsPlot2.setDisplayLimitValues(false);

//set the chart numbers for each plot
controlChartsPlot1.setChartNumber(0);
controlChartsPlot2.setChartNumber(1);

//ask for warning limits on the first chart
controlChartsPlot1.setShowOuterWarningLimits(true);
controlChartsPlot1.setShowInnerWarningLimits(true);

//add a smoother to the second chart
controlChartsPlot2.setSmootherType("EWMA");

//make the calculation bean a listener for changes in the FileDataSource bean
fileDataSource1.addDataChangeListener(controlCharts1.listenerForDataChange);

//make the table and plot beans listeners for changes in the calculation bean
controlCharts1.addDataChangeListener(controlChartsTable1.listenerForDataChange);
controlCharts1.addDataChangeListener(controlChartsPlot1.listenerForDataChange);
controlCharts1.addDataChangeListener(controlChartsPlot2.listenerForDataChange);

//instruct the fileDataSource bean to read the file
fileDataSource1.readData();
```

The beans can be added to an applet on a web page, or they may be instructed to save their output in image files. Typical output is shown below:



Although this approach is convenient for skilled programmers, it is not easy to implement in a client-server environment.

Exposing Statistical Procedures ASP.NET Web Services

ASP.NET is a powerful and widely used way to create web applications. It provides tools for creating the client side of web applications, and tools for developing web services that run on a server. XML is used to communicate between an application and a web service.

In developing the STATGRAPHICS .NET Web services, we first constructed an XML scripting language. A typical script is shown below:

```
<?xml version="1.0"?>
<statgraphics>
  <globals>
    <OutputLanguage>English</OutputLanguage>
    <SigDigits>6</SigDigits>
    <StatAdvisor>Both</StatAdvisor>
    <ConfLevel>95</ConfLevel>
    <TableRows>1000</TableRows>
    <GraphWidth>4.0</GraphWidth>
    <GraphHeight>4.0</GraphHeight>
    <FunctionResolution>101</FunctionResolution>
    <ContourResolution>51</ContourResolution>
    <HTMLFileName>temp/myoutput.htm</HTMLFileName>
  </globals>
  <data>
    <FileName>temp/nonlin.xml</FileName>
    <DecimalSeparator>.</DecimalSeparator>
    <DateFormat>MM/DD/YYYY</DateFormat>
    <MissingValue>NA</MissingValue>
  </data>
  <proc name="SREG">
    <input>
      <Y>Chlorine</Y>
      <X>Weeks</X>
    </input>
    <options>
      <Model>Linear</Model>
      <AltFit>None</AltFit>
    </options>
    <output>
      <table>Summary</table>
      <table>LackOfFit</table>
      <table name="Forecasts">
        <X>20</X>
        <X>30</X>
        <X>40</X>
        <ConfLevel>95</ConfLevel>
        <Limits>TwoSided</Limits>
      </table>
      <table>Comparisons</table>
      <table>Residuals</table>
      <table>Influential</table>
      <graph name="Model">
        <Plot>All</Plot>
        <Resolution>101</Resolution>
        <PredLimits>Yes</PredLimits>
        <ConfLimits>Yes</ConfLimits>
        <ConfLevel>95</ConfLevel>
        <Limits>TwoSided</Limits>
      </graph>
      <graph>Observed</graph>
      <graph name="ResidsVsX">
        <Plot>Studentized</Plot>
      </graph>
      <graph name="ResidsVsPred">
```

```
        <Plot>Studentized</Plot>
      </graph>
      <graph name="ResidsVsRow">
        <Plot>Studentized</Plot>
      </graph>
    </output>
    <results>
      <Predicted>PREDICTED</Predicted>
      <Residual>RESIDUALS</Residual>
    </results>
  </proc>
</statgraphics>
```

The first line indicates that the file contains XML (Extended Markup Language), which is a popular grammatical system for constructing custom markup languages. The second line contains the opening root element <statgraphics> tag, while the last line contains the closing </statgraphics> tag. Between these tags are several major blocks of code:

1. **Globals** – Elements with a set of "global" tags set system options that apply to all procedures that follow. There may be more than one *Globals* section if options need to be changed midway through a script.

2. **Data** – Elements within a set of "data" tags specify the source or sources of the data to be analyzed. STATGRAPHICS may access up to 10 sources of data simultaneously, which it loads into 10 virtual datasheets. More than one *Data* section is allowed. Procedures will always use the most recent data specified.

3. **Profile** – Defines a graphics profile, which is a set of attributes that control the appearance of a graph. Once defined, a profile may be applied to any graph or used to set the default attributes for all graphs.

4. **Proc** – The "proc" tag invokes a specific statistical procedure. Within these tags are 4 subsections:

    a. **Input** – specifies the names of the data columns or STATGRAPHICS expressions based on those columns that contain the data input for the procedure.

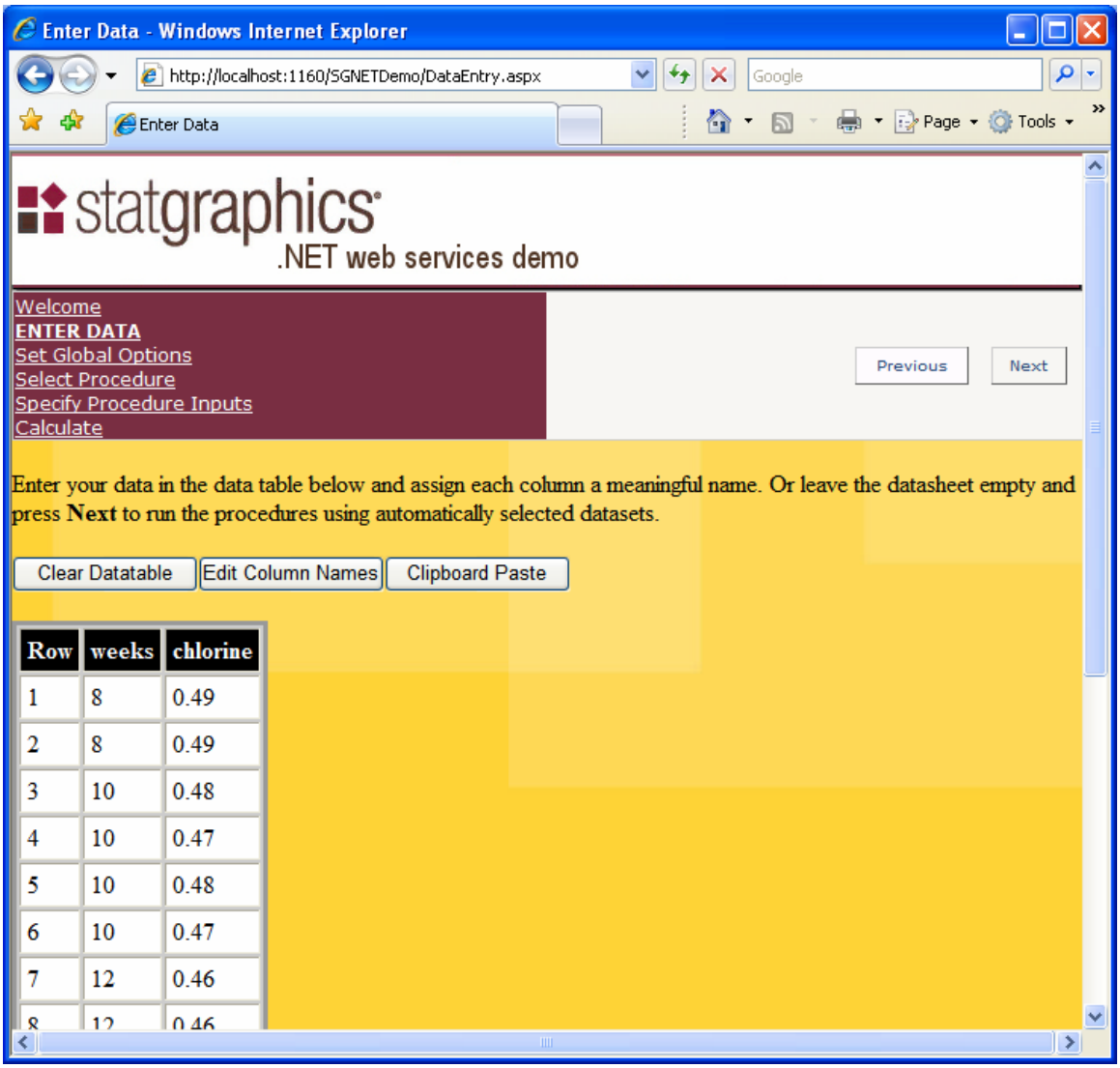
    b. **Options** – specifies the values of any *Analysis Options*.

    c. **Output** – specifies the tables and graphs to be created, together with their *Pane Options*.

    d. **Results** – specifies the calculated results that should be saved, together with names for each item.

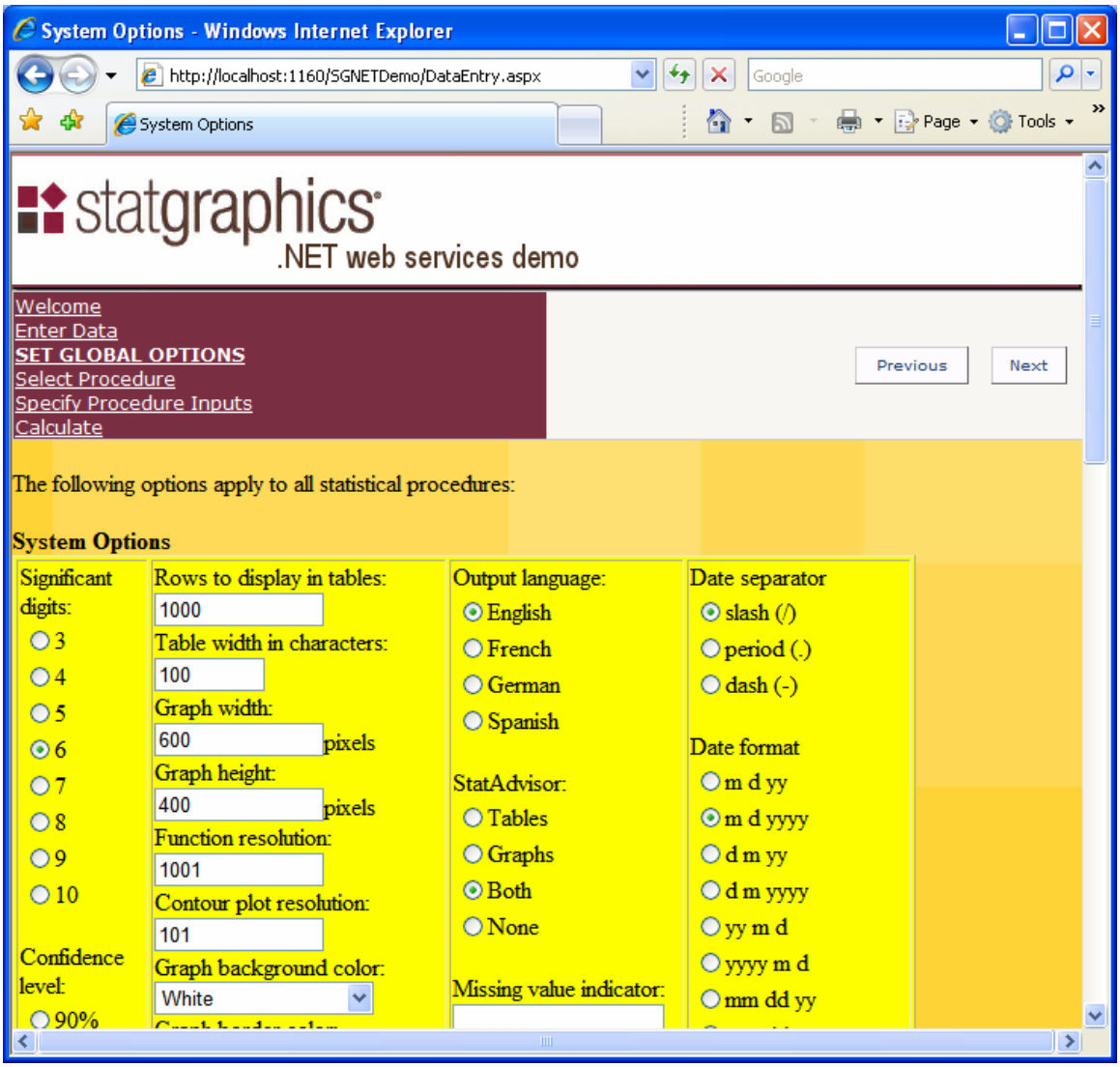
A typical application utilizes the Web Services in the following manner:

Step 1: The data to be analyzed is defined. This may be done interactively on a web page as shown below:



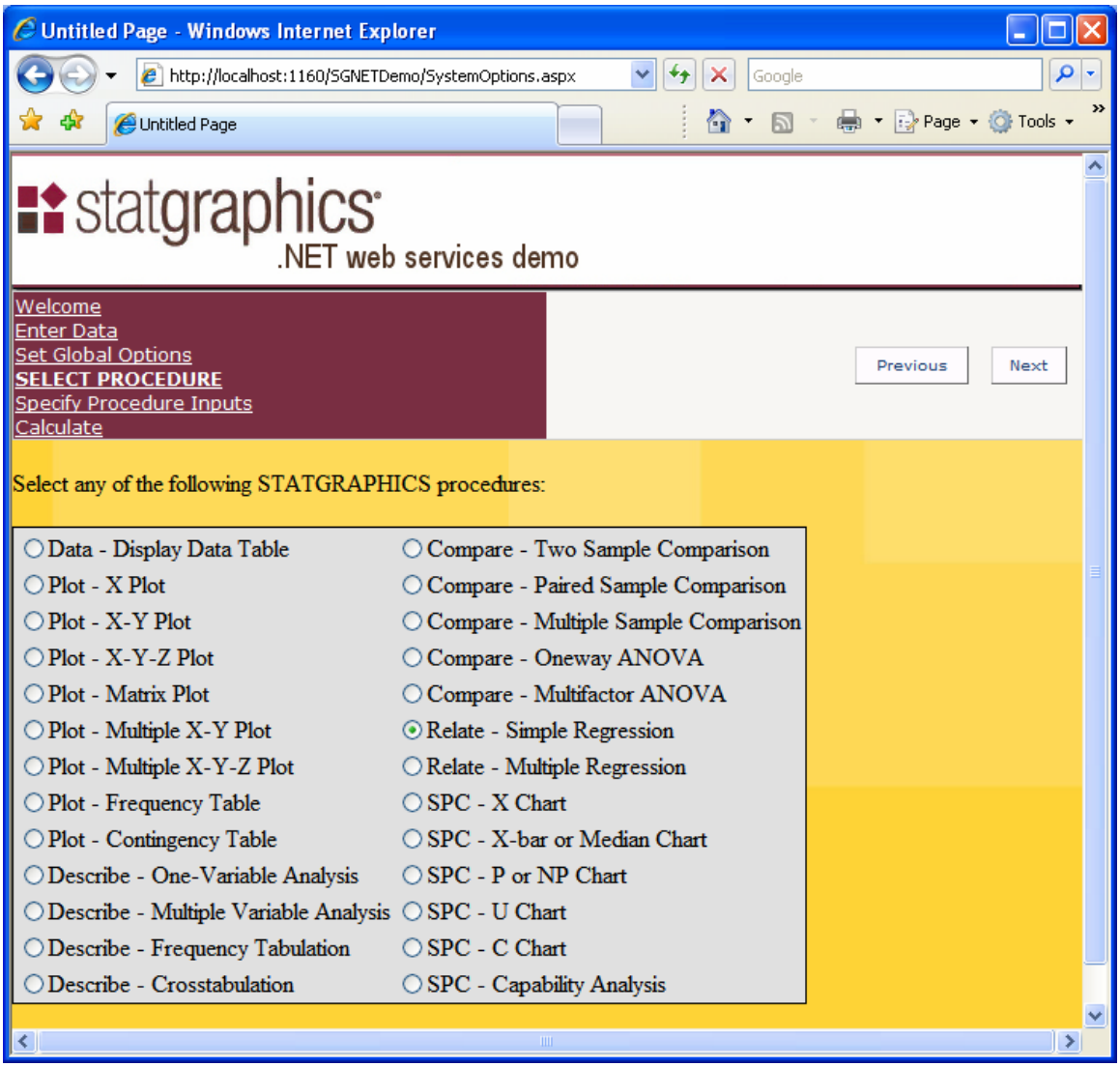
A query could instead be issued against a database on a server. The resulting data must be placed in an XML file for access by the web services.

Step 2: Global options are set.



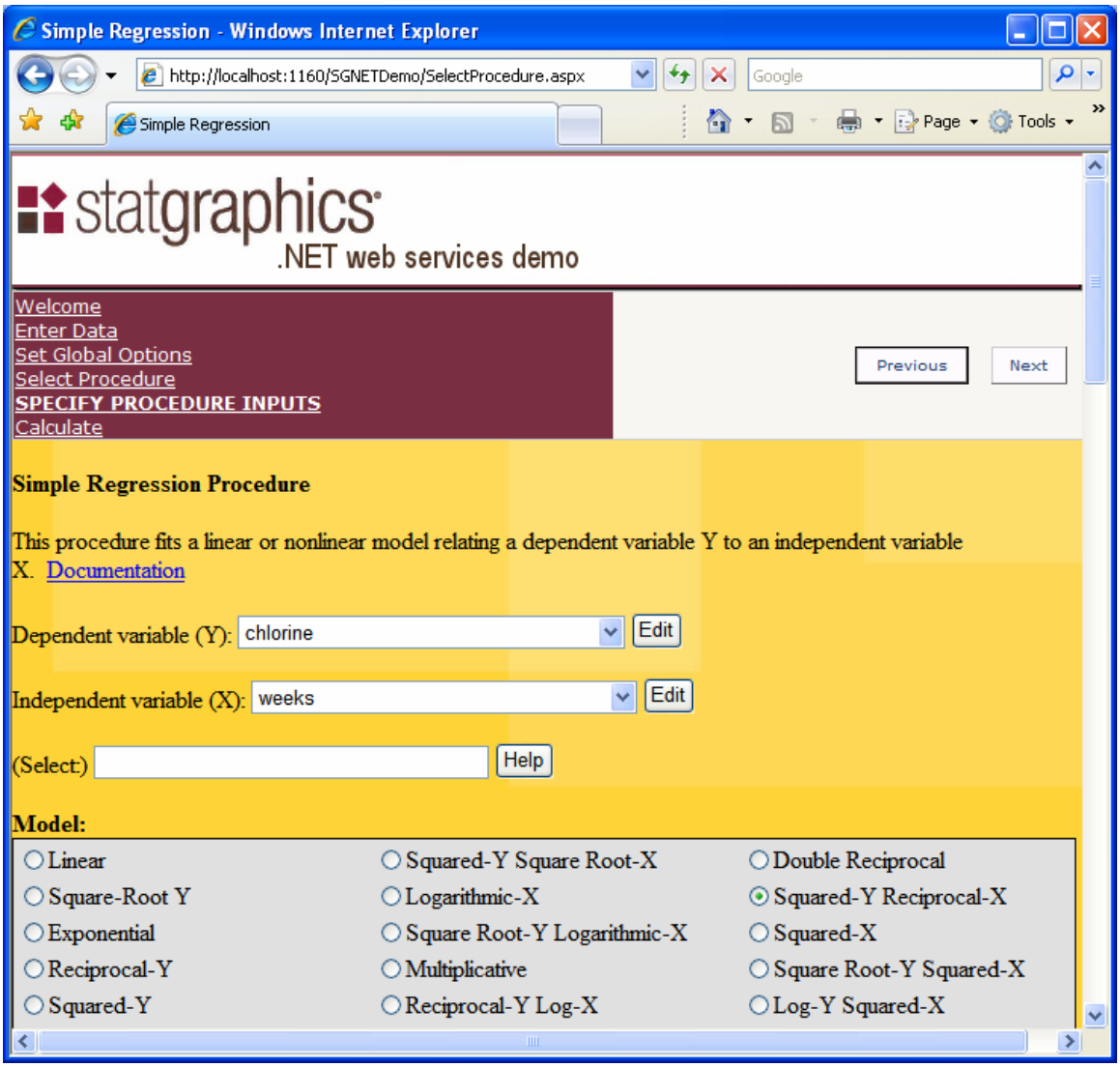
Global options control things such as the number of significant digits in the output, the size and resolution of the graphics, and the output language. These settings are passed to the web services in the GLOBALS section of the XML script.

Step 3: The statistical procedure is selected.



This selection is passed to the web services using a PROC statement in the XML script.

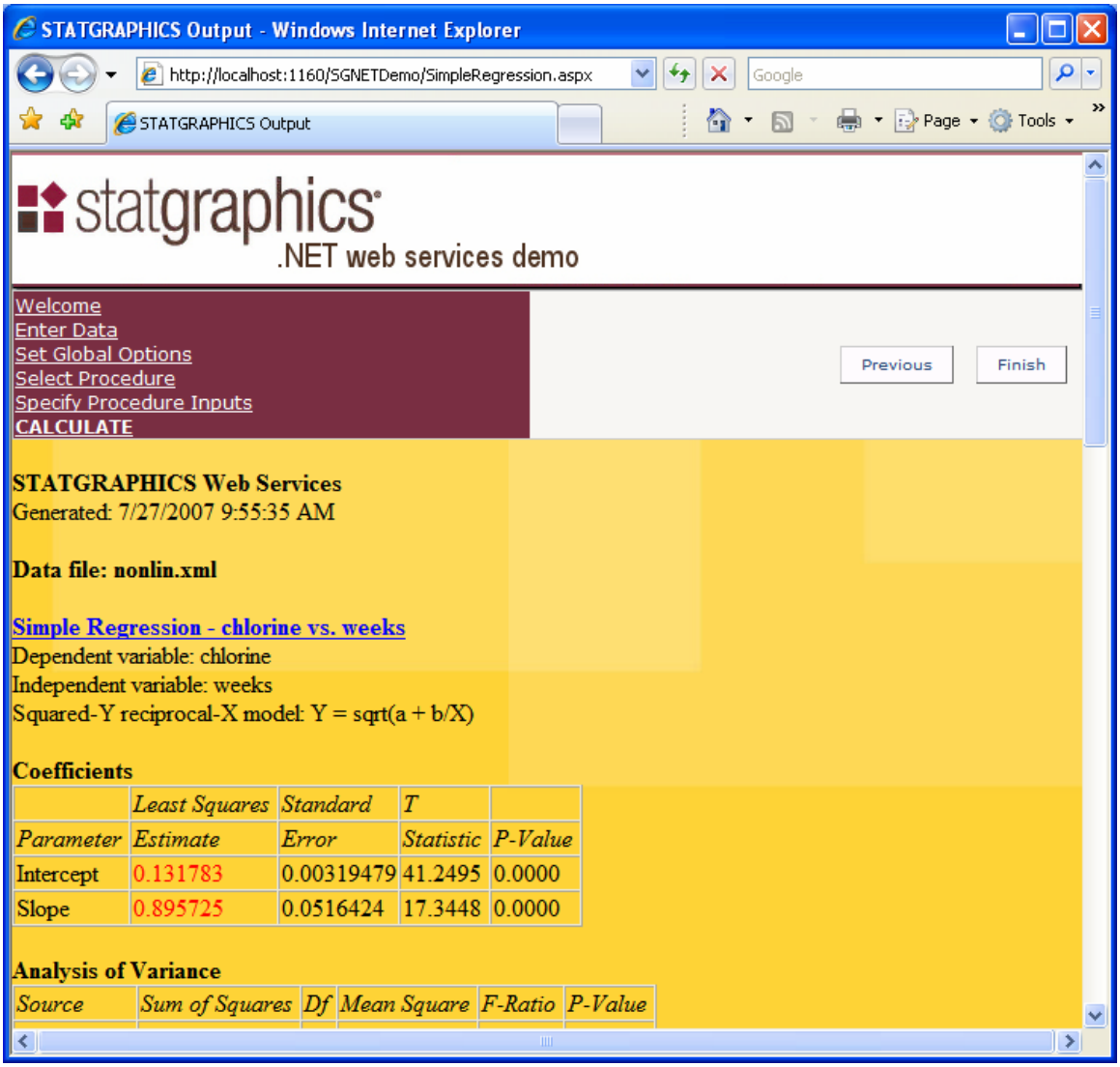
Step 4: Procedure inputs are specified.



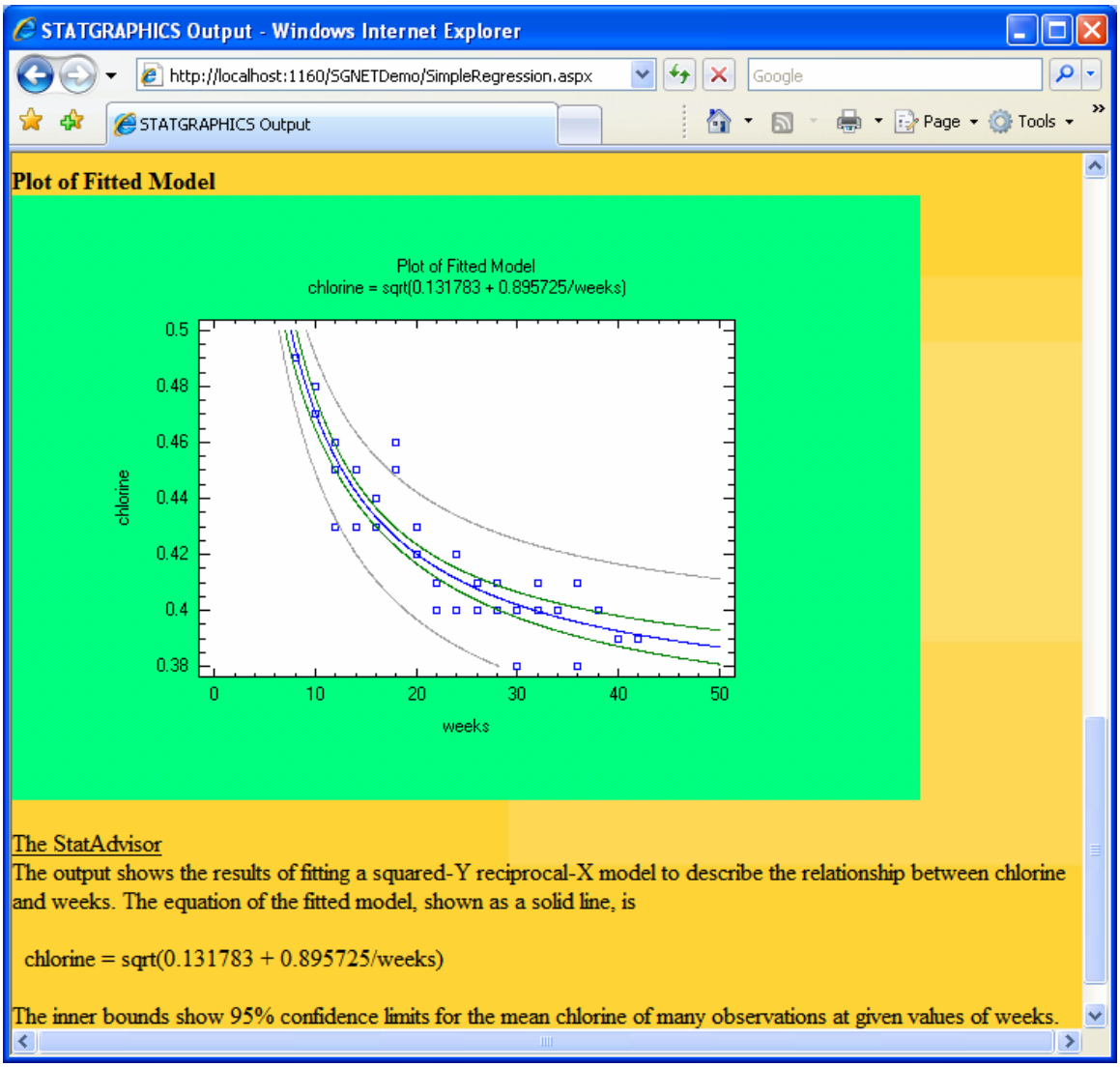
The input includes the names of the fields containing the data to be analyzed, names of output fields to be saved, and procedure specific options. These settings are passed to the web services in the corresponding PROC section of the XML script.

Step 5: Calculations are performed and the output returned.

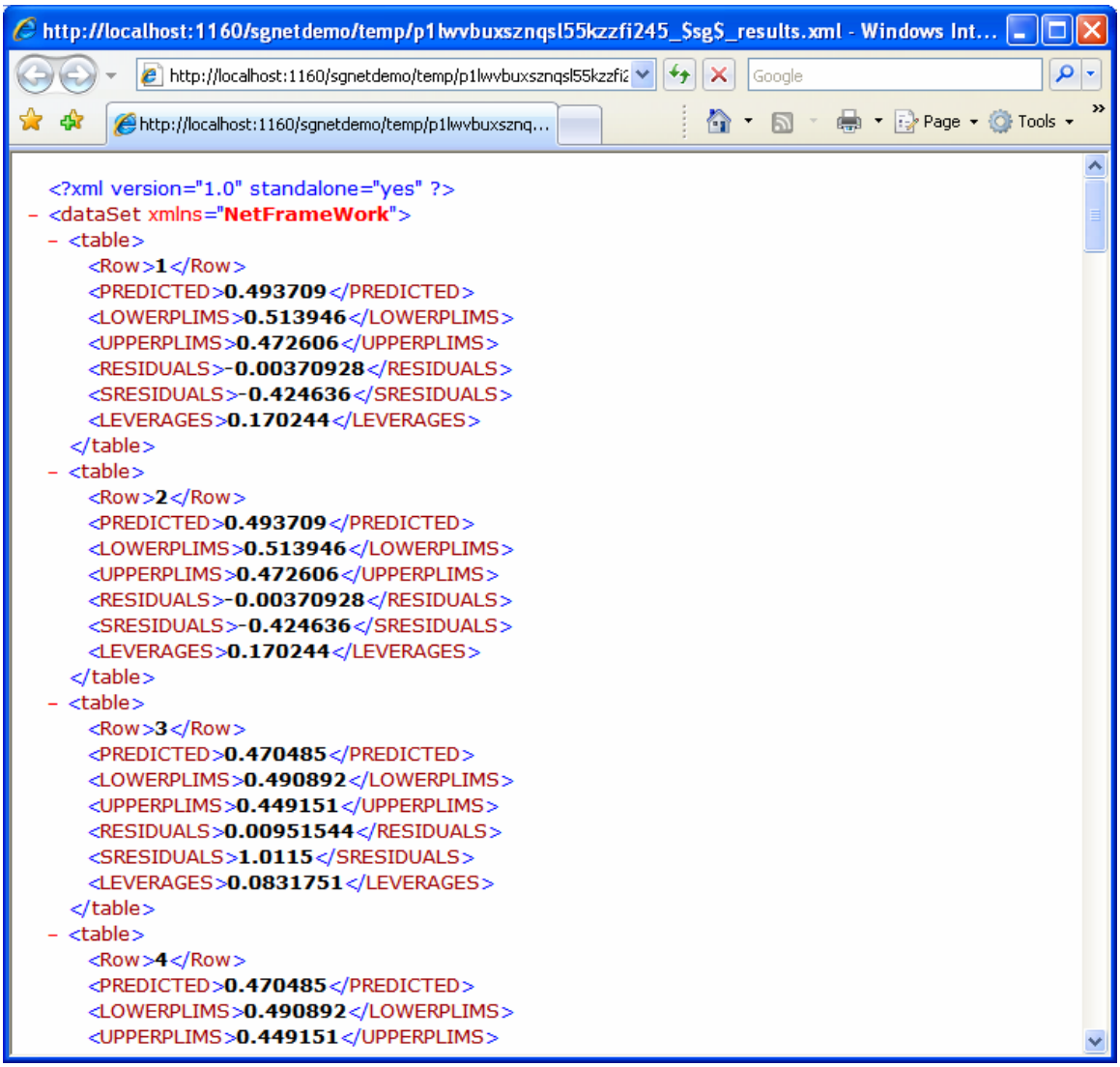
The web services then execute the script and return the output as an HTML page. Numerical output is returned in standard HTML tables so that it may be easily copied to applications such as Microsoft Excel:



Graphs are returned as imbedded images so that they can be imbedded in other HTML pages if desired:



Any calculated results are returned as XML:



Creating XML Scripts

To ease the development of XML scripts, the program's GUI can be modified to interpret and create such scripts. In STATGRAPHICS, we have added a "Show XML" option to various windows and dialog boxes, which displays the XML script required to create the output in that window. The script can be copied and pasted into other documents. We have also added two lines to the *File* menu:

> *Execute XML Script*: read san XML script and creates the requested output within the GUI.
>
> *Create XML Script:* saves an XML script that creates the contents of the current StatFolio when submitted to the Web Services.

Conclusion

ASP.NET Web Services provide a convenient mechanism for exposing statistical calculations to external web applications. Simple XML scripts can be created and posted to the server, which will return the output in a web-friendly format. The approach makes it possible for web application developers to access the statistical calculations of a program while bypassing its normal GUI. If desired, the GUI can be modified to interpret those same XML scripts, so that users can reproduce the same analyses within the menu-driven application.