Paper SAS491-2017

From Source to Target—Hadoop Capabilities of SAS® Data Integration Studio

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ABSTRACT

This paper demonstrates how to use the capabilities of SAS® Data Integration Studio to extract, load, and transform your data within a Hadoop environment. The transformations that can be used in each layer of the ELT process are illustrated using a sample use case, and the functionality of each is described. The use case steps through the process from source to target.

INTRODUCTION

For the sample use case, consider an organization that has information about its customers stored in three disparate source of record databases that support three independent lines of business. When a new customer is added to, or updated in, any of the three databases, an existing process sends the customer's information to a third-party vendor to obtain enriched demographic information for that customer and this information is consolidated into a single batch feed back to the organization once per day.

The organization wishes to use SAS® Data Integration Studio to develop an end-to-end data integration process that will incrementally extract new and updated customer data from its three customer databases, and have that data consolidated and integrated with the customer demographic data, to create a single conformed customer dimension table in their Hadoop environment to be used for Analytics and Marketing initiatives in conjunction with their customer activity data.

Sample use case assumptions:

1. The customers in each line of business are unique, no master customer data management or entity resolution is done as part of this sample use case.
2. The customer demographic information has the necessary source system customer identifier to join back to the customer information files.
3. Customer activity data is not included in the examples as this data would be integrated using the same techniques described in the examples provided.

This paper provides examples on how to create SAS® Data Integration Studio jobs, using out of the box transformations, which will execute code within the Hadoop environment. A sample HDFS directory structure dividing HDFS into zones, the data process flow between those zones, and intended usage of each zone is also described. A discussion or analysis of architecting a Hadoop platform or efficiencies of the Hadoop platform is outside the scope of this paper.

PROCESS OVERVIEW

Figure 1 illustrates the end-to-end process flow.

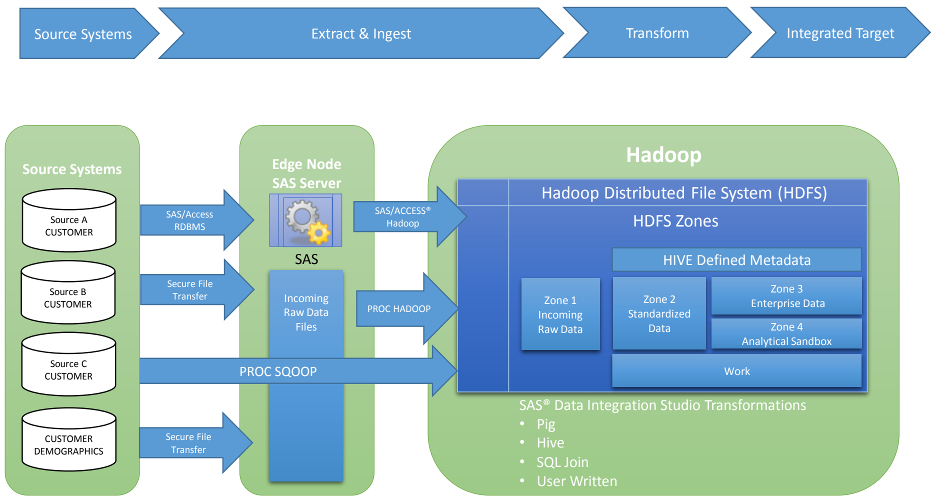


Figure 1. Process Overview

The end-to-end process consists of the following steps:

1. Data is extracted or transferred from the source systems using various technologies and methods and ingested into HDFS Zone 1 in its original or raw extracted format. After a period of time, data can be purged from Zone 1.
2. Raw data from Zone 1 is reformatted, standardized, and conformed and stored into Zone 2. Zone 2 retains all of the history of updates to the Customer and Customer Demographic files by extract date.
3. Hive metadata structures are defined for files in Zone 2 and Zone 3.
4. The Customer and Customer Demographic files from Zone 2 are integrated into a target data structure and storage format in Zone 3 and will be the most current data for a customer. The data structure and storage format used in Zone 3 will be optimized for end-user access.
5. Data from Zone 2 and Zone3 can be manipulated further and used for analytical purposes in the Zone 4 Analytical Sandbox.
6. A temporary Work area of HDFS is used by the Data Integration process for storage of temporary in-process data. Data in this zone will use Hive metadata and storage formats for efficient data processing.

Table 1 summarizes the HDFS storage zones.

Zone	Description	Hive Metadata	Usage
Zone 1	Raw incoming data organized by extract date. May be purged after a period of time.	No	Not accessible to end users.
Zone 2	Data with some formatting and standardization applied. This zone contains a full history of transactions and incremental data (new and updated records) organized by extract date.	Yes	Accessible to limited number of end users for discovery and historical data queries.
Zone 3	Enterprise Data that is fully integrated into purpose-driven target data structures. Contains as-of-today view of data.	Yes	Accessible to end users. Data is structured and stored in a format to optimize end-user access.
Zone 4	Analytical Sandbox.	Yes	Data Scientist area for data discovery and model building. May use data from Zone 2 and Zone 3.
Work	Temporary work area for the data integration process.	Yes	Not accessible to end users. Data is stored in a format to optimize transformation processing.

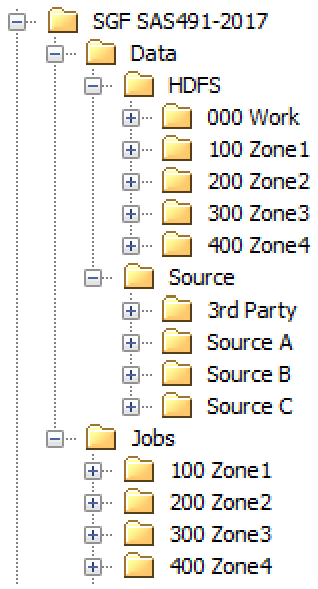
Table 1. HDFS Storage Zones

The HDFS folder structure for Zones 1 – Zone 3 is organized as follows:

```
/zone1/CUSTOMER_DEMOGRAPHICS
      /SOURCE_A_CUSTOMER
      /SOURCE_B_CUSTOMER
      /SOURCE_C_CUSTOMER
                              /YYYYMMDD/  ← Extract Date
/zone2/CUSTOMER_DEMOGRAPHICS
      /CUSTOMER

                        /YYYYMMDD/ ← Extract Date

/zone3/CUSTOMER
               /YYYYMMDD/    ← Extract Date
```

In order to organize the metadata objects within SAS® Data Integration Studio, the following metadata folder structure was created.

Display 1 illustrates the metadata folder structure.

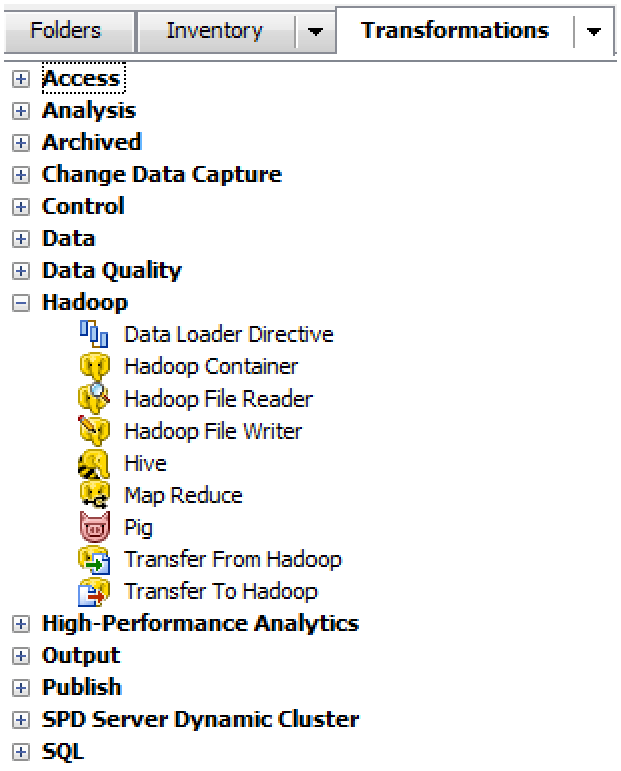


Display 1. Metadata Folder Structure

SAS® DATA INTEGRATION STUDIO TRANSFORMATIONS

The SAS® Data Integration Studio Hadoop Transformations that are available to be used are located in the Hadoop folder on the Transformations Tab.

Display 2 illustrates the SAS® Data Integration Studio Hadoop Transformations.



- Access
- Analysis
- Archived
- Change Data Capture
- Control
- Data
- Data Quality
- Hadoop
  - Data Loader Directive
  - Hadoop Container
  - Hadoop File Reader
  - Hadoop File Writer
  - Hive
  - Map Reduce
  - Pig
  - Transfer From Hadoop
  - Transfer To Hadoop
- High-Performance Analytics
- Output
- Publish
- SPD Server Dynamic Cluster
- SQL

Display 2. SAS® Data Integration Studio Hadoop Transformations.

The sample use case for this paper uses the following transformations Specific to Hadoop.

HIVE

The Hive transformation enables you to submit your own HiveQL code in the context of a job. Apache Hive is a data warehouse infrastructure built on top of Hadoop for data queries, analysis, and summarization. It provides an SQL-like language called HiveQL. The Hive transformation uses the SAS/ACCESS® software Interface for Hadoop (SAS Institute Inc. 2016a).

PIG

The Pig transformation enables you to submit your own Pig Latin code in the context of a job. Pig Latin is a high-level language used for expressing and evaluating data analysis programs. The Pig transformation uses the HADOOP procedure (SAS Institute Inc. 2016b).

TRANSFER TO HADOOP

The Transfer to Hadoop transformation uses the HADOOP procedure to transfer files to HDFS.

The sample use case for this paper also uses the following transformations that are not specific to Hadoop, for Hadoop functionality.

JOIN

The Join transformation uses the SAS/ACCESS® Interface for Hadoop to pass HiveQL statements to Hadoop.

SET OPERATORS

The Set Operators transformation uses the SAS/ACCESS® Interface for Hadoop to pass HiveQL statements to Hadoop.

USER WRITTEN

The User Written transformation will be used to execute the SQOOP procedure from within a SAS® Data Integration Studio job.

SOURCE TO ZONE 1 (HDFS INGEST)

Figure 2 illustrates the process from Source to Zone 1.

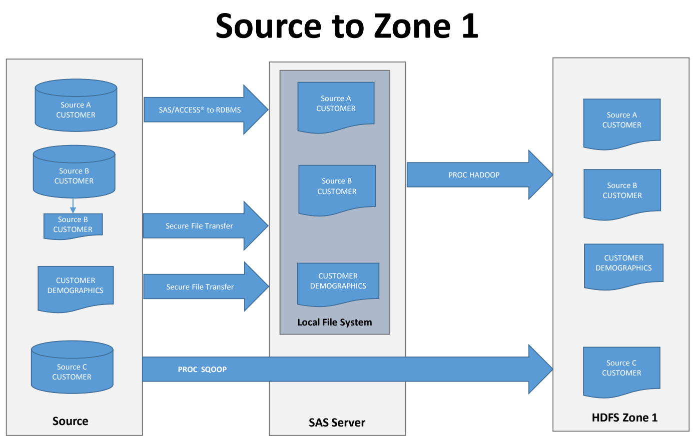


Figure 2. Source to Zone 1

Data is extracted and transferred from the source systems using various technologies and methods and ingested into HDFS Zone 1. The data is ingested into HDFS in its original extracted format with no transformation of the data.

Table 2 summarizes the extraction and HDFS ingestion methods used for this use case.

Scenario	Source	Extract Method	SAS® Data Integration Studio Transformations
1	Source A – CUSTOMER	Data is extracted from the database to an extract file on the SAS server using SQL.	SQL Join File Writer Transfer to Hadoop
2	Source B – CUSTOMER CUSTOMER_DEMOGRAPHICS	Data has been pre-extracted from the database and will be pulled or pushed to the SAS server using a secure file transfer method.	sFTP Transfer to Hadoop
3	Source C - CUSTOMER	Data is extracted from the database using Apache Sqoop and ingested directly into HDFS without an intermediate file being created on the SAS server.	User Written using PROC SQOOP

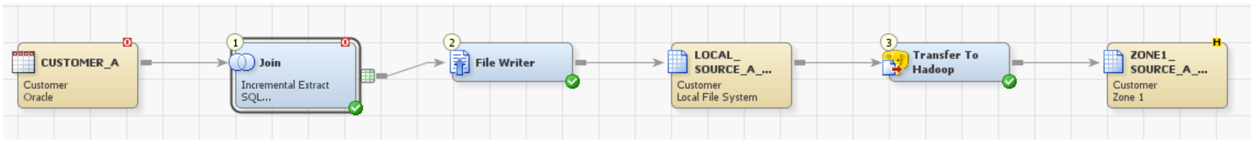
Table 2. Source to Zone 1

SCENARIO 1 – SOURCE SYSTEM A

In this scenario:

1. The SQL Join transformation is used to incrementally extract rows from the Customer table in source system A's Oracle database based on a source timestamp.
2. The File Writer transformation is then used to write the extracted data to a file on the SAS server's local file system.
3. The file is then ingested into HDFS Zone 1 using the Transfer to Hadoop Transformation.

Display 3 illustrates the data flow from the Oracle source to the HDFS Zone 1 target.



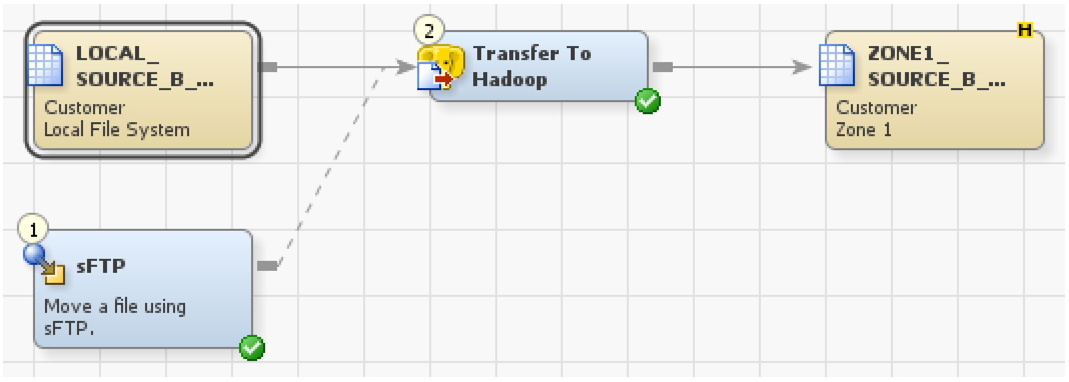
Display 3. Scenario 1 – Source system A

SCENARIO 2 – SOURCE SYSTEM B

In this scenario:

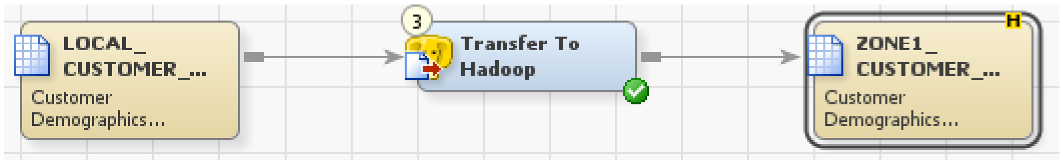
1. The sFTP transformation is used to securely transfer an incremental Customer extract file from source system B to the SAS server.
2. The Customer Demographic file has been pushed to the SAS server.
3. The extract files are then ingested into HDFS Zone 1 using the Transfer to Hadoop Transformation.

Display 4 illustrates the data flow from the source to the HDFS Zone 1 target.



Display 4. Scenarion 2 – Source System B

Display 5 illustrates the data flow from the source to the HDFS Zone 1 target.



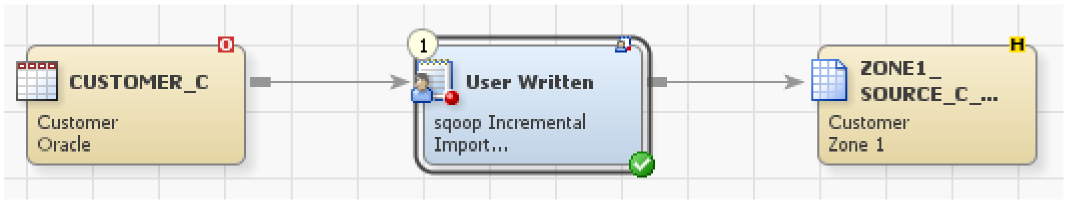
Display 5. Scenario 2 – Customer Demographic Data.

SCENARIO 3 – SOURCE SYSTEM C

In this scenario:

1. The User Written transformation is used with PROC SQOOP to incrementally extract rows from the Customer table in source system C's Oracle database based on a source timestamp.
2. The data is ingested directly into HDFS Zone 1 by Sqoop.

Display 6 illustrates the data flow from the Oracle source to the HDFS Zone 1 target.



Display 6. Scenario 3 – Source System C

In this job, a User Written transformation has been used to call PROC SQOOP since a transformation does not yet exist. The User Written code is provided below.

```
OPTIONS SET=SAS_HADOOP_RESTFUL=1;

%let hadoopuser=hadoopuser;
%let hadooppwd=password;
%let dbuser=dbuser;
%let passwordfile=/pfile;
%let oozieurl=http://xxxxxxx.xxx.sas.com:11000/oozie;
%let namenode=hdfs://xxxxxxx.xxx.sas.com:8020;
%let jobtracker=xxxxxxx.xxx.sas.com:8032;
%let wfhdfspath=hdfs://xxxxxxx.xxx.sas.com:8020/user/xxxxx/myworkflow.xml;
%let connect=jdbc:oracle:thin:@xxxxxx.na.sas.com:1521/sid;
%let import_table=%SCAN(&_INPUT,2);
%let file_format=--as-textfile;


/* Incremental Load into &target_dir./&extract_date */

proc sqoop
  hadoopuser="&hadoopuser"
  hadooppwd="&hadooppwd"
  dbuser="&dbuser"
```

```
     passwordfile="&passwordfile"
     oozieurl="&oozieurl"
     namenode="&namenode"
     jobtracker="&jobtracker"
     wfhdfspath="&wfhdfspath"
     deletewf
     COMMAND=" import
     --connect &connect
     -table &import_table
     --target-dir &_OUTPUT
     &file_format
     --incremental lastmodified
     --check-column LAST_MODIFIED_DT --last-value &last_value"
   ;
   run;
```

Sqoop provides an incremental import mode that can be used to retrieve only rows newer than some previously imported set of rows (Apache Software Foundation 2017).

Table 3 shows Sqoop incremental import arguments.

Argument	**Description**
--check-column (col)	Specifies the column to be examined when determining which rows to import.
--incremental (mode)	Specifies how Sqoop determines which rows are new. Legal values for mode include append and lastmodified.
--last-value (value)	Specifies the maximum value of the check column from the previous import.

Table 3. Incremental Import Arguments

ZONE1 TO ZONE2

Figure 3 illustrates the process from Zone 1 to Zone 2.

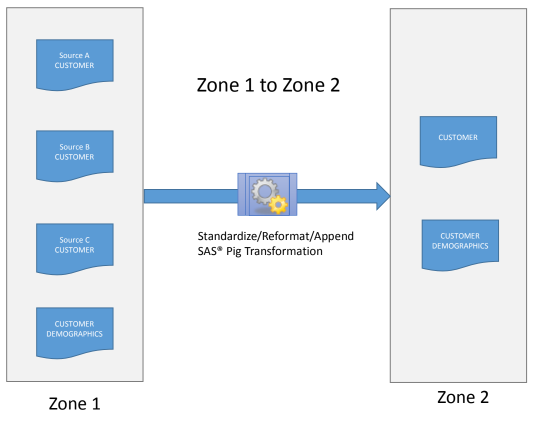


Figure 3. Zone 1 to Zone 2

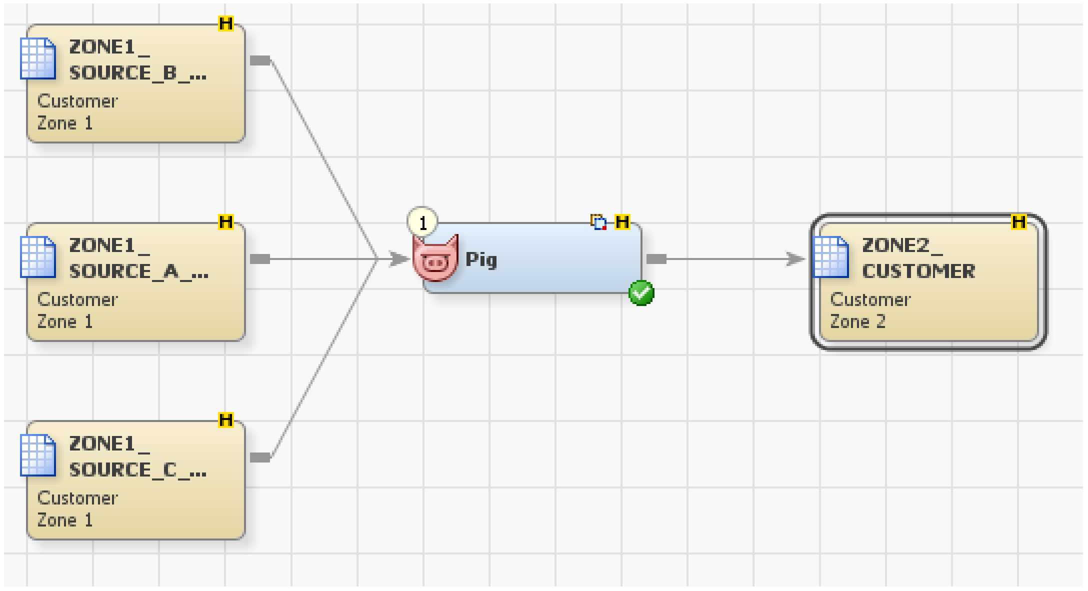
Raw Customer data from Zone 1 is reformatted into a common standardized format, appended and stored into Zone 2.

Table 4 summarizes the Zone 1 to Zone 2 methods used for this use case.

Source	**Transformation**	**SAS® Data Integration Studio Transformations**
Source A – CUSTOMER Source B – CUSTOMER Source C – CUSTOMER	Reformat into standardized conformed format. Append files. Write data to Zone 2.	Pig
CUSTOMER_DEMOGRAPHICS	Reformat. Write data to Zone 2.	Pig

Table 4. Zone 2 to Zone 3

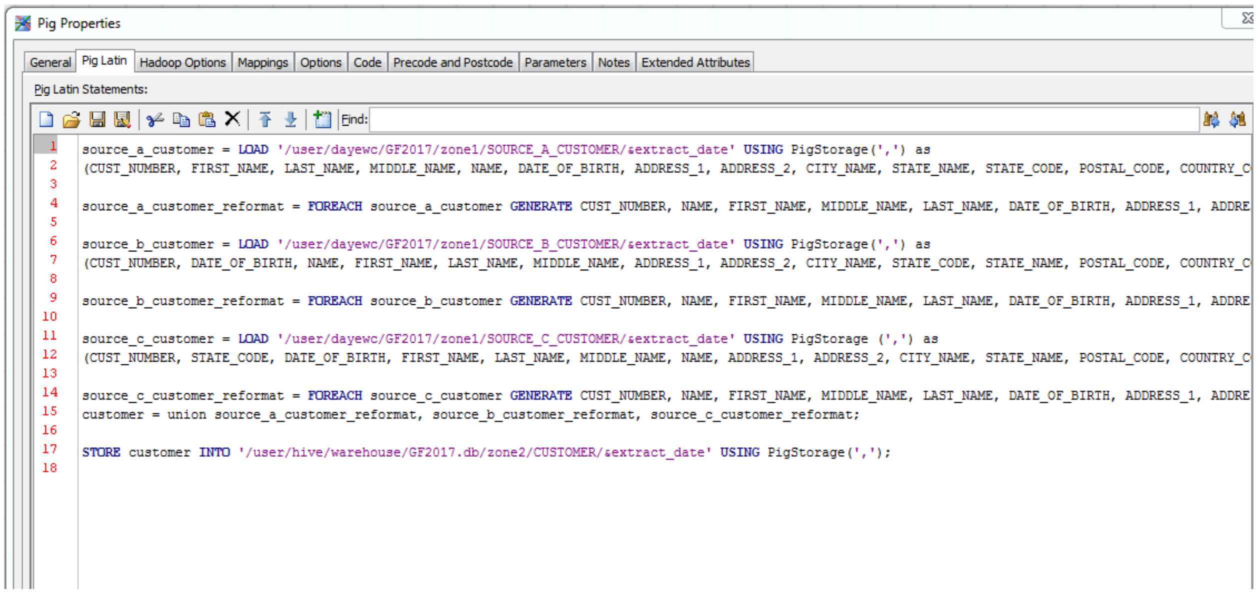
Display 7 illustrates the data flow from HDFS Zone 1 to the HDFS Zone 2 target.



Display 7. Zone 1 to Zone 2 - Customer

In this job, the Pig transformation has been used to reformat the three Customer files into a single common format and append the three files so that a Hive structure can be applied to the combined incremental data. Pig Latin was chosen for the use case to efficiently manipulate the raw text files ingested into Zone 1 into a standardized structure in Zone2.

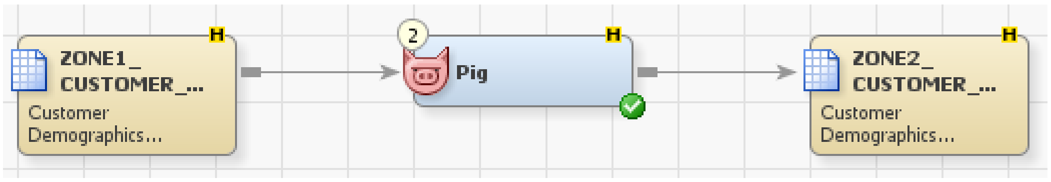
Display 8 shows the Pig Latin tab for the code that was written to reformat and append the Customer files.



```
source_a_customer = LOAD '/user/dayewc/GF2017/zone1/SOURCE_A_CUSTOMER/&extract_date' USING PigStorage(',') as
(CUST_NUMBER, FIRST_NAME, LAST_NAME, MIDDLE_NAME, NAME, DATE_OF_BIRTH, ADDRESS_1, ADDRESS_2, CITY_NAME, STATE_NAME, STATE_CODE, POSTAL_CODE, COUNTRY_C

source_a_customer_reformat = FOREACH source_a_customer GENERATE CUST_NUMBER, NAME, FIRST_NAME, MIDDLE_NAME, LAST_NAME, DATE_OF_BIRTH, ADDRESS_1, ADDRE

source_b_customer = LOAD '/user/dayewc/GF2017/zone1/SOURCE_B_CUSTOMER/&extract_date' USING PigStorage(',') as
(CUST_NUMBER, DATE_OF_BIRTH, NAME, FIRST_NAME, LAST_NAME, MIDDLE_NAME, ADDRESS_1, ADDRESS_2, CITY_NAME, STATE_CODE, STATE_NAME, POSTAL_CODE, COUNTRY_C

source_b_customer_reformat = FOREACH source_b_customer GENERATE CUST_NUMBER, NAME, FIRST_NAME, MIDDLE_NAME, LAST_NAME, DATE_OF_BIRTH, ADDRESS_1, ADDRE

source_c_customer = LOAD '/user/dayewc/GF2017/zone1/SOURCE_C_CUSTOMER/&extract_date' USING PigStorage (',') as
(CUST_NUMBER, STATE_CODE, DATE_OF_BIRTH, FIRST_NAME, LAST_NAME, MIDDLE_NAME, NAME, ADDRESS_1, ADDRESS_2, CITY_NAME, STATE_NAME, POSTAL_CODE, COUNTRY_C

source_c_customer_reformat = FOREACH source_c_customer GENERATE CUST_NUMBER, NAME, FIRST_NAME, MIDDLE_NAME, LAST_NAME, DATE_OF_BIRTH, ADDRESS_1, ADDRE
customer = union source_a_customer_reformat, source_b_customer_reformat, source_c_customer_reformat;

STORE customer INTO '/user/hive/warehouse/GF2017.db/zone2/CUSTOMER/&extract_date' USING PigStorage(',');
```

Display 8. Pig Latin Tab.

Display 9 illustrates the data flow from HDFS Zone 1 to the HDFS Zone 2 target.



Display 9. Zone 1 to Zone 2 – Customer Demographics

ZONE 2 TO ZONE 3

Figure 4 illustrates the process from Zone 2 to Zone 3.

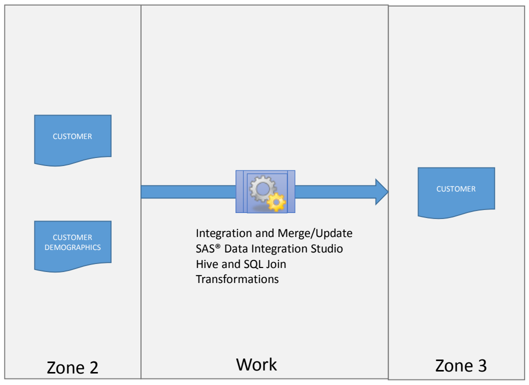

CUSTOMER
CUSTOMER DEMOGRAPHICS
Zone 2
Integration and Merge/Update SAS® Data Integration Studio Hive and SQL Join Transformations
Work
CUSTOMER
Zone 3

Figure 4. Zone 2 to Zone 3

The customer dimension table will be updated in Zone 3 using the merge/update method described in Hadoop Application Architectures. (Grover et al. 2015) Since HDFS is a write-once filesystem and Hive has limited update capabilities, the general method is to re-create the target table by merging the new and changed records (Upserts) that were incrementally extracted from the source with the existing target table records and then update the Hive metastore so that the target table now points to the new updated file. This use case implements an SCD Type I update into Zone 3 but the sample job could easily be modified for a Type II update. In our use case, Zone 2 maintains all history of updates to the Customer and Customer Demographic tables and can be used for historical data queries.

Zone 2 to Zone 3 processing will use the SQL join transformation and the HDFS Work Zone extensively. In order to ensure that all generated HiveQL executes within the Hadoop cluster, the properties must be set on all SQL transformations as specified in Table 5. All intermediate and target Hive tables required by the SAS® Data Integration Studio jobs have been created and registered in the SAS® Metadata Repository and a Target Table Pass-Through Action of Truncate is used. All Hive tables are created as external Hive tables.

Table 5 Ensure the following SQL Transformation Properties are set accordingly:

Join Property	**Value**
Pass Through	Yes
Target Table is Pass Through	Yes
Target Table Pass-Through Action	Truncate

Table 5. SQL Transformation Properties.

This will ensure pass-through code generation in the form:

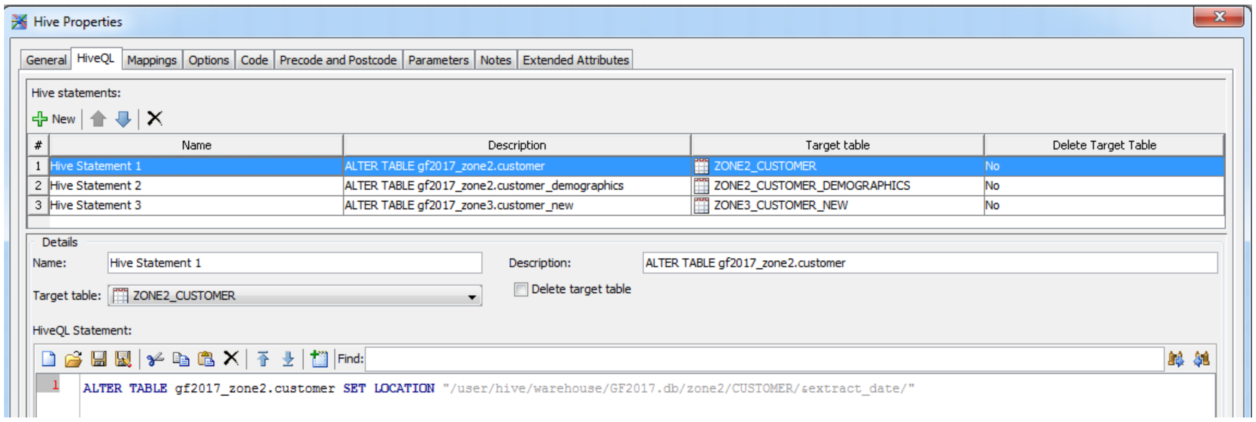
```
proc sql;
   connect to HADOOP
   (
       SERVER="server" AUTHDOMAIN="auth" PORT=NNNN
   );
   execute
 (
insert overwrite table …
…
) by HADOOP;
disconnect from HADOOP;
quit;
```

ZONE 2 TO ZONE 3 STEP-BY-STEP

Step 1: Use a Hive transformation to set the location of the current incremental CUSTOMER and CUSTOMER_DEMOGRAPHIC files in Zone 2 and the new target CUSTOMER table in Zone 3.

```
ALTER TABLE gf2017_zone2.customer SET LOCATION
"/user/hive/warehouse/GF2017.db/zone2/CUSTOMER/&extract_date/"

ALTER TABLE gf2017_zone2.customer_demographics SET LOCATION
"/user/hive/warehouse/GF2017.db/zone2/CUSTOMER_DEMOGRAPHICS/&extract_date/"

ALTER TABLE gf2017_zone3.customer_new SET LOCATION
"/user/hive/warehouse/GF2017.db/zone3/CUSTOMER/&extract_date/"
```

Display 10 illustrates the HiveQL tab for setting the location of the Zone 2 CUSTOMER file.



#	Name	Description	Target table	Delete Target Table
1	Hive Statement 1	ALTER TABLE gf2017_zone2.customer	ZONE2_CUSTOMER	No
2	Hive Statement 2	ALTER TABLE gf2017_zone2.customer_demographics	ZONE2_CUSTOMER_DEMOGRAPHICS	No
3	Hive Statement 3	ALTER TABLE gf2017_zone3.customer_new	ZONE3_CUSTOMER_NEW	No

Details

Name: Hive Statement 1

Description: ALTER TABLE gf2017_zone2.customer

Target table: ZONE2_CUSTOMER

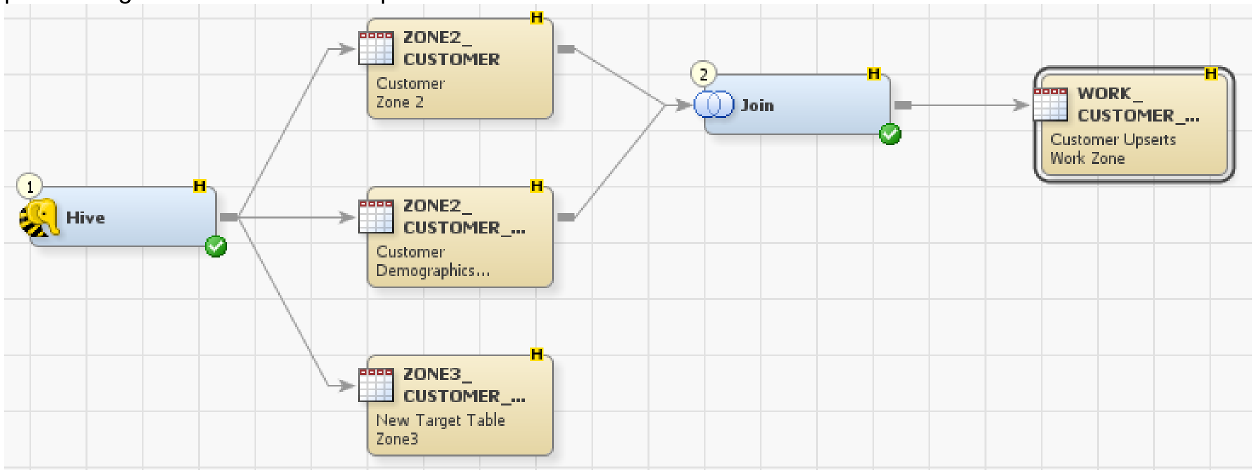
☐ Delete target table

```
ALTER TABLE gf2017_zone2.customer SET LOCATION "/user/hive/warehouse/GF2017.db/zone2/CUSTOMER/&extract_date/"
```

Display 10. HiveQL Tab of Hive Transformation

Step 2: Use an SQL Join transformation to join the CUSTOMER and CUSTOMER_DEMOGRAPHIC tables in Zone 2 and insert into the CUSTOMER_UPSERTS table in the Work Zone.

Display 11 illustrates the process flow for steps 1 and 2. All transformations have an 'H' indicating the processing occurs within Hadoop.



Display 11. Process Flow for Steps 1 and 2

Step 3: Use an SQL Join transformation to identify unchanged rows.

```
insert overwrite table gf2017_work.CUSTOMER_UNCHANGED
select CUSTOMER.<col1>..CUSTOMER.<coln>
from gf2017_zone3.CUSTOMER as CUSTOMER left join
     gf2017_work.CUSTOMER_UPSERTS as CUSTOMER_UPSERTS
     on (CUSTOMER.cust_number = CUSTOMER_UPSERTS.cust_number
         and CUSTOMER.source_system = CUSTOMER_UPSERTS.source_system)
where CUSTOMER_UPSERTS.cust_number IS NULL
```

Step 4: Use an SQL Join transformation to identify updated rows.

```
insert overwrite table gf2017_work.CUSTOMER_UPDATES
select CUSTOMER_UPSERTS.<col1>..CUSTOMER_UPSERTS.<coln>
from gf2017_work.CUSTOMER_UPSERTS as CUSTOMER_UPSERTS,
     gf2017_zone3.CUSTOMER as CUSTOMER
     where CUSTOMER_UPSERTS.cust_number = CUSTOMER.cust_number
     and   CUSTOMER_UPSERTS.source_system = CUSTOMER.source_system
```

Step 5: Use a User Written transformation to store the starting surrogate key value in a SAS macro variable.

```
select coalesce(max(cust_sk),0) format=22. into: max_cust_sk
from gf2017_zone3.CUSTOMER;
```

Step 6: Use an SQL Join transformation to identify new rows and assign a surrogate key.

```
insert overwrite table gf2017_work.CUSTOMER_INSERTS
select row_number() OVER () + &max_cust_sk as cust_sk,
CUSTOMER_UPSERTS.<col1>..CUSTOMER_UPSERTS.<coln>
from gf2017_work.CUSTOMER_UPSERTS as CUSTOMER_UPSERTS left join
     gf2017_zone3.CUSTOMER as CUSTOMER
```

```
        on (CUSTOMER_UPSERTS.cust_number = CUSTOMER.cust_number
            and CUSTOMER_UPSERTS.source_system = CUSTOMER.source_system)
  where CUSTOMER.cust_number IS NULL
```

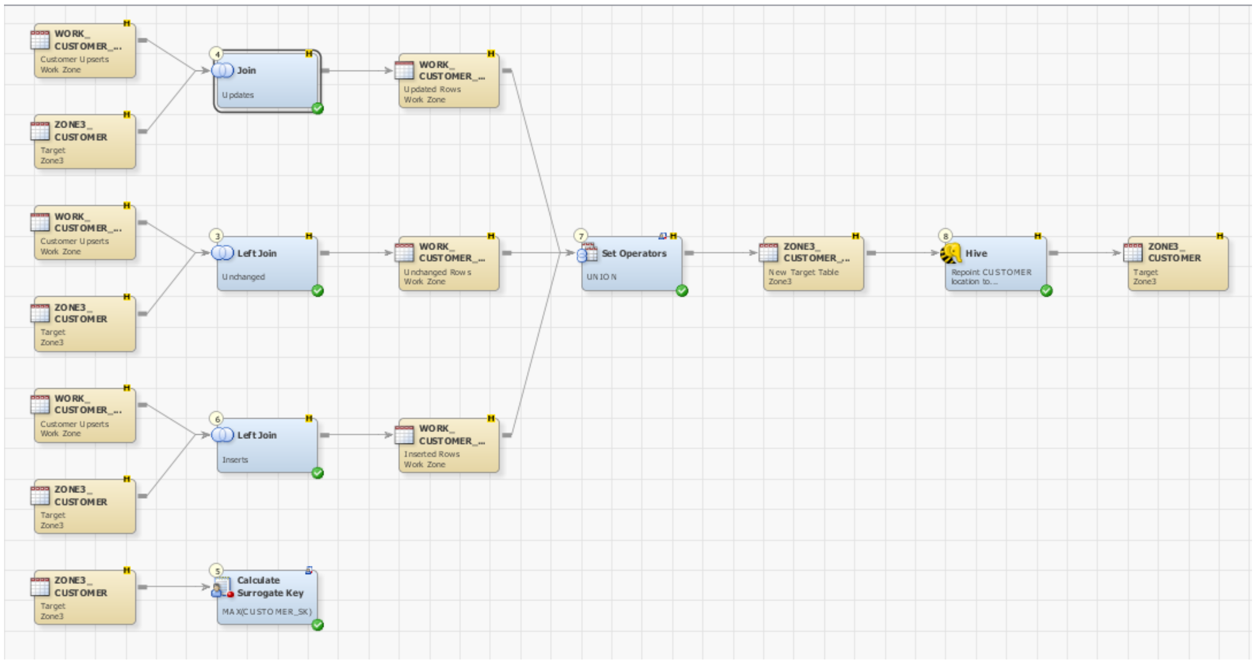
Step 7: Use a Set Operators transformation to append new, unchanged inserts and updates.

```
     insert overwrite table gf2017_zone3.CUSTOMER_NEW
      select ...
         current_date as load_dt,
      from
         gf2017_work.CUSTOMER_UNCHANGED as CUSTOMER_UNCHANGED
      union all
      select ...
         current_date as load_dt,
      from
         gf2017_work.CUSTOMER_INSERTS as CUSTOMER_INSERTS
      union  all
      select ...
         current_date as load_dt,
      from
         gf2017_work.CUSTOMER_UPDATES as CUSTOMER_UPDATES
```

Step 8: Use a Hive transformation to repoint the Zone 3 location of the target table to the new data location. The previous day's folder can then be deleted.

```
ALTER TABLE gf2017_zone3.customer SET LOCATION
"/user/hive/warehouse/GF2017.db/zone3/CUSTOMER/&extract_date/"
```

Display 12 illustrates the process flow for steps 3 through 8. All transforms have an 'H' indicating the processing occurs within Hadoop.



WORK_ CUSTOMER_... Customer Upserts Work Zone
ZONE3_ CUSTOMER Target Zone3
Join Updates
WORK_ CUSTOMER_... Updated Rows Work Zone
WORK_ CUSTOMER_... Customer Upserts Work Zone
ZONE3_ CUSTOMER Target Zone3
Left Join Unchanged
WORK_ CUSTOMER_... Unchanged Rows Work Zone
Set Operators UNION
ZONE3_ CUSTOMER_... New Target Table Zone3
Hive Repoint CUSTOMER location to...
ZONE3_ CUSTOMER Target Zone3
WORK_ CUSTOMER_... Customer Upserts Work Zone
ZONE3_ CUSTOMER Target Zone3
Left Join Inserts
WORK_ CUSTOMER_... Inserted Rows Work Zone
ZONE3_ CUSTOMER Target Zone3
Calculate Surrogate Key MAX(CUSTOMER_SK)

Display 12. Process Flow for Steps 3 - 8

CONCLUSION

As this paper demonstrates, it is possible to transition from a traditional data platform to a big data Hadoop platform fairly seamlessly by taking advantage of the existing capabilities within *SAS*® Data Integration Studio.

Using out of the box features of *SAS*® Data Integration Studio, a very robust ETL and data architecture can be implemented and maintained in the Hadoop ecosystem. Existing and new SAS data management professionals do not have to learn and maintain complex Map Reduce code, instead development is done using a familiar interface in *SAS*® Data Integration Studio, which captures all of the technical metadata about each job in the *SAS*® Metadata Repository. By doing so, SAS can provide cross platform (Hadoop to RDBMS) data lineage for auditing and impact analysis functions.

A major implementation limitation in Hadoop (limited UPDATE capabilities) was overcome, demonstrating the ability to create and maintain SCD Dimensional tables within a Hadoop environment. This allows for the use of Hadoop as more than a Data Lake, but also an end-user queryable platform for big data solutions.

This paper also demonstrates strategies to maximize the performance of the ETL subsystem by leveraging *SAS*® Data Integration Studio push-down processing that pushes the processing down into the Hadoop cluster thereby minimizing any data movement between data storage (HDFS) and the data processing engine (SAS).

The *SAS*® Data Integration Platform provides the tools you need to source, transform, and present your data in an effective and efficient manner by using the massively parallel processing power of Hadoop. By leveraging the *SAS*® Data Integration Platform you are ready to take on the challenges of the big data era!

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ACKNOWLEDGMENTS

The authors extend their thanks and gratitude to the following individuals:

Tom Hahl, SAS Institute Inc.

Nancy Rausch, SAS Institute Inc.

Chris Watson, SAS Institute Inc.

Venu Kadari, SAS Institute Inc.

RECOMMENDED READING

- *SAS® Data Integration Studio 4.9: User's Guide*

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