Paper 48-28

Automotive Warranty Data Analysis on the World Wide Web

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ABSTRACT

Trillium Teamologies assembled a team possessing SAS and Java expertise to create a warranty analysis web application for an automotive OEM. This paper discusses development strategies considered in building the application, including architectural and security considerations. Criteria are provided for deciding among client load models that range from thin (webAF[®] model) through integrated object (Enterprise Guide[®] model) to full client (SAS/AF[®] model) approaches. This paper includes some of the development considerations and decisions made in web-enabling an enterprise wide application:

- choice of web technology (CGI v. Java)
- applet v. servlet methodology
- development environment (AppDevStudio[®] v. Forte)
- populating list box controls (on-demand access v.
- server page caching)
- processing large tasks through a batch queue facility
- using ODS to deliver reports in *.pdf form

Choice of model is dependent on cost, complexity, control, and response time requirements.

INTRODUCTION

The automotive industry spends billions of dollars to cover warranty claims each year. Analysis of repair claims is key to improvement in vehicle design, production, maintenance and image. Reliability is associated with warranty history and directly impacts the market value of new cars sold, lease residual values, and used car values. Quality, reliability, and durability indices are the data mining gems of warranty analysis. Automotive companies strive to improve these indicators, which impact both sales and profitability.

A leading automotive manufacturer had developed a warranty analysis system called QWIK (Quality With Information and Knowledge) as a SAS/AF client server application. This system provides quality control, reliability, and durability feedback to both internal (OEM) and supplier audiences. QWIK analysis serves as a basis for allocating financial incentives to suppliers who meet and exceed quality standards set by the OEM. Likewise, the analysis of this data provides serves as one basis for risk-sharing between the OEM and the supplier community.

The OEM selected Trillium Teamologies (TTI) to develop *QWIK Web*, a web version of the QWIK full client product. QWIK Web is designed to reduce client-side software licensing costs, simplify report production, and re-use existing code.

Now available are QWIK (as a fully featured client/server application), QWIK Web (as a thin client subset of QWIK), and Enterprise Guide (for freestyle reporting against the data). To meet the customer's requirements, the team was confronted with a number of decisions concerning methodology, design, and choice of development toolsets. This paper offers a simple set of criteria in helping make such decisions, and a discussion of how other business requirements were met.

SOFTWARE REQUIREMENTS

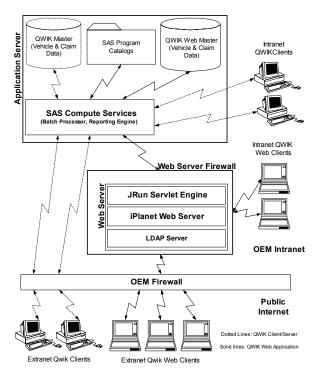
QWIK Web reflects a three-tier architecture: browser, web server, and application server. The browser tier requires Microsoft Internet Explorer 5.0 or Netscape 4.1 and Adobe Acrobat Reader 5.0. The web server tier requires Sun iPlanet 4.1 Web Server, LDAP, JRUN, Sun Java 2 Platform (J2EE), JDBC, RMI, and SAS Java classes. The application server requires Version 8.2 under Solaris of the following SAS software products: Base SAS[®], SAS/CONNECT[®], SAS/SHARE[®], SAS/AF[®], SAS/STAT[®], SAS/QC[®], and SAS/GRAPH[®]. AppDev Studio[®] version 2.02 and Sun Forte 3.0 served as development environments.

The full-client edition of QWIK has fifty SAS/AF Frames containing 450 form elements. There are about 50,000 lines of SAS code that split execution cycles between client and server. The new QWIK Web application serves up fifteen pages containing 225 form elements. There are about 26,000 lines of Java, JSP, HTML, and SAS code that execute on web and application servers.

ARCHITECTURE

QWIK (full client) and QWIK Web (thin client) share the same application server and data sources. The full client interface is supplied by SAS/AF Frame entries, while the thin client interface consists of a browser that displays HTML pages sent by the web server.

QWIK Production Environment



The web server houses QWIK Web classes, JavaServer Pages, form design elements, and style sheets. The application server houses SAS programs, reference tables, and production files.

SECURITY

The OEM Intranet does not operate like the typical Internet environment. Communication for authentication is unidirectional, and the messages sent are "Dead on Arrival". This causes authentication problems. In addition, when the application server requires a user to change password, there is no way to read a request sent by the telnet session on the Unix server. Lightweight Directory Access Protocol (LDAP) was chosen to overcome the inherent limitations of server communication in the customer's environment.

The LDAP server sits on top of the web server application folder, requesting login before access to the directory. The LDAP server has several scripts to allow the user to modify the password, reset the password after the expiration period and allow only one user to have a single instance of the web application running.

Using the LDAP approach, the customer's requirements for security were met.

DESIGN CHOICES

A number of design and development choices are required in the course of building a product. Following are some of the design choices made in building QWIK Web.

Web Technology (CGI v. Java)

Java technology offers multi-threaded access, high security, and persistent connection with a single image of SAS on the application server. These features supported choice of webAF over CGI-based SAS/InterNet[®] as development framework.

Applet v. Servlet Methodology

JavaServer Page, Java servlet, and JavaScript technology was selected over Java applets. Server side advantages include ease of maintenance, platform independence, security deployment, minimal impact on client resources, and consistency with industry trends in development preference.

IDE (AppDevStudio v. Forte)

AppDevStudio 2.02 continues to evolve as an Interactive **D**evelopment **E**nvironment tool. Sun Forte 3.0 represents a more robust tool for the Java developer. Both are useful in their own way.

Populating Controls (cache v. read)

QWIK Web controls, and list boxes in particular, draw from several dozen SAS data sets that reside on the application server. To maximize performance, it was decided to cache selection alternatives in a class on the web server. There are now only three occasions where application server data sets must be addressed during session.

Queuing Execution Intensive Tasks

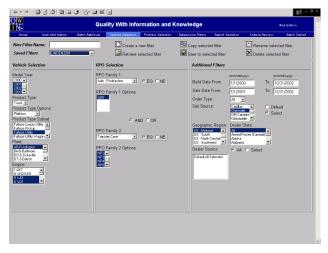
One of the most significant features of the QWIK full client edition that has been replicated in QWIK Web is the batch facility. Web users are accustomed to sub-second response time, yet applications that work against large files using complex logical operations take more than a second to complete process. The batch queue facility conditions customers to the prospect of a longer wait, yet frees up time to submit other requests or go on to other tasks as the job submitted works its way to completion.

Presentation of Results

Finally, trial and error taught us that some forms of presentation through a browser are better than others. After repeated attempts to encapsulate heavily annotated SAS/GRAPH output in HTML as *.gif and *.jpg files, we discovered that Adobe Acrobat Reader 5.0 (*.pdf) provides an excellent Output Delivery System (ODS) target.

QWIK WEB OPERATION

QWIK Web guides the warranty analyst through two distinct phases. The first phase involves selection of vehicle, claim, and report attributes that may be stored in a filter under the user's ID. The second phase consists of queuing the request, processing millions of rows, and delivering results. The following image depicts selection of vehicle attributes.



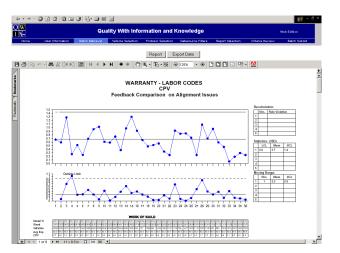
Other pages provide for selection of issues, choice of report type, review of current criteria, submission of a request to the application server, retrieval of results, and administrative functions.

No request to process is granted until all required information has been supplied. There is extensive error handling associated with the process of defining a QWIK Web report. JavaScript is the primary tool used in trapping errors at the form element level, while JSP code handles errors that occur within and across pages.

Selections are stored in a Java Bean. The act of submitting a request is that point where Java data structures on the web server transfer content to SAS data structures on the application server. A batch record is created, and the user's personal queue is displayed. The "Batch Retrieval" page is the user's link to report product.

| | tresh Retrie | er Information ve Dei | | Vehicle Selection Problem Selec | tion Datasource Filt | ers Repor | Selection | Criteria Review | Batch Submit |
|-----|--------------|--------------------------|------------|---|----------------------|-----------|--------------|-----------------|--------------|
| 6.8 | Date | Time | | Batch Desc. | Туря | Obs. | User Id | Status | Select |
| 642 | 04/26/2002 | 12:21:14 | 05/08/2002 | Control Chart of Alignment Issues | Centrel Chart | 17 | queikpro d | Complete | |
| 617 | 04/26/2002 | 10:42:24 | 05/06/2002 | Incremental Fan Chart en Alignment Issues | Fan Charl | 20 | quikprod | Complete | |
| 615 | 04/26/2002 | 10:40:48 | 05/05/2002 | Feedback Comparison on Alignment Issues | Centrel Chart | 68 | quiliprod | Complete | |
| 612 | 04/25/2002 | 10:13:59 | 05/05/2002 | Issues Related to Alignment | Detail Report | 12 | quikprod | Complete | |
| 510 | 04/25/2002 | 9.52:13 | 05/05/2002 | N0110 as Related Alignment Issue | Detail Report | 129 | quikprod | Complete | |
| 809 | 04/26/2002 | 9.51.00 | 05/06/2002 | Verbatims Detail on Alignment Issues | Detail Report | 1044 | queikpro d | Complete | |
| 808 | 04/26/2002 | 9.50.09 | 05/08/2002 | Detail Report on Alignment laives | Detail Report | 6208 | queikpro d | Complete | |
| 607 | 04/26/2002 | 9.41.33 | 05/06/2002 | BY Analysis of Alignment Issues | BY Analysis | 34 | queikprod | Complete | |
| 000 | 04/20/2002 | 9.37:50 | 05/06/2002 | Profile Report on Alignment Issues | Profile Report | 634 | quikprod | Complete | |
| 605 | 04/25/2002 | 9.33.40 | 05/05/2002 | Top Alignment issues | Top Issues Chart | 33 | quiliprod | Complete | |
| 572 | 04/25/2002 | 11:00:10 | 05/05/2002 | Linden | Top Issues Chart | 1 | quikprod | Complete | |
| 563 | 04/23/2002 | 14:23:14 | 05/03/2002 | Fremant | Top Issues Chart | 1 | quelkpro d | Complete | |
| 508 | 04/18/2002 | 16:34:55 | 04/28/2002 | OM Test Care 6 | Detail Report | 300 | queikprod | Complete | |
| 489 | 04/18/2002 | 13:48:37 | 04/28/2002 | bruces job #1 | Centrel Chart | 11 | queikpro d | Complete | |
| 476 | 04/18/2002 | 9.68.01 | 04/28/2002 | Neticape-Alaska | Fan Chart | 20 | quikprod | Complete | |
| 476 | 04/18/2002 | 9.55:10 | 04/28/2002 | retest | Centrel Chart | 17 | quiliprod | Complete | |
| 474 | 04/18/2002 | 9.45.39 | 04/28/2002 | Netscape 1 | Top Issues Chart | 1 | quelikg co d | Complete | |
| | 04/17/2002 | 13:51:17 | 04/27/2002 | Top Issues on MY2001 Linden Trusks | Top Issues Chart | 1 | quikprod | Complete | |

Once processing completes, a report can be retrieved and then printed or exported using Adobe Acrobat Reader 5.0.



Report options include a top issue chart, control charts, reports on claim incidence and cost by category, and detail listings that drill down to specific vehicles and associated claims.

JAVA GLOSSARY

Java uses the *package.class.method(parameters)* statement style. This syntax is common in object oriented languages like SAS/AF, C++, C#, VB.NET, Eiffel, and Smalltalk. Any new object is defined as an instance of a class in the Java class hierarchy. Each new class inherits the attributes and behaviors of its parent, and can subsequently be modified to suit a particular purpose. Classes reside in packages that must be identified at the top of each Java program. Here are definitions for a few of the many web development constructs.

HTTP: HyperText Transfer Protocol v 1.1 is a request-response protocol consisting of a request method (e.g., GET, POST), a URI, header fields, and a body. HTTP Servlets written in Java manage state (sessions) on top of stateless HTTP, process data submitted by an HTML form, and provide dynamic content to the user through a browser.

HTML: HyperText Markup Language v 4.0 is the publishing language of the World Wide Web. HTML provides for publication of text, media, hyperlinks, scripting languages, style sheets, and printing facilities.

J2EE: The Sun Microsystems Java 2 Platform, Enterprise Edition, v 1.3.1 API specification supplies packages for writing Java applications.

Servlet: Java Servlets v 2.2 are modules developed by a programmer that run in a server application to answer client requests. Servlets make use of the Java packages "javax.servlet" and "javax.servlet.http".

JSP: JavaServer Page v 1.1 technology is an extension of servlet methods. The JSP combines static HTML templates with code for generating dynamic content.

Java Classes: In object oriented design, a *class* is the set of all programming objects that share common attributes and behaviors. *Methods* are program behaviors that act upon objects. A character variable is an *instance* of a class, while a trim operation on this variable's value would exemplify use of a method on the object.

JavaScript: JavaScript is an interpreted language that serves to extend HTML by handling events on the client side. Error trapping, messaging, and dialogs are often implemented in JavaScript.

RMI: Java Remote Method Invocation enables the programmer to create distributed applications in which the methods of remote Java objects can be invoked from other Java virtual machines, possibly on different hosts.

ROCF: The SAS Remote Object Class Factory is the entity which, given a connection and an interface to a model, creates the remote object and returns a handle to the remote object back to the viewer. For example, ROCF can serve as interface between a model SCL object on the application server and a Java object on the web server. Remote objects can be used, via the model interface, just like any other Java object. Client side Java objects include applets, servlets, Java beans, and JavaServer Pages.

JAVA CODE

QWIK Web application flow consists of :

- starting the application
- caching form element values
- providing for selection of values
- error handling
- processing and storing selections
- sending selections to the application server
- producing a report

"Model Year" is among the vehicle attributes required for a report to run. The following code fragments trace the life of "Model Year" as a list box selectable item.

QWIK Web application classes extend Java and SAS/webAF classes. These are stored in the "tti" package. All *.java files are compiled into *.class files, and are made available to one another by "import" statements in Java programs and "include" directives in JSP programs.

StartServlet.java initiates population of application controls.

List and drop-down boxes require values supplied by SAS data sets resident on the application server. *QWIKCommonVariables.java* creates string variables representing these data sets.

```
// Identify the Model Year data source
public interface QWIKCommonVariables{
    public final String TABLE_MODEL_YEAR=
    "Qwikdata.Web_years";
}
```

The table "ModelYears" is associated with the "Qwikdata" libref in the SAS autoexec on the application server. This table contains a code value for model year ("vinyr") in the first column and associated description in the second column ("modelyr"). The following routine iterates through the SAS data set in loading two Java collection objects: "staticModelYearCodes" and "staticModelYearDescriptions".

QWIKCommonData.class imports data from the application server

// Identify resources import tti.*; import java.io.*; import com.sas.*; // Establish application server connection com.sas.rmi.Rocf rocf=new com.sas.rmi.Rocf(); com.sas.rmi.Connection con=new com.sas.rmi.Connection(); con.setPort(tti.QWIKCommonVariables.port); // Create a remote object on the app server si=(SubmitInterface)rocf.newInstance (SubmitInterface.class.con); dataset=(com.sas.sasserver.dataset. DataSetInterface)rocf.newInstance

(com.sas.sasserver.dataset. DataSetInterface.class,con); // Cache Model Year codes (values) and descriptions private com.sas.collection.StringCollection staticModelYearValues; private com.sas.collection.StringCollection staticModelYearDescriptions; try{ dataSet.setDataSet(TABLE_MODEL_YEAR); dataSet.setDisplayedColumns(new String[]
 {"vinyr", "modelyr"});
iTotalNumberOfRows=dataSet.getRowCount(); codes=new String[iTotalNumberOfRows]; values=new String[iTotalNumberOfRows]; for (iCurrentRow=0; iCurrentRow<iTotalNumberOfRows; iCurrentRow++) { values[iCurrentRow] = (String) dataSet.getCell (iCurrentRow+1,1).toString().trim(); descriptions[iCurrentRow] = (String) dataSet.getCell (iCurrentRow+1,2).toString().trim(); } staticModelYearValues=new
 com.sas.collection.StringCollection (values); staticModelYearDescriptions=new com.sas.collection.StringCollection (descriptions); values=null; descriptions=null; iTotalNumberOfRows=0; iCurrentRow=0; } catch (com.sas.table.TableException e) { Application Logger.fatal ("Error in caching Model Year."); // Instantiate public GET methods public com.sas.collection.StringCollection getModelYearValues() { return new com.sas.collection.StringCollection (staticModelYearValues.toStringArray()); public com.sas.collection.StringCollection getModelYearDescriptions() { return new com.sas.collection.StringCollection (staticModelYearDescriptions. toStringArray()); } QWIKUserOptions.java is the central event processing module of the application. The following method (getModelYear) uses the SAS ListboxInterface method for storing selected Model Year codes and associated descriptions. public com.sas.servlet.beans.ListboxInterface qetModelYear() { return createListbox ("selectModelYear",false, commonData.getModelYearValues(), commonData.getModelYearDescriptions(), userBean.collModelYear,4); } Another QWIKUserOptions public method gets up to the minute user selections stored in the user bean. // Public GET method

```
// Public GET method
public com.sas.collection.StringCollection
    getModelYearData() {
        return userBean.collModelYear;
}
```

analysis-step1.jsp contains HTML code for presenting users with
the "Model Year" list box along with Java statements for
handling selections.
<! --Identify resources-- >

```
<%@ include file='../includes.jsp' %>
// Populate the list box
com.sas.servlet.beans.ListboxInterface
  listboxModelYear=user_Options.getModelYear();
// Communicate selections
userOptions.setModelYear(request.
    getParameterValues("selectModelYear"));
<! -- Supply page content-- >
<html>
    <br><hr noshade> Model Year: <br>
< %
  listboxModelYear.setCustomAttributes
       (" multiple ");
  listboxModelYear.write(out);
%>
</html>
QWIKUserBean.java stores user selections in Java collections.
// Import SAS string collection class
```

// Define a collection for selected values
public class QWIKUserBean() {
 public QWIKUserBean() {
 public com.sas.collection.StringCollection
 collModelYear=new
 com.sas.collection.StringCollection();
 }
}

import com.sas.collection.StringCollection;

analysis-step5.jsp sends selection parameters from the web server to the application server for processing against production files.

```
<! --Identify resources-- >
<%@include file="../includes.jsp" %>
<%@page import="com.sas.sasserver.*,
    com.sas.sasserver.submit.SubmitInterface,
    com.sas.rmi.Connection,
    com.sas.collection.StringCollection,
    com.sas.collection.SortedCollection,
    java.util.Properties,
    java.sql.DriverManager,
    java.sql.Driver"
    contentType="text/html"
%>
// Establish connection to the app server
com.sas.sasserver.submit.SubmitInterface
```

```
si=null;
com.sas.sasserver.dataset.DataSetInterface
    dataSet=null;
com.sas.rmi.Rocf rocf=new com.sas.rmi.Rocf();
com.sas.rmi.Connection
    con=new com.sas.rmi.Connection();
con.setServerArchitecture(con, "UNIX");
con.setHost(tti.QWIKCommonVariables.host);
con.setUsernamePrompt("login:");
con.setUsername(tti.QWIKCommonVariables.user);
con.setPasswordPrompt("Password:");
con.setPassword(tti.QWIKCommonVariables.pass);
con.setCommandPrompt
    (tti.QWIKCommonVariables.prompt);
con.setCommandPromptTimeout
(tti.QWIKCommonVariables.timeout);
con.setCommand("/app/sas82/sas
    -dmr -comamid tcp
    -device grlink -noterminal -autoexec
    /app/sas82/autoexe.sas
                               -config
    /app/sas82/sasv8.cfg -altlog
    /qwikweb/saslog.log
    -no\\$syntaxcheck");
con.setPort(tti.QWIKCommonVariables.port);
con.setFunnelHost
    (tti.QWIKCommonVariables.host);
```

```
// Instantiate the SAS submit interface
si=(SubmitInterface)rocf.newInstance
  (SubmitInterface.class,con);
si.setProgramText(
  "options mprint mlogic symbolgen fullstimer;" +
   "libname qwikweb '/qwikweb' access=readonly;" +
   "filename pgms catalog 'qwikweb.webprograms';" +
   "%let ModelYear = %str(" +
        user_Options.getModelYearData().
        toString(',',false).replace('"',' ') +
        ");" +
   "%include pgms(javabean);" +
   "%javabean;");
rocf.stop();
```

ROCF behaves like the SAS/CONNECT remote submit, and the submit interface looks like a submit block in SAS/AF SAS Component Language. In addition to using macro variables, the developer can use an SCL object or JDBC to communicate Java variable values to SAS on the application server side.

To complete the cycle, here is sample SAS code for processing Model Year values selected by the QWIK Web warranty analyst.

```
%macro javabean;
data work.javabean;
   length ModelYear $ 20;
ModelYear=symget(`ModelYear');
run;
%mend javabean;
```

In sum, the web server starts by caching items, the user selects from these options, a parameter file passes to the application server to subset and report on production files, and the user retrieves results once processing completes.

CHOICE OF MODEL

QWIK Web, Enterprise Guide, and QWIK form a continuum from thin through integrated object to full client technologies. Choice of technology depends on requirements. We suggest use of the following table in considering these options.

| Requirements | Build with webAF | Use Enter- prise Guide | Build with SAS/AF |
|------------------------------------|---------------------|------------------------------|-------------------------|
| Minimize development cost | No | Yes | No |
| Minimize maintenance cost | Yes | Yes | No |
| Minimize user training and support | Yes | No | Yes |
| Standardize reporting | Yes | No | Yes |
| Minimize response time | Yes | Yes | Yes |

Minimize development cost: Commercial off the shelf software (COTS) is often preferred over custom development. If you don't have a budget for software development, then Enterprise Guide is a great tool for communicating with a Version 8 SAS Server. However, if you have very specific requirements that cannot be addressed by a reporting tool, then development could proceed using webAF for a web based solution, or SAS/AF as a client server solution.

Minimize maintenance cost: The only maintenance required of a COTS product is upgrading to newer releases. webAF represents somewhat lower maintenance cost because most changes occur only on the server side. SAS/AF solutions can be the most robust, but require distribution of client side modules with each maintenance release.

Minimize user training and support: Both web and client server solutions provide a structured environment for the user. Enterprise Guide is very user friendly, but requires a relatively

sophisticated audience. Opportunity for error is often greater when there is greater flexibility in defining elements of the reporting process.

Standardize reporting: Since the automotive OEM is sharing risk and reward with the supplier community on the basis of QWIK Web reports, it is essential that both parties have an opportunity to replicate findings without resorting to code review. Structured applications provide uniformity in results, all other things being equal.

Minimize response time: All three models offer efficient means of responding, whether target data reside in SAS data sets or data base tables on the server. QWIK and QWIK Web feature a batch queue facility that sets appropriate expectations regarding time to completion for tasks that are more resource (CPU and I/O) intensive.

Casual users benefit most from a webAF based solution. The Enterprise Guide solution is good for the slightly more adventurous analyst. And a full client solution based on the SAS/AF model provides for both structured interaction with an application, and free form exploration on the client side with subsets drawn down from the server.

CONCLUSION

Providing web access to corporate data in a securely managed environment is the direction that all companies are exploring today. Web enabled applications are platform independent, providing access to many more users than the full client alternative. The user need only have a web browser to access a complex analytical production application that provides summary and decision support feedback based on user selections. It demonstrates that a SAS based application can be distributed over the web, without losing significant functionality. Further, it represents a cost-effective solution to the problem of sharing corporate data with suppliers while maintaining security.

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