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SAS® Scoring Accelerator 1.8 for Greenplum

User's Guide

SAS® Documentation

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Chapter 1

Introduction to the SAS Scoring Accelerator for Greenplum

Overview of the SAS Scoring Accelerator for Greenplum

When using conventional processing to access data inside a Greenplum database, SAS Enterprise Miner asks the SAS/ACCESS engine for all rows of the table being processed. The SAS/ACCESS engine generates an SQL SELECT * statement that is passed to the Greenplum database. That SELECT statement fetches all the rows in the table, and the SAS/ACCESS engine returns them to SAS Enterprise Miner. As the number of rows in the table grows over time, network latency grows because the amount of data that is fetched from the Greenplum database to the SAS scoring process increases.

The SAS Scoring Accelerator for Greenplum embeds the robustness of SAS Enterprise Miner scoring models directly in the highly scalable Greenplum database. By using the SAS In-Database technology and the SAS Scoring Accelerator for Greenplum, the scoring processing is done inside the database, and thus does not require the transfer of data.

The SAS Scoring Accelerator for Greenplum takes the models that are developed by SAS Enterprise Miner and translates them into scoring functions that can be deployed inside Greenplum. After the scoring functions are published, the functions extend the Greenplum SQL language and can be used in SQL statements like other Greenplum functions.

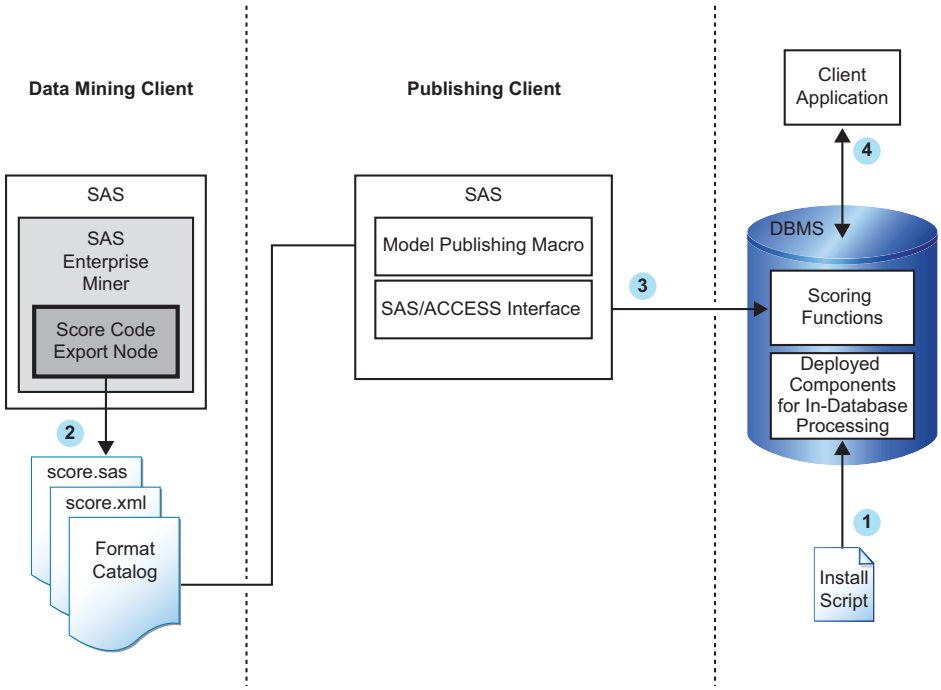
The SAS Scoring Accelerator for Greenplum consists of two components:

- the Score Code Export node in SAS Enterprise Miner. This extension exports the model scoring logic, including metadata about the required input and output variables, from SAS Enterprise Miner.
- the publishing client that includes the %INDGP_PUBLISH_MODEL macro. This macro translates the scoring model into .c and .h files for creating the scoring functions and generates a script of Greenplum commands for registering the scoring functions. The publishing client then uses the SAS/ACCESS Interface to Greenplum to publish the scoring functions to Greenplum.

How the SAS Scoring Accelerator for Greenplum Works

Using SAS Enterprise Miner, you can generate SAS DATA step code that contains scoring functions. The SAS Scoring Accelerator for Greenplum takes the scoring model code, the associated property file that contains model inputs and outputs, and a catalog of user-defined formats, and deploys, or publishes, them to the Greenplum database. Inside the Greenplum database, one or more scoring functions are created and registered for use in SQL queries. Figure 1.1 illustrates this process.

Figure 1.1 *Process Flow Diagram*



1 Install the components that are necessary for in-database processing in the Greenplum database.

   For more information, see Chapter 2, "Deployed Components for In-Database Processing," on page 5.

   Note: This is a one-time installation process.

2 Use SAS Enterprise Miner to create a scoring model, and use the Score Code Export node to export files that are used to create the scoring functions to a score output directory.

   For more information, see Chapter 3, "Exporting the Scoring Model Files from SAS Enterprise Miner," on page 7.

3 Start SAS 9.2 and run the SAS publishing macros.

   For more information, see Chapter 4, "Publishing the Scoring Model Files," on page 19.

4 After the scoring functions are created, they are available to use in any SQL expression in the same way that Greenplum built-in functions are used.

For more information, see Chapter 5, "Scoring Functions Inside the Greenplum Database," on page 27.

Chapter 2

Deployed Components for In-Database Processing

Overview of Deployed Components for In-Database Processing

The following components are deployed:

- the SAS 9.2 Formats Library for Greenplum. The SAS 9.2 Formats Library for Greenplum contains many of the formats that are available in Base SAS and processes any formats that might be included in your scoring model.
- the binary file for the SAS_COMPILEUDF function. The %INDGP_PUBLISH_COMPILEUDF macro publishes the SAS_COMPILEUDF function in the SASLIB schema of a Greenplum database. The SAS_COMPILEUDF function compiles the scoring model source files into shared object files and links to the SAS 9.2 Formats Library for Greenplum.

Components that are deployed to Greenplum for in-database processing are contained in a self-extracting TAR file (accelgplmfmt.sh) on the SAS Software Depot.

For more information about creating the SAS Software Depot, see your Software Order e-mail. For more information about installing and configuring these components, see the *SAS In-Database Products: Administrator's Guide*.

Chapter 3

Exporting the Scoring Model Files from SAS Enterprise Miner

Overview of the Score Code Export Node

Users of SAS Enterprise Miner develop data mining models that use measured attributes to either characterize or predict the value of an event. These models are developed on historical data where an event has been measured or inferred. The models are then applied to new data for which the attributes are known, but the event has not yet occurred. For example, a model can be created based on a credit institution's records of payments that customers made and missed last year and then used to predict which customers will miss payments this year.

SAS Enterprise Miner creates SAS language score code for the purpose of scoring new data. Users run this code in production systems to make business decisions for each record of new data.

The Score Code Export node is an extension for SAS Enterprise Miner that exports files that are necessary for score code deployment. Extensions are programmable add-ins for the SAS Enterprise Miner environment.

The following icon is the Score Code Export node as it appears in a SAS Enterprise Miner process flow diagram.

The following files are exported by the Score Code Export node:

- the SAS scoring model program (score.sas).
- a properties file that contains a description of the variables that are used and created by the score code (score.xml).
- a format catalog, if the scoring program contains user-defined formats.
- an XML file containing descriptions of the final variables that are created by the score code. This file can be kept for decision-making processes.
- a ten-row sample of the scored data set showing typical cases of the input attributes, intermediate variables, and final output variables used to develop the score code. This data set can be used to test and debug new scoring processes.
- a ten-row sample table of the training data set showing the typical cases of the input attributes used to develop the score code.

For more information about the exported files, see "Output Files" on page 11. For more information about using SAS Enterprise Miner, see the SAS Enterprise Miner Help.

Using the Score Code Export Node Compared with Registering Models on the SAS Metadata Server

SAS Enterprise Miner can register models directly in the SAS Metadata Server. Models registered in the SAS Metadata Server are used by SAS Data Integration Studio, SAS Enterprise Guide, and SAS Model Manager for creating, managing, and monitoring production and analytical scoring processes.

The Score Code Export node exports score code created by SAS Enterprise Miner into a format that can be used by the SAS Scoring Accelerator for Greenplum. The exported files are stored in a directory, not the SAS Metadata Server.

The Score Code Export node does not replace the functionality of registering models in the SAS Metadata Server.

Using the Score Code Export Node

Using the Score Code Export Node in a Process Flow Diagram

The **Score Code Export node** icon is located on the **Utility** tab, as shown in Figure 3.1:

Figure 3.1 *The Diagram Toolbar with the SAS Score Code Export Node Icon Highlighted*

To use the Score Code Export node, you need a process flow diagram that contains nodes that produce score code and that flow to a Score node. The Score node aggregates the score code for the entire analysis path. The Score node must precede the Score Code Export node in the process flow diagram.

Figure 3.2 shows a valid data mining process for exporting score code:

Figure 3.2 *Data Mining Process Flow Diagram*

Requirement: The Score Code Export node exports score code that contains only one DATA step. For a list of SAS Enterprise Miner nodes that produce score code, see "SAS Enterprise Miner Tools Production of Score Code" on page 14.

After the process flow diagram is in place, set the properties for the Score node and the Score Code Export node:

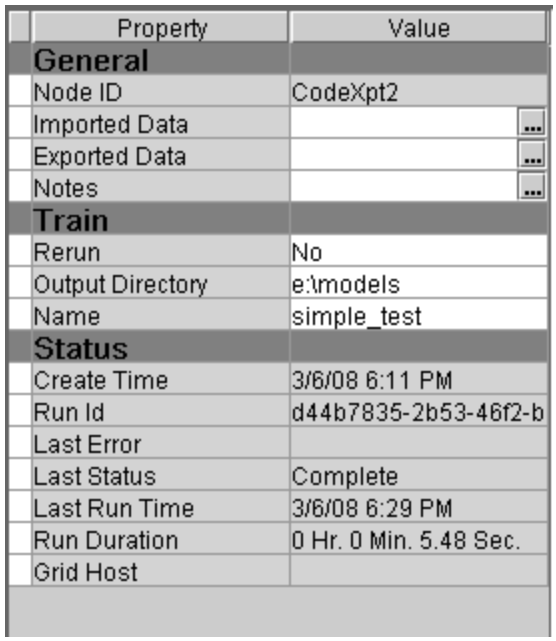
1. Select the Score node. Ensure that the following properties are set to their default value of Yes:
   - **Use Output Fixed Names**
   - **C Score**
2. Select the Score Code Export node and set the properties. The **Output Directory** property specifies the directory to store the export files. The **Name** property specifies the folder that contains the output files created by the Score Code Export node. For information about the properties, see "Score Code Export Node Properties" on page 9.

After the properties are set, you are ready to export the score code. Right-click the Score Code Export node and select **Run**. When SAS Enterprise Miner completes processing, the Run Status window opens to indicate that the run completed. Click the **Results** button to view the output variables and the listing output. For information about the output, see "Output Created by the Score Code Export Node" on page 10.

Score Code Export Node Properties

When the Score Code Export node is selected in the diagram workspace, the Properties panel displays all of the properties that the node uses and their associated values, as shown in Figure 3.3.

Figure 3.3 *Properties Panel*



Property	Value
General	
Node ID	CodeXpt2
Imported Data	...
Exported Data	...
Notes	...
Train	
Rerun	No
Output Directory	e:\models
Name	simple_test
Status	
Create Time	3/6/08 6:11 PM
Run Id	d44b7835-2b53-46f2-b
Last Error	
Last Status	Complete
Last Run Time	3/6/08 6:29 PM
Run Duration	0 Hr. 0 Min. 5.48 Sec.
Grid Host	

The following Train properties are associated with the Score Code Export node:

- **Rerun** – Use this property to force the node to run again. This property is useful if the macro variable controlling the target directory and folder name has changed.
- **Output Directory** – Enter a fully qualified name for the location of an output directory to contain the score code files. If no directory is entered, a default directory named Score is created in the SAS Enterprise Miner project directory. You can change the value of the default directory by setting the &EM_SCOREDIR=*directory* macro variable in the SAS Enterprise Miner project start-up code or server start-up code.
- **Name** – Enter the name of the model that you are creating. The name is used to create a new subdirectory in the output directory that contains the exported score files. If no name is entered, a default name is generated as a combination of the &SYSUSERID automatic macro variable and an incremental index (for example, userID, userID_2, userID_3).

  You can replace the &SYSUSERID automatic macro variable with a custom name by setting the &EM_SCOREFOLDER=*score-folder-name* macro variable in the SAS Enterprise Miner project start-up code or server start-up code. An incremental index preceded by an underscore is added to *score-folder-name*.

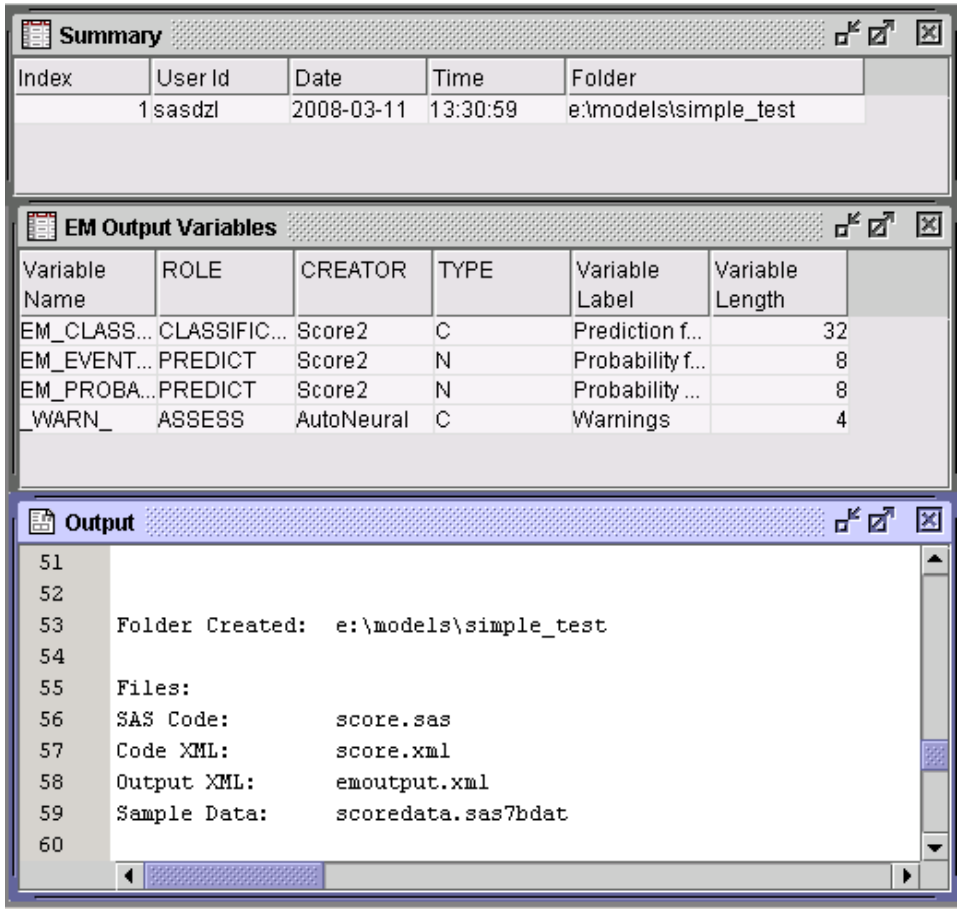
The General and Status properties for the Score Code Export node function just as they do for other nodes.

Output Created by the Score Code Export Node

Results Window

Using the values set in the Properties panel (Figure 3.3), the Score Code Export node creates the following output in the Results window:

Figure 3.4 *Results Using Sample Properties*



Output Files

The Score Code Export node writes the following output files, and a format catalog, if applicable, to the location specified by the Output Directory property. These files are used as input to the %INDGP_PUBLISH_MODEL macro that creates the scoring functions.

File or Folder	Description

score.sas	SAS language score code created by SAS Enterprise Miner. This code can be used directly in a SAS program. A sample program based on the properties shown in Figure 3.3 looks like this:
	`data testout ;`
	`  set simpletest.scoredata ;`
	`  %include "c:\models\simpletest\score.sas";`
	`run;`

score.xml	A description of the variables that are used and created by the scoring code. XML files are created by a machine process for the use of machine processes. Do not edit the XML file. **Restriction:** The maximum number of input variables for a scoring function is 128.

File or Folder	Description
emoutput.xml	A description of the final variables that are created by the scoring code. This file can be kept for decision-making processes. These variables include the primary classification, prediction, probability, segment, profit, and loss variables created by a data mining process. The list does not include intermediate variables created by the analysis. For more information about these variables, see "Fixed Variable Names" on page 13. *Note:* The emoutput.xml file is not used by the %INDGP_PUBLISH_MODEL macro.
scoredata.sas7bdat	A ten-row sample of the scored data set showing typical cases of the input attributes, intermediate variables, and final output variables. Use this data set to test and debug new scoring processes. *Note:* The scoredata.sas7bdat file is not used by the %INDGP_PUBLISH_MODEL macro.
traindata.sas7bdat	A ten-row sample table of the training data set showing typical cases of the input attributes used to develop the score code. *Note:* The traindata.sas7bdat file is not used by the %INDGP_PUBLISH_MODEL macro.
Format catalog	If the training data contains SAS user-defined formats, the Score Code Export node creates a format catalog. The catalog contains the user-defined formats in the form of a look-up table. This file has an extension of .sas7bcat.

Output Variables

The score code produced by SAS Enterprise Miner creates both intermediate variables, such as imputed values of missing values, transformations, and encodings; and output variables, such as predicted value and probability. Any of these created variables can be used in a scoring process.

TIP The number of input parameters on a scoring function has a direct impact on performance. The more parameters there are, the more time it takes to score a row. A recommended best practice is to make sure that only variables that are involved in a model score evaluation are exported from SAS Enterprise Miner.

The most important output variables for the scoring process follow a naming convention using a prefix, as shown in the following table.

Role	Type	Prefix	Key	Suffix	Example
Prediction	N	P_	Target variable name		P_amount
Probability	N	P_	Target variable name	Predicted event value	P_purchaseYES P_purchaseNO

Role	Type	Prefix	Key	Suffix	Example
Classification	$	I_	Target variable name		I_purchase
Expected Profit	N	EP_	Target variable name		EP_conversion
Expected Loss	N	EL_	Target variable name		EL_conversion
Return on Investment	N	ROI_	Target variable name		ROI_conversion
Decision	$	D_	Target variable name		D_conversion
Decision Tree Leaf	N	_NODE_			_NODE_
Cluster number or SOM cell ID	N	_SEGMENT_			_SEGMENT_

Fixed Variable Names

The Score node of SAS Enterprise Miner maps the output variable names to fixed variable names. This mapping is appropriate in cases where there is only one prediction target or one classification target. In other cases, refer to the output variable names described in the previous table.

Using the fixed variable names enables scoring users to build processes that can be reused for different models without changing the code that processes the outputs. These fixed names are listed in the emoutput.xml file and are described in the following table. Most scoring processes return one or more of these variables.

Role	Type	Fixed Name	Description
Prediction	N	EM_PREDICTION	The prediction value for an interval target.
Probability	N	EM_PROBABILITY	The probability of the predicted classification, which can be any one of the target variable values.

Role	Type	Fixed Name	Description
Probability	N	EM_EVENTPROBABILITY	The probability of the target event. By default this is the first value in descending order. This is often the event of interest. The user can control the ordering in SAS Enterprise Miner.
Classification	$	EM_CLASSIFICATION	The predicted target class value.
Expected Profit	N	EM_PROFIT	Based on the selected decision.
Expected Loss	N	EM_LOSS	Based on the selected decision.
Return on Investment	N	EM_ROI	Based on the selected decision.
Decision	$	EM_DECISION	Optimal decision based on a function of probability, cost, and profit or loss weights.
Decision Tree Leaf, Cluster number, or SOM cell ID	N	EM_SEGMENT	Analytical customer segmentation.

SAS Enterprise Miner Tools Production of Score Code

The following table shows the types of score code created by each node in SAS Enterprise Miner. Users can develop their own nodes, known as extension nodes, which can create either SAS DATA step or SAS program score code. However, this code is not converted to PMML, C, or Java.

Node	SAS DATA Step	SAS Program	PMML	C	Java	Greenplum
Sample						
Input Data	*	*	*	*	*	*
Sample	*	*	*	*	*	*
Partition	*	*	*	*	*	*
Append	N	Y	N	N	N	N
Merge	N	Y	N	N	N	N
Time Series	N	Y	N	N	N	N

Node	SAS DATA Step	SAS Program	PMML	C	Java	Greenplum
Filter	Y When the user keeps the created filter variable.	*	N	Y	Y	Y
Explore						
Association	N	Y	Y	N	N	N
Cluster	Y	N	Y	Y	Y	Y
DMDB	*	*	*	*	*	*
Graph Explore	*	*	*	*	*	*
Market Basket	N	Y	N	N	N	N
Multiplot	*	*	*	*	*	*
Path	N	Y	Y	N	N	N
SOM	Y	N	N	Y	Y	Y
Stat Explore	*	*	*	*	*	*
Text Miner	N	Y	N	N	N	N
Variable Clustering	Y	N	N	Y	Y	Y
Variable Selection	Y	N	N	Y	Y	Y
Drop	*	*	*	*	*	*
Impute	Y	N	Y	Y	Y	Y
Interactive Binning	Y	N	N	Y	Y	Y
Replacement	Y	N	N	Y	Y	Y
Principle Components	Y	N	N	Y	Y	Y
Rules Builder	Y	N	N	Y	Y	Y
Transform Variables	Y	N	N	Y	Y	Y
Model						

Node	SAS DATA Step	SAS Program	PMML	C	Java	Greenplum
Autoneural	Y	N	Y	Y	Y	Y
Decision Tree	Y	N	Y	Y	Y	Y
Dmine Regression	Y	N	Y	Y	Y	Y
Dmine Neural	Y	N	N	Y	Y	Y
Ensemble	Y	N	N	Y	Y	Y
Gradient Boosting	Y	N	N	Y	Y	Y
MBR	N	Y	N	N	N	N
Model Import	*	*	*	*	*	*
Neural Network	Y	N	Y	Y	Y	Y
Partial Least Squares	Y	N	N	Y	Y	Y
Rule Induction	Y	N	N	Y	Y	Y
SVM — Linear Kernel	Y	N	Y	Y	Y	Y
SVM — Nonlinear Kernel	N	Y	N	N	N	N
Two Stage	Y	N	N	Y	Y	Y
Assess						
Cutoff	Y	N	N	Y	Y	Y
Decisions	Y	N	N	Y	Y	Y
Model Comparison	Y	N	N	Y	Y	Y
Score	Y	N	N	Y	Y	Y
Segment Profile	*	*	*	*	*	*
Utility						
Control Point	*	*	*	*	*	*

Node	SAS DATA Step	SAS Program	PMML	C	Java	Greenplum
Start Groups	Y	N	N	Y	Y	Y
End Groups	Y	N	N	Y	Y	Y
Metadata	*	*	*	*	*	*
Reporter	*	*	*	*	*	*
SAS Code The user can enter either SAS DATA step code or SAS program code	Y	Y	N	N	N	N
Credit Scoring						
Credit Exchange	*	*	*	*	*	*
Interactive Grouping	Y	N	N	Y	Y	Y
Scorecard	Y	N	N	Y	Y	Y
Reject Inference	Y	N	N	Y	Y	Y
*** The node does not produce this type of score code.**						

Chapter 4

Publishing the Scoring Model Files

Overview of the Publishing Process

The SAS publishing macros are used to publish the formats and the scoring functions in Greenplum.

The %INDGP_PUBLISH_MODEL macro creates the files that are needed to build the scoring functions and publishes the scoring functions with those files to a specified database in Greenplum. Only the EM_ output variables are published as Greenplum scoring functions. For more information about the EM_ output variables, see "Fixed Variable Names" on page 13.

The %INDGP_PUBLISH_MODEL macro uses some of the files that are created by the SAS Enterprise Miner Score Code Export node: the scoring model program (score.sas file), the properties file (score.xml file), and, if the training data includes SAS user-defined formats, a format catalog.

The %INDGP_PUBLISH_MODEL macro performs the following tasks:

- takes the score.sas and score.xml files and produces the set of .c and .h files. These .c and .h files are necessary to build separate scoring functions for each of a fixed set of quantities that can be computed by the scoring model code.
- if a format catalog is available, processes the format catalog and creates an .h file with C structures, which are also necessary to build the scoring functions.
- produces a script of the Greenplum commands that are used to register the scoring functions on the Greenplum database.
- transfers the .c and .h files to Greenplum.
- calls the SAS_COMPILEUDF function to compile the source files into object files and links to the SAS 9.2 Formats Library for Greenplum.

- calls the SAS_COPYUDF function to copy the new object files to ***full-path-to-pkglibdir/SAS*** on the whole database array (master and all segments) , where ***full-path-to-pkglibdir*** is the path that was defined during installation.
- uses the SAS/ACCESS Interface to Greenplum to run the script to create the scoring functions with the object files.

The scoring functions are registered in Greenplum with shared object files, which are loaded at run time. These functions are stored in a permanent location. The SAS object files and the SAS 9.2 Formats Library for Greenplum are stored in the ***full-path-to-pkglibdir/SAS*** directory on all nodes, where ***full-path-to-pkglibdir*** is the path that was defined during installation.

Greenplum caches the object files within a session.

Note: You can publish scoring model files with the same model name in multiple databases and schemas. Because all model object files for the SAS scoring function are stored in the ***full-path-to-pkglibdir/SAS*** directory, the publishing macros use the database, schema, and model name as the object filename to avoid potential naming conflicts.

Running the %INDGP_PUBLISH_MODEL Macro

%INDGP_PUBLISH_MODEL Macro Run Process

To run the %INDGP_PUBLISH_MODEL macro, complete the following steps:

1. Create a scoring model using SAS Enterprise Miner.
2. Use the SAS Enterprise Miner Score Code Export node to create a score output directory and populate the directory with the score.sas file, the score.xml file, and, if needed, the format catalog.
3. Start SAS 9.2 and submit the following commands in the Program Editor or Enhanced Editor:

```
%indgppm;
%let indconn = user=youruserid password=yourpwd
    dsn=yourdsn | server=yourserver database=your db
   schema=yourschema;
```

The %INDGPPM macro searches the autocall library for the indgppm.sas file. The indgppm.sas file contains all the macro definitions that are used in conjunction with the %INDGP_PUBLISH_MODEL macro. The indgppm.sas file should be in one of the directories listed in the SASAUTOS= system option in your configuration file. If the indgppm.sas file is not present, the %INDGPPM macro call (%INDGPPM; statement) issues the following message:

```
macro indgppm not defined
```

The INDCONN macro variable is used to provide credentials to connect to Greenplum. You must specify user, password, either the DSN or the server and database names, and schema. You must assign the INDCONN macro variable before the %INDGP_PUBLISH_MODEL macro is invoked.

The value of the INDCONN macro variable for the %INDGP_PUBLISH_MODEL macro has one of these formats:

USER=*username* PASSWORD=*password* DSN=*dsnname*

USER=*username* PASSWORD=*password* SERVER=*servername* DATABASE=*databasename* SCHEMA=*schemaname*

USER=<'>*username*<'>
specifies the Greenplum user name (also called the user ID) that is used to connect to the database. If the user name contains spaces or nonalphanumeric characters, you must enclose it in quotation marks.

PASSWORD=<'>*password*<'>
specifies the password that is associated with your Greenplum user ID. If the password contains spaces or nonalphabetic characters, you must enclose it in quotation marks.

TIP You can use only PASSWORD= or PW= for the password argument. Other aliases such as PASS= or PWD= are not supported and cause an error.

DSN=<'>*datasourcename*<'>
specifies the configured Greenplum ODBC data source to which you want to connect. If the DSN contains spaces or nonalphabetic characters, you must enclose it in quotation marks.

Requirement: You must specify either the DSN= argument or the SERVER= and DATABASE= arguments in the INDCONN macro variable.

SERVER=<'>*servername*<'>
specifies the Greenplum server name or the IP address of the server host. If the server name contains spaces or nonalphanumeric characters, you must enclose it in quotation marks.

Requirement: You must specify either the DSN= argument or the SERVER= and DATABASE= arguments in the INDCONN macro variable.

DATABASE=<'>*databasename*<'>
specifies the Greenplum database that contains the tables and views that you want to access. If the database name contains spaces or nonalphanumeric characters, you must enclose it in quotation marks.

Requirement: You must specify either the DSN= argument or the SERVER= and DATABASE= arguments in the INDCONN macro variable.

SCHEMA=<'>*schemaname*<'>
specifies the schema name for the database.

TIP If you do not specify a value for the SCHEMA argument, the value of the USER argument is used as the schema name. The schema must be created by your database administrator.

TIP The INDCONN macro variable is not passed as an argument to the %INDGP_PUBLISH_MODEL macro. This information can be concealed in your SAS job. You might want to place it in an autoexec file and set the permissions on the file so that others cannot access the user ID and password.

4. Run the %INDGP_PUBLISH_MODEL macro. For more information, see "%INDGP_PUBLISH_MODEL Macro Syntax" on page 22.

   Messages are written to the SAS log that indicate the success or failure of the creation of the scoring functions.

%INDGP_PUBLISH_MODEL Macro Syntax

%INDGP_PUBLISH_MODEL

(DIR=*input-directory-path*, MODELNAME=*name*
<, DATASTEP=*score-program-filename*>
<, XML=*xml-filename*>
<, DATABASE=*database-name*>
<, FMTCAT=*format-catalog-filename*>
<, ACTION=CREATE | REPLACE | DROP>
<, OUTDIR=*diagnostic-output-directory*>
);

Arguments

DIR=*input-directory-path*
specifies the directory where the scoring model program, the properties file, and the format catalog are located.

This is the directory that is created by the SAS Enterprise Miner Score Code Export node. This directory contains the score.sas file, the score.xml file, and, if user-defined formats were used, the format catalog.

Requirement: You must use a fully qualified pathname.

Interaction: If you do not use the default directory that is created by SAS Enterprise Miner, you must specify the DATASTEP=, XML=, and, if needed, FMTCAT= arguments.

See: "Special Characters in Directory Names" on page 25

MODELNAME=*name*
specifies the name that is prepended to each output function to ensure that each scoring function name is unique on the Greenplum database.

Restriction: The scoring function name is a combination of the model and output variable names. A scoring function name cannot exceed 63 characters. For more information, see "Scoring Function Names" on page 27.

Requirement: The model name must be a valid SAS name that is 10 characters or fewer. For more information about valid SAS names, see the topic on rules for words and names in *SAS 9.2 Language Reference: Concepts*.

Interaction: Only the EM_ output variables are published as Greenplum scoring functions. For more information about the EM_ output variables, see "Fixed Variable Names" on page 13 and "Scoring Function Names" on page 27.

DATASTEP=*score-program-filename*
specifies the name of the scoring model program file that was created by using the SAS Enterprise Miner Score Code Export node.

Default: score.sas

Restriction: Only DATA step programs that are produced by the SAS Enterprise Miner Score Code Export node can be used.

Interaction: If you use the default score.sas file that is created by the SAS Enterprise Miner Score Code Export node, you do not need to specify the DATASTEP= argument.

XML=*xml-filename*
specifies the name of the properties XML file that was created by the SAS Enterprise Miner Score Code Export node.

Default: score.xml

Restriction: Only XML files that are produced by the SAS Enterprise Miner Score Code Export node can be used.

Restriction: The maximum number of output variables is 128.

Interaction: If you use the default score.xml file that is created by the SAS Enterprise Miner Score Code Export node, you do not need to specify the XML= argument.

DATABASE=*database-name*
specifies the name of a Greenplum database to which the scoring functions and formats are published.

Interaction: The database that is specified by the DATABASE= argument takes precedence over the database that you specify in the INDCONN macro variable. For more information, see "%INDGP_PUBLISH_MODEL Macro Run Process" on page 20.

FMTCAT=*format-catalog-filename*
specifies the name of the format catalog file that contains all user-defined formats that were created by the FORMAT procedure and that are referenced in the DATA step scoring model program.

Restriction: Only format catalog files that are produced by the SAS Enterprise Miner Score Code Export node can be used.

Interaction: If you use the default format catalog that is created by the SAS Enterprise Miner Score Code Export node, you do not need to specify the FMTCAT= argument.

Interaction: If you do not use the default catalog name (FORMATS) or the default library (WORK or LIBRARY) when you create user-defined formats, you must use the FMTSEARCH system option to specify the location of the format catalog. For more information, see PROC FORMAT in the *Base SAS 9.2 Procedures Guide*.

ACTION=CREATE | REPLACE | DROP
specifies one of the following actions that the macro performs:

CREATE	creates a new function.
REPLACE	overwrites the current function, if a function by the same name is already registered.
DROP	causes all functions for this model to be dropped from the Greenplum database.

Default: CREATE

TIP If the function has been previously defined and you specify ACTION=CREATE, you will receive warning messages from Greenplum. If the function has been previously defined and you specify ACTION=REPLACE, no warnings are issued.

OUTDIR=*diagnostic-output-directory*
specifies a directory that contains diagnostic files.

Files that are produced include an event log that contains detailed information about the success or failure of the publishing process and sample SQL code (SampleSQL.txt). For more information about the SampleSQL.txt file, see "Scoring Function Names" on page 27.

TIP This argument is useful when testing your scoring models.

See: "Special Characters in Directory Names" on page 25

Model Publishing Macro Example

```
%indgppm;
%let indconn = user=user1 password=open1 dsn=green6 schema=myschema;
%indgp_publish_model( dir=C:\SASIN\baseball1, modelname=baseball1, outdir=C:\test);
```

The %INDGP_PUBLISH_MODEL macro produces a text file of Greenplum CREATE FUNCTION commands as shown in the following example.

Note: This example file is shown for illustrative purposes. The text file that is created by the %INDGP_PUBLISH_MODEL macro cannot be viewed and is deleted after the macro is complete.

```
CREATE FUNCTION baseball1_EM_eventprobablility
(
"CR_ATBAT" float,
"CR_BB" float,
"CR_HITS" float,
"CR_HOME" float,
"CR_RBI" float,
"CR_RUNS" float,
"DIVISION" varchar(31),
"LEAGUE" varchar(31),
"NO_ASSTS" float,
"NO_ATBAT" float,
"NO_BB" float,
"NO_ERROR" float,
"NO_HITS" float,
"NO_HOME" float,
"NO_OUTS" float,
"NO_RBI" float,
"NO_RUNS" float,
"YR_MAJOR" float
)
RETURNS varchar(33)
AS '/usr/local/greenplum-db-3.3.4.0/lib/postgresql/SAS/sample_dbitest_homeeq_5.so',
   'homeeq_5_em_classification'
```

After the scoring functions are installed, they can be invoked in Greenplum using SQL, as illustrated in the following example. Each output value is created as a separate function call in the select list.

```
select baseball1_EM_eventprobability
(
"CR_ATBAT",
"CR_BB",
"CR_HITS",
"CR_HOME",
"CR_RBI",
"CR_RUNS",
"DIVISION",
"LEAGUE",
"NO_ASSTS",
"NO_ATBAT",
"NO_BB",
```

```
"NO_ERROR",
"NO_HITS",
"NO_HOME",
"NO_OUTS"
) as homeRunProb from MLBGP;
```

Special Characters in Directory Names

If the directory names that are used in the macros contain any of the following special characters, you must mask the characters by using the %STR macro quoting function. For more information, see the %STR function and macro string quoting topic in *SAS Macro Language: Reference*.

Character	How to Represent
blank[1]	%str( )
*[2]	%str(*)
;	%str(;)
,	%str(,)
=	%str(=)
+	%str(+)
-	%str(-)
>	%str(>)
<	%str(<)
^	%str(^)
|	%str(|)
&	%str(&)
#	%str(#)
/	%str(/)
~	%str(~)
%	%str(%%)
'	%str(%')
"	%str(%")
(	%str(%()

Character	How to Represent
)	%str(%))
¬	%str(¬)

[1]Only leading blanks require the %STR function, but you should avoid using leading blanks in directory names.

[2]Asterisks (*) are allowed in UNIX directory names. Asterisks are not allowed in Windows directory names. In general, you should avoid using asterisks in directory names.

Here are some examples of directory names with special characters:

Directory	Code representation
c:\temp\Sales(part1)	`c:\temp\Sales%str(%()part1%str(%))`
c:\temp\Drug "trial" X	`c:\temp\Drug %str(%")trial(%str(%") X`
c:\temp\Disc's 50% Y	`c:\temp\Disc%str(%')s 50%str(%%) Y`
c:\temp\Pay,Emp=Z	`c:\temp\Pay%str(,)Emp%str(=)Z`

Greenplum Permissions

You must have Greenplum superuser permissions to execute the %INDGP_PUBLISH_MODEL macro that publishes the scoring functions. Greenplum requires superuser permissions to create C functions in the database.

Chapter 5

Scoring Functions Inside the Greenplum Database

Scoring Function Names

The names of the scoring functions that are built in Greenplum have the following format:

```
modelname_EM_outputvarname
```

modelname is the name that was specified in the MODELNAME argument of the %INDGP_PUBLISH_MODEL macro. *modelname* is always followed by _EM_ in the scoring function name. For more information about the MODELNAME argument, see "%INDGP_PUBLISH_MODEL Macro Syntax" on page 22.

outputvarname is derived from the names of the EM_ output variables in the score.xml file that is generated from the SAS Enterprise Miner Score Code Export node. For more information about the score.xml file, see "Fixed Variable Names" on page 13.

One scoring function is created for each EM_ output variable in the score.xml file. For example, if the scoring model DATA step program takes ten inputs and creates three new variables, then three scoring functions are defined, each with the name of an output variable. For example, if you set MODELNAME=credit in the %INDGP_PUBLISH_MODEL macro, and the EM_ output variables are "EM_PREDICTION", "EM_PROBABILITY", and "EM_DECISION", then the name of the scoring functions that are created would be "credit_EM_PREDICTION", "credit_EM_PROBABILITY", and "credit_EM_DECISION".

Note: A scoring function name cannot exceed 63 characters.

CAUTION:

When the scoring function is generated, the names are case-insensitive. Consequently, if you have model names "Model01" and "model01", and you create two scoring functions, the second scoring function will overwrite the first scoring function.

Using the Scoring Functions

The scoring functions are available to use in any SQL expression in the same way that Greenplum built-in functions are used. For an example, see "Model Publishing Macro Example" on page 24.

There are four ways to see the scoring functions that are created:

- From Greenplum, you can start psql to connect to the database and submit an SQL statement. In this example, 'SCHEMA' is the actual schema value.

```
psql -h hostname -d databasename -U userid
select proname
   from pg_catalog.pg_proc f, pg_catalog.pg_namespace s
   where f.pronamespace=s.oid and upper(s.nspname)='SCHEMA';
```

- From SAS you can use SQL procedure code that produces output in the LST file. The following example assumes that the model name that you used to create the scoring functions is **mymodel**.

```
proc sql noerrorstop;
  connect to greenplm (user=username pw=password dsn= dsnname db=database);

select *
   from connection to greenplm
      (select proname
       from pg_catalog.pg_proc f, pg_catalog.pg_namespace s
       where f.pronamespace=s.oid and upper(s.nspname)='SCHEMA');
   disconnect from greenplm;
quit;
```

  You can also use the SASTRACE and SASTRACELOC system options to generate tracing information. For more information about these system options, see the *SAS 9.2 Language Reference: Dictionary*.

- You can look at the SampleSQL.txt file that is produced when the %INDGP_PUBLISH_MODEL macro is successfully run. This file can be found in the output directory (OUTDIR argument) that you specify in the macro.

  The SampleSQL.txt file contains basic code that, with modifications, can be used to run your score code inside Greenplum.

  For example, the SampleSQL.txt file refers to an ID column in **allmush1_intab** that is populated with a unique integer from 1 to *n*, with *n* being the number of rows in the table. The ID column uniquely identifies each row. You would replace the ID column with your own primary key column.

  Note: The function and table names must be fully qualified if the function and table are not in the same schema.

  The following example assumes that the model name that you used to create the scoring functions is **allmush1**.

```
drop table allmush1_outtab;
create table allmush1_outtab(
 id integer
,"EM_CLASSIFICATION" varchar(33)
,"EM_EVENTPROBABILITY" float
```

```
,"EM_PROBABILITY" float
);
insert into allmush1_outtab(
 id
,"EM_CLASSIFICATION"
,"EM_EVENTPROBABILITY"
,"EM_PROBABILITY"
)
select id,
 allmush1_em_classification("BRUISES"
,"CAPCOLOR"
,"GILLCOLO"
,"GILLSIZE"
,"HABITAT"
,"ODOR"
,"POPULAT"
,"RINGNUMB"
,"RINGTYPE"
,"SPOREPC"
,"STALKCBR"
,"STALKROO"
,"STALKSAR"
,"STALKSHA"
,"VEILCOLO")
  as "EM_CLASSIFICATION",
 allmush1_em_eventprobability("BRUISES"
,"CAPCOLOR"
,"GILLCOLO"
,"GILLSIZE"
,"HABITAT"
,"ODOR"
,"POPULAT"
,"RINGNUMB"
,"RINGTYPE"
,"SPOREPC"
,"STALKCBR"
,"STALKROO"
,"STALKSAR"
,"STALKSHA"
,"VEILCOLO")
  as "EM_EVENTPROBABILITY",
 allmush1_em_probability("BRUISES"
,"CAPCOLOR"
,"GILLCOLO"
,"GILLSIZE"
,"HABITAT"
,"ODOR"
,"POPULAT"
,"RINGNUMB"
,"RINGTYPE"
,"SPOREPC"
,"STALKCBR"
,"STALKROO"
,"STALKSAR"
,"STALKSHA"
,"VEILCOLO")
```

```
    as "EM_PROBABILITY"
  from allmush1_intab ;
```

- You can look at the SAS log. A message that indicates whether a scoring function is successfully or not successfully executed is printed to the SAS log.

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