PERFORMANCE ADVANTAGES OF HADOOP ETL OFFLOAD WITH THE INTEL PROCESSOR-POWERED DELL | CLOUDERA | SYNCSORT SOLUTION

Complete Hadoop® ETL jobs faster.

ETL jobs created by an entry-level technician using the Dell™ | Cloudera® | Syncsort® solution for Hadoop ran faster.*

60.3% less time to execute an ETL job for performing data validation

17.6% less time to execute an ETL job with slowly changing dimensions (SCD)

17.9% less time to execute an ETL job that integrates mainframe datasets

*compared to a senior engineer using DIY open-source tools

Four Dell PowerEdge™ R730xd servers and two Dell PowerEdge R730 servers, powered by the Intel® Xeon® processor E5-2600 v3 product family, in a Hadoop cluster.

Many companies are adopting Hadoop solutions to handle large amounts of data stored across clusters of servers. Hadoop is a distributed, scalable approach to managing Big Data that is very powerful and can bring great value to organizations. Companies use extract, transform, and load (ETL) jobs to bring together data from many different applications or systems on different hardware in order to modify or adjust the data in some way, and then put it into a new format that they can mine for useful information.

Using traditional ETL can require highly experienced, expensive, and hard-to-find programmers to create jobs for execution. Dell, Cloudera, and Syncsort offer an integrated Hadoop ETL solution that allows entry-level technicians—after only a few days of training—to perform the same tasks that these Hadoop specialists perform, often even more quickly.

In the Principled Technologies labs, one entry-level technician and one highly experienced Hadoop expert worked to create three Hadoop analysis use cases. After two and a half days of intensive training from Dell, the beginner used Syncsort DMX-h to create these use cases. Our Hadoop expert designed and created the use cases from scratch. In addition to finding that the Dell | Cloudera | Syncsort solution was faster, easier, and less expensive to implement, we discovered that the ETL use cases our

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Commissioned by Dell

beginner created with this solution ran up to 60.3 percent more quickly than those our expert created with open-source tools.[1]

BOOST PERFORMANCE WITH THE DELL | CLOUDERA | SYNCSORT SOLUTION

Extract, Transform, and Load

ETL refers to the following process in database usage and data warehousing:

- Extract the data from multiple sources
- Transform the data so it can be stored properly for querying and analysis
- Load the data into the final database, operational data store, data mart, or data warehouse

The Dell | Cloudera | Syncsort solution is a reference architecture that offers a reliable, tested configuration that incorporates Dell hardware on the Cloudera Hadoop platform, with Syncsort's DMX-h ETL software. For organizations that want to optimize their data warehouse environments, the Dell | Cloudera | Syncsort reference architecture can greatly reduce the time needed to deploy Hadoop when using the included setup and configuration documentation as well as the validated best practices. Leveraging the Syncsort DMX-h software means Hadoop ETL jobs can be developed using a graphical interface in a matter of hours, with minor amounts of training, and with no need to spend days developing code. The Dell | Cloudera | Syncsort solution also offers professional services with Hadoop and ETL experts to help fast track your project to successful completion.[2]

To learn about the cost and performance advantages of the Dell | Cloudera | Syncsort solution, we conducted a series of tests in the Principled Technologies labs.[3] We had an entry-level technician and a highly experienced Hadoop expert work to create three Hadoop ETL jobs using different approaches to meet the goals of several use cases. The Dell | Cloudera | Syncsort reference architecture includes four Dell PowerEdge R730xd servers and two Dell PowerEdge R730 servers, powered by the Intel® Xeon® processor E5-2600 v3 product family.

The entry-level worker, who had no familiarity with Hadoop and less than one year of general server experience, used Syncsort DMX-h to carry out these tasks. Our expert had 18 years of experience designing, deploying, administering, and benchmarking enterprise-level relational database management systems (RDBMS). He has deployed, managed, and benchmarked Hadoop clusters, covering several Hadoop distributions and several Big Data strategies. He set up the cluster and designed and created the use cases using only free open-source do-it-yourself (DIY) tools. Based on their experiences, we learned that using the Dell | Cloudera | Syncsort solution was faster, easier, and—because a lower-level employee could use it to create ETL jobs—far less expensive to implement.

[1] Based on "Performance advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution," August 2015. Claim compares a use case based on data validation and preprocessing.

[2] Learn more at en.community.dell.com/dell-blogs/dell4enterprise/b/dell4enterprise/archive/2015/06/09/fast-track-data-strategies-etl-offload-hadoop-reference-architecture

[3] See Cost advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution www.principledtechnologies.com/Dell/Dell_Cloudera_Syncsort_cost_0715.pdf and Design advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution www.principledtechnologies.com/Dell/Dell_Cloudera_Syncsort_design_0715.pdf.

In addition to savings that come from having a less highly compensated employee perform the design work more quickly, the Dell | Cloudera | Syncsort solution offers another avenue to cost-effectiveness: performance.

In this paper, we provide a quick overview of the Dell | Cloudera | Syncsort solution and then present the results of our performance testing.

ABOUT SYNCSORT DMX-h

Syncsort DMX-h is a high-performance data integration software that runs natively in Hadoop, providing everything needed to collect, prepare, blend, transform, and distribute data. DMX-h, with its Intelligent Execution, allows users to graphically design sophisticated data flows once and deploy on any compute framework (Apache MapReduce, Spark, etc. on premise or in the cloud), future-proofing the applications while eliminating the need for coding.

Using an architecture that runs ETL processing natively in Hadoop, without code generation, Syncsort DMX-h lets users maximize performance without compromising on the capabilities and typical use cases of conventional ETL tools. In addition, the software packages' industrial-grade capabilities to deploy, manage, monitor, and secure your Hadoop environment.

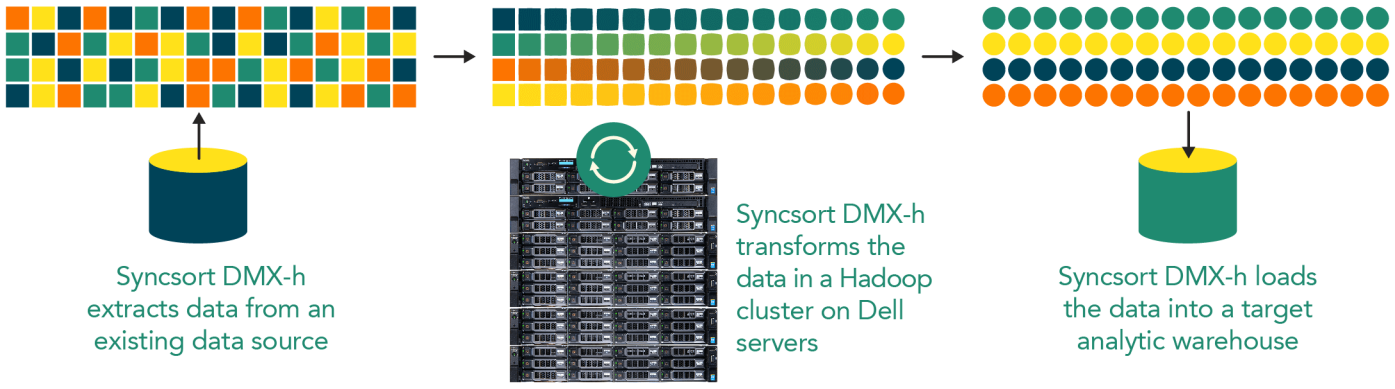


Figure 1: How the Dell | Cloudera | Syncsort solution for Hadoop works.

Syncsort SILQ®

Syncsort SILQ is a technology that pairs well with DMX-h. SILQ is a SQL offload utility designed to help users visualize and move their expensive data warehouse (SQL) data integration workloads into Hadoop. SILQ supports a wide range of SQL flavors and can parse thousands of lines of SQL code in seconds, outputting logic flowcharts, job analysis, and DMX-h jobs. SILQ has the potential to take an overwhelming SQL workload migration process and make it simple and efficient.

WHAT WE FOUND

In this section, we discuss our findings. For detailed configuration of our test systems, see Appendix A and for the detailed testing procedure, see Appendix B.

Use case 1: Fact dimension load with Type 2 SCD

Businesses often feed their Business Intelligence decisions using the Dimensional Fact Model, which uses a set of dimensional tables (tables with active and historical data about a specific category, such as Geography or Time) to feed a fact table (a table that joins the active records of all the dimensional tables on a common field) summarizing current business activity. While some dimension tables never change, some often experience updates. The dimension tables must be up-to-date to feed the fact table correctly, and many businesses would like to keep historical data as well for archival purposes.

A common method to identify changes in data is to compare historical and current data using Changed Data Capture (CDC). A common method for updating records while retaining the outdated record is Type 2 Slowly Changing Dimensions (SCD). We used outer joins and conditional formatting to implement CDC and identify changed records. We then implemented Type 2 SCD to mark outdated records with an end-date and insert the updated data as a new, current record (in our case, we used a perpetual end-date of 12/31/9999 to specify a current record). We then fed the information from the dimensional tables downstream to a fact table that could be queried for Business Intelligence.

Both the Syncsort DMX-h and DIY jobs that we created performed Type 2 SCD to feed the Dimensional Fact Model, but the Syncsort DMX-h job was able to complete the task 17.6 percent faster (see Figure 2).[4]

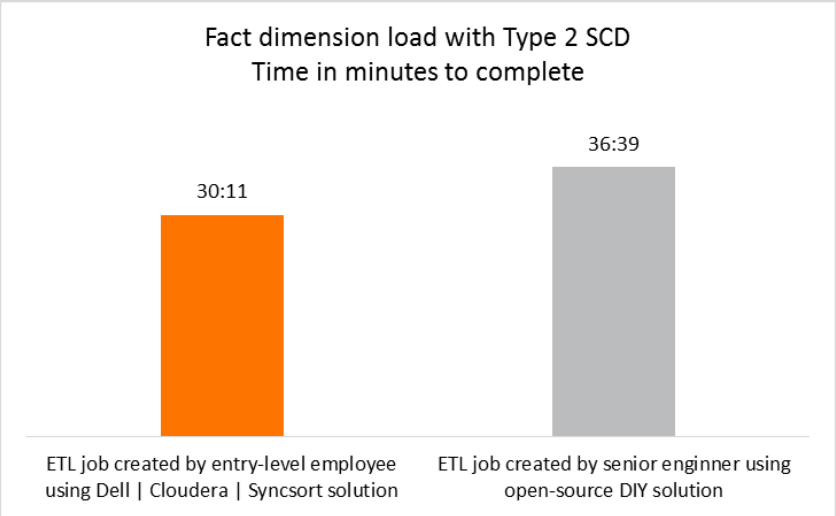


Figure 2: Time to complete the fact dimension load with Type 2 SCD use case. (Lower numbers are better.)

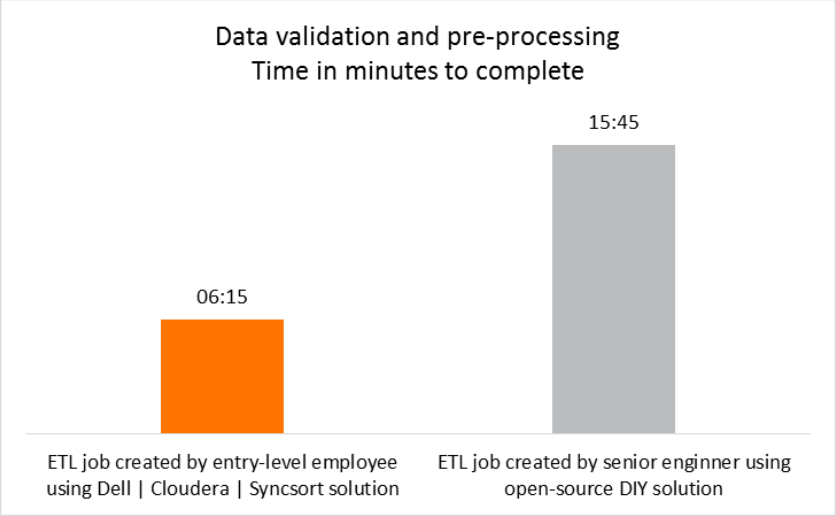
[4] Based on "Performance advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution," August 2015. Claim compares a use case based on slowly changes dimensions.

Use case 2: Data validation and pre-processing

Data validation is an important part of any ETL process. It is important for a business to ensure that only usable data makes it into their data warehouse. And when data is unusable, it's important to mark that unusable data with an error message explaining why it's invalid. Data validation can be performed with conditions and filters to check for and discard data that is badly formatted or nonsensical.

Both the Syncsort DMX-h and DIY jobs that we created performed accurate data validation, but the Syncsort DMX-h job was able to complete the task 60.3 percent faster (see Figure 3). The Syncsort DMX-h GUI made it easy to quickly try new filters and sample the outputs. Being able to rapidly prototype the data validation job meant less time spent revising.[5]

Figure 3: Time to complete the data validation and pre-processing use case. (Lower numbers are better.)



Use case 3: Vendor mainframe file integration

The need to reformat heterogeneous data sources into a more useable format is a common requirement of businesses with many varied data sources. Often companies have high-value data locked away in the mainframe and want to assimilate that data into the cluster. Some mainframe data types use a COBOL copybook to specify field formats. Syncsort DMX-h makes the process of reformatting mainframe data sources easy by allowing the user to link a COBOL copybook into metadata and automatically interpret the flat file's record layout—one of many data integration features Syncsort DMX-h offers. Syncsort DMX-h enabled an inexperienced IT person with no prior exposure to mainframe-formatted files to interpret these legacy data types, all without disturbing the integrity of the original data.

[5] Based on "Performance advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution," August 2015. Claim compares a use case based on data validation and preprocessing.

Both the Syncsort DMX-h and DIY jobs that we created were able to reformat the mainframe data successfully, but the Syncsort DMX-h job was able to complete the task 17.9 percent faster (see Figure 4).[6]

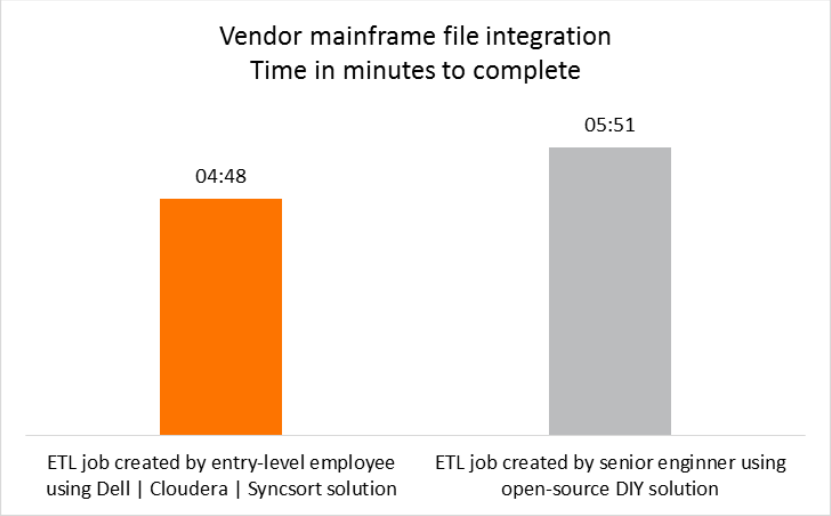


Figure 4: Time to complete the vendor mainframe file integration use case. (Lower numbers are better.)

CONCLUSION

High-level Hadoop analysis requires custom solutions to deliver the data that you need, and the faster these jobs run the better. What if ETL jobs created by an entry-level employee after only a few days of training could run even faster than the same jobs created by a Hadoop expert with 18 years of database experience?

This is exactly what we found in our testing with the Dell | Cloudera | Syncsort solution. Not only was this solution was faster, easier, and less expensive to implement, but the ETL use cases our beginner created with this solution ran up to 60.3 percent more quickly than those our expert created with open-source tools.

Using the Dell | Cloudera | Syncsort solution means that your organization can compensate a lower-level employee for half as much time as a senior engineer doing less-optimized work. That is a clear path to savings.

[6] Based on "Performance advantages of Hadoop ETL offload with the Intel processor-powered Dell | Cloudera | Syncsort solution," August 2015. Claim compares a use case based on file integration.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 5 provides detailed configuration information for the test systems.

Edge node	Dell PowerEdge R730	Dell PowerEdge R730xd
Hadoop cluster		
Roll assignment	Edge node, name node	Data node
Number of systems	2	4
Power supplies		
Total number	2	2
Vendor and model number	Dell 0HTRH4A01	Dell 0HTRH4A01
Wattage of each (W)	750	750
Cooling fans		
Total number	6	6
RPM	3,600	3,600
General		
Number of processor packages	2	2
Number of cores per processor	10	10
Number of hardware threads per core	2	2
System power management policy	Performance	Performance
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2650 v3	E5-2650 v3
Socket type	FCLGA2011-3	FCLGA2011-3
Core frequency (GHz)	2.30	2.30
Bus frequency	9.6 GT/s	9.6 GT/s
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache	20 MB	20 MB
Platform		
Vendor and model number	Dell PowerEdge R730	Dell PowerEdge R730
Motherboard model number	0599V5A06	0599V5A06
BIOS name and version	Dell 1.2.10	Dell 1.2.10
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	128	128
Vendor and model number	Samsung® M393A2G40DB0-CPB	Samsung M393A2G40DB0-CPB
Type	DDR-4	DDR-4
Speed (MHz)	2,133	2,133
Speed running in the system (MHz)	2,133	2,133
Size (GB)	16	16
Number of RAM module(s)	8	8
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual

Edge node	Dell PowerEdge R730	Dell PowerEdge R730xd
Operating system		
Name	CentOS 6.5	CentOS 6.5
Build number	2.6.32-504.23.4.el6.x86_64	2.6.32-504.23.4.el6.x86_64
File system	EXT4	EXT4
Language	English	English
RAID controller		
Vendor and model number	PERC H730 Mini	PERC H730 Mini
Firmware version	25.2.2-0004	25.2.2-0004
Driver version	N/A	N/A
Cache size (MB)	1,024	1,024
Hard drives		
Vendor and model number	Toshiba® TH0W69TH2123353R026QA00	Toshiba MG03SCA400 (4TB), Toshiba AL13SEB300 (300GB)
Number of drives	8	12 (4TB), 2 (300GB)
Size (GB)	1,000	4,000, 300
Type	Physical disk	Physical disk

Figure 5: System configuration information for the test systems.

APPENDIX B – HOW WE TESTED

Installing the Dell | Cloudera Apache Hadoop Solution

We installed Cloudera Hadoop (CDH) version 5.4 onto our cluster by following the "Dell | Cloudera Apache Hadoop Solution Deployment Guide – Version 5.4" with some modifications. The following is a high-level summary of this process.

Configuring the Dell Force10 S55 and Dell PowerConnect S4810 switches

We used the Dell Force10 S55 switch for 1GbE external management access from our lab to the Edge Node. We configured two Dell PowerConnect S4810 switches for redundant 10GbE cluster traffic.

Configuring the BIOS, firmware, and RAID settings on the hosts

We used the Dell Deployment Tool Kit to configure our hosts before OS installation. We performed these steps on each host.

1. Boot into the Dell DTK USB drive using BIOS boot mode.
2. Once the CentOS environment loads, choose the node type (infrastructure or storage), and enter the iDRAC connection details.
3. Allow the system to boot into Lifecycle Controller and apply the changes. Once this is complete, the system will automatically reboot once more.

Installing the OS on the hosts

We installed CentOS 6.5 using a kickstart file with the settings recommended by the Deployment Guide. We performed these steps on each node.

1. Boot into a minimal CentOS ISO and press Tab at the splash screen to enter boot options.
2. Enter the kickstart string and required options, and press Enter to install the OS.
3. When the OS is installed, run yum updates on each node, and reboot to fully update the OS.

Installing Cloudera Manager and distributing CDH to all nodes

We used Installation Path A in the Cloudera support documentation to guide our Hadoop installation. We chose to place Cloudera Manager on the Edge Node so that we could easily access it from our lab network.

1. On the Edge Node, use wget to download the latest cloudera-manager-installer.bin, located on archive.cloudera.com.
4. Run the installer and select all defaults.
5. Navigate to Cloudera Manager by pointing a web browser to `http://<Edge_Node_IP_address>:7180`.
6. Log into Cloudera Manager using the default credentials `admin/admin`.
7. Install the Cloudera Enterprise Data Hub Edition Trial with the following options:
    a. Enter each host's IP address.
    b. Leave the default repository options.
    c. Install the Oracle® Java® SE Development Kit (JDK).
    d. Do not check the single user mode checkbox.
    e. Enter the root password for host connectivity.
8. After the Host Inspector checks the cluster for correctness, choose the following Custom Services:
    a. HDFS
    b. Hive

c. Hue
d. YARN (MR2 Included)

9. Assign roles to the hosts using the information in Figure 6 below.

Service	Role	Node(s)
HBase		
	Master	nn01
	HBase REST Server	nn01
	HBase Thrift Server	nn01
	Region Server	nn01
HDFS		
	NameNode	nn01
	Secondary NameNode	en01
	Balancer	en01
	HttpFS	nn01
	NFS Gateway	nn01
	DataNode	dn[01-04]
Hive		
	Gateway	[all nodes]
	Hive Metastore Server	en01
	WebHCat Server	en01
	HiveServer2	en01
Hue		
	Hue Server	en01
Impala		
	Catalog Server	nn01
	Impala StateStore	nn01
	Impala Daemon	nn01
Key-value Store Indexer		
	Lily Hbase Indexer	nn01
Cloudera Management Service		
	Service Monitor	en01
	Activity Monitor	en01
	Host Monitor	en01
	Reports Manager	en01
	Event Server	en01
	Alert Publisher	en01
Oozie		
	Oozie Server	nn01
Solr		
	Solr Server	nn01
Spark		
	History Server	nn01
	Gateway	nn01

Service	Role	Node(s)
Sqoop 2		
	Sqoop 2 Server	nn01
YARN (MR2 Included)		
	ResourceManager	nn01
	JobHistory Server	nn01
	NodeManager	dn[01-04]
Zookeeper		
	Server	nn01, en01, en01

Figure 6: Role assignments.

10. At the Database Setup screen, copy down the embedded database credentials and test the connection. If the connections are successful, proceed through the wizard to complete the Cloudera installation.

Installing the Syncsort DMX-h environment

Installation of the Syncsort DMX-h environment involves installing the Job Editor onto a Windows server, distributing the DMX-h parcel to all Hadoop nodes, and installing the dmxd service onto the NameNode. We used the 30-day trial license in our setup.

Installing Syncsort DMX-h onto Windows

We used a Windows VM with access to the NameNode to run the Syncsort DMX-h job editor.

1. Run dmexpress_8-1-0_windows_x86.exe on the Windows VM and follow the wizard steps to install the job editor.

Distributing the DMX-h parcel via Cloudera Manager

We downloaded the DMX-h parcel to the Cloudera parcel repository and used Cloudera Manager to pick it up and send it to every node.

1. Copy dmexpress-8.1.7-el6.parcel_en.bin to the EdgeNode and set execute permissions for the root user.
2. Run dmexpress-8.1.7-el6.parcel_en.bin and set the extraction directory to /opt/cloudera/parcel-repo.
3. In Cloudera Manager, navigate to the Parcels section and distribute the DMExpress parcel to all nodes.

Installing the dmxd daemon on the NameNode

We placed the dmxd daemon on the NameNode in order to have it in the same location as the YARN ResourceManager.

1. Copy dmexpress-8.1.7-1.x86_64_en.bin to the NameNode and set execute permissions for the root user.
2. Run dmexpress-8.1.7-el6.parcel_en.bin to install the dmxd daemon.

Post-install configuration

We made a number of changes to the cluster in order to suit our environment and increase performance.

Relaxing HDFS permissions

We allowed the root user to read and write to HDFS, in order to simplify the process of performance testing.

1. In Cloudera Manager, search for “Check HDFS Permissions” and uncheck the HDFS (Service-Wide) checkbox.

Setting YARN parameters

We made a number of parameter adjustments to increase resource limits for our map-reduce jobs. These parameters can be found using the Cloudera Manager search bar. Figure 7 shows the parameters we changed.

Parameter	New value
yarn.nodemanager.resource.memory-mb	80 GiB
yarn.nodemanager.resource.cpu-vcores	35
yarn.scheduler.maimum-allocation-mb	16 GiB

Figure 7: YARN resource parameter adjustments.

Custom XML file for DMX-h jobs

We created an XML file to set cluster parameters for each job. In the Job Editor, set the environment variable DMX_HADOOP_CONF_FILE to the XML file path. The contents of the XML file are below.

```
<?xml version="1.0"?>

<configuration>

<!-- Specify map vcores resources  -->
<property>
<name>mapreduce.map.cpu.vcores</name>
<value>2</value>
</property>

<!-- Specify reduce vcores resources -->
<property>
<name>mapreduce.reduce.cpu.vcores</name>
<value>4</value>
</property>

<!-- Specify map JVM Memory resources -->
<property>
<name>mapreduce.map.java.opts</name>
<value>-Xmx2048m</value>
</property>

<!-- Specify reduce JVM Memory resources -->
<property>
<name>mapreduce.reduce.java.opts</name>
<value>-Xmx7168m</value>
</property>

<!-- Specify map Container Memory resources -->
<property>
<name>mapreduce.map.memory.mb</name>
```

```
<value>2560</value>
</property>

<!-- Specify reduce Container Memory resources -->
<property>
<name>mapreduce.reduce.memory.mb</name>
<value>8704</value>
</property>

<!-- Specify reducers to be used -->
<property>
<name>mapreduce.job.reduces</name>
<value>32</value>
</property>

</configuration>
```

Creating the Syncsort DMX-h use cases

In our testing, we measured the time required to design and create DMX-h jobs for three use cases. Screenshots of the DMX-h jobs for each use case appear below.

Use case 1: Fact dimension load with Type 2 Slowly Changing Dimensions (SCD)

We used outer joins and conditional reformatting to implement Type 2 SCD for use case 1. Figure 8 shows the UC1 job layout.

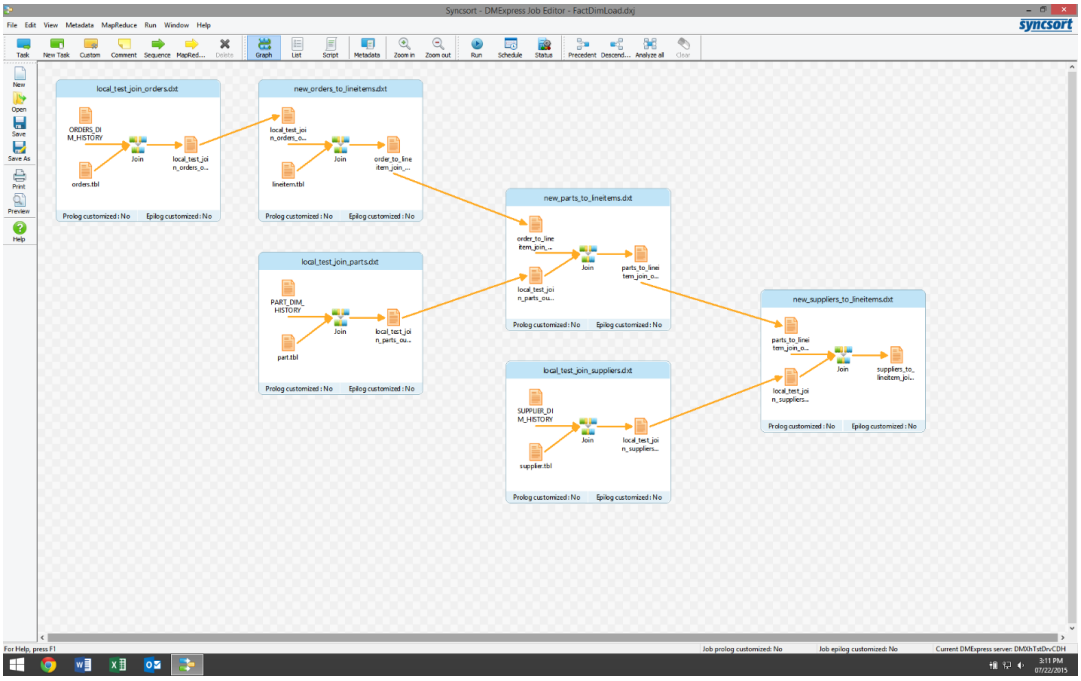


Figure 8: Use case 1 job layout.

Use case 2: Data validation and pre-processing

We used a copy task with conditional filters to implement Data Validation for use case 2. Figure 9 shows the UC2 job layout.

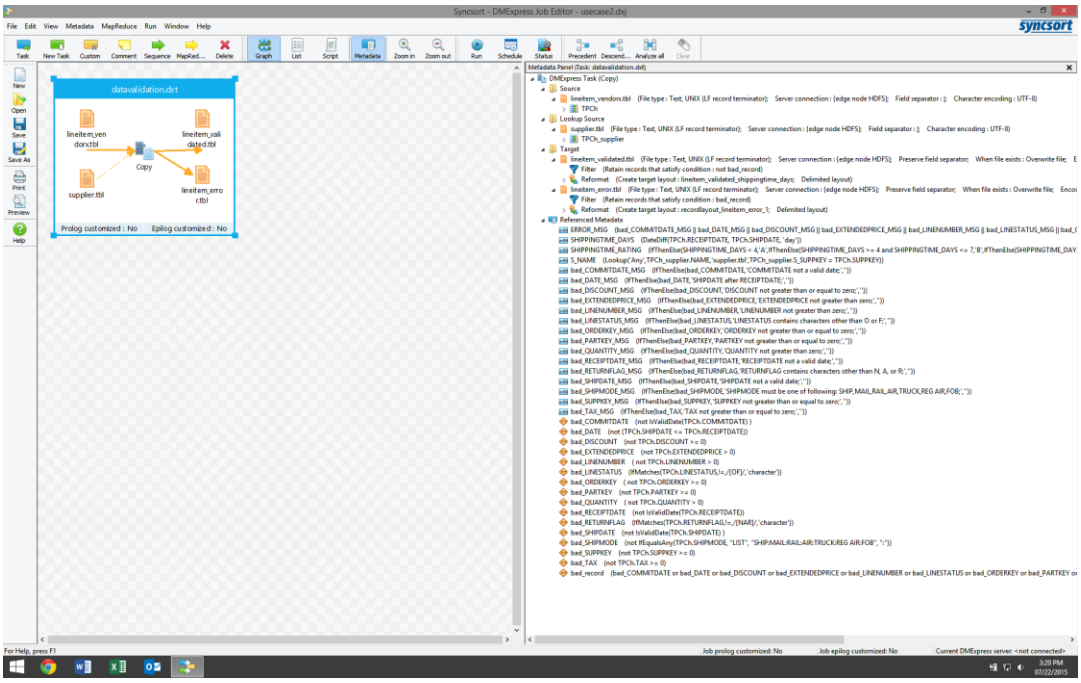


Figure 9: Use case 2 job layout.

Use case 3: Vendor mainframe file integration

We used a copy task with imported metadata to implement Vendor Mainframe File Integration for use case 3. Figure 10 shows the UC3 job layout.

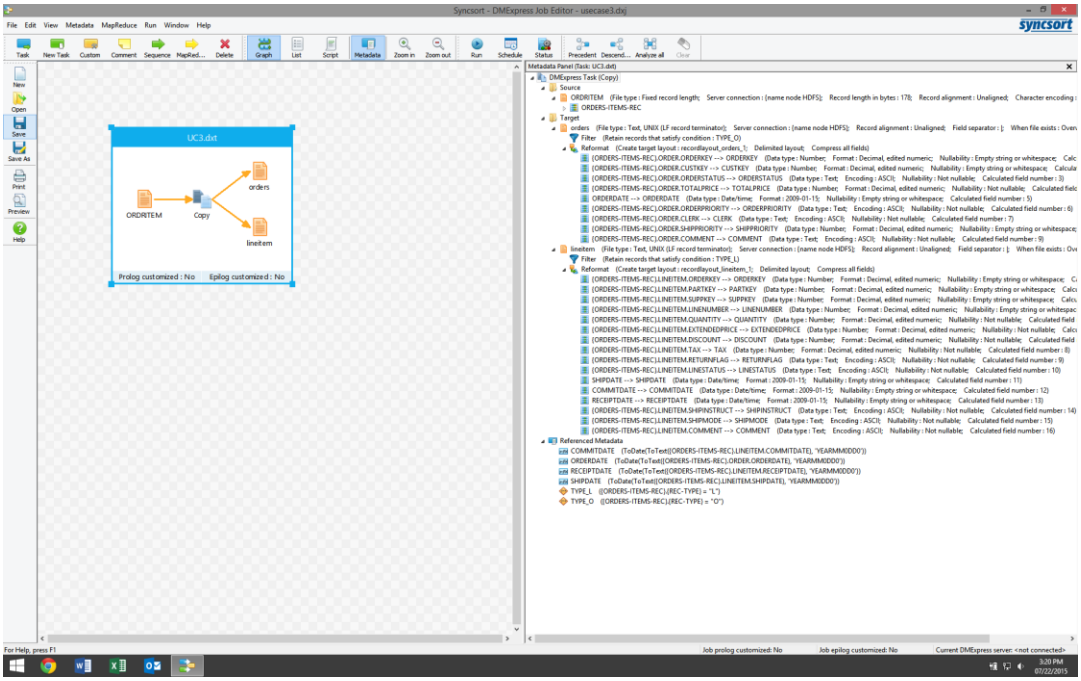


Figure 10: Use case 3 job layout.

Creating the DIY use cases

We used Pig, Python and Java to implement the DIY approaches to each use case. The DIY code for each use case appears below.

Use case 1: Fact dimension load with Type 2 Slowly Changing Dimensions (SCD)

```
set pig.maxCombinedSplitSize 2147483648
set pig.exec.mapPartAgg true

-- uc1

-----------------
-----------------
-- parameters and constants

-- input and output files
%DECLARE IN_O_UPDATES  '/UC1/200/Source/orders.tbl'
%DECLARE IN_P_UPDATES  '/UC1/200/Source/part.tbl'
%DECLARE IN_S_UPDATES  '/UC1/200/Source/supplier.tbl'
%DECLARE IN_O_HISTORY  '/UC1/200/Source/ORDERS_DIM_HISTORY'
%DECLARE IN_P_HISTORY  '/UC1/200/Source/PART_DIM_HISTORY'
%DECLARE IN_S_HISTORY  '/UC1/200/Source/SUPPLIER_DIM_HISTORY'
%DECLARE IN_LINEITEM   '/UC1/200/Source/lineitem.tbl'
%DECLARE OUT_O_HISTORY '/DIY/200/UC1/ORDERS_DIM_HISTORY'
%DECLARE OUT_P_HISTORY '/DIY/200/UC1/PART_DIM_HISTORY'
%DECLARE OUT_S_HISTORY '/DIY/200/UC1/SUPPLIER_DIM_HISTORY'
%DECLARE OUT_FACT      '/DIY/200/UC1/SOLD_PARTS_DIM_FACT'

-- "interior" fields for the i/o tables. needed to assist with column projections
%DECLARE HI_O_FIELDS
'ho_custkey,ho_orderstatus,ho_totalprice,ho_orderdate,ho_orderpriority,ho_clerk,ho_shippr
iority'
%DECLARE HI_P_FIELDS
'hp_name,hp_mfgr,hp_brand,hp_type,hp_size,hp_container,hp_retailprice'
%DECLARE HI_S_FIELDS 'hs_name,hs_address,hs_nationkey,hs_phone,hs_acctbal'
%DECLARE UP_O_FIELDS
'uo_custkey,uo_orderstatus,uo_totalprice,uo_orderdate,uo_orderpriority,uo_clerk,uo_shippr
iority'
%DECLARE UP_P_FIELDS
'up_name,up_mfgr,up_brand,up_type,up_size,up_container,up_retailprice'
%DECLARE UP_S_FIELDS 'us_name,us_address,us_nationkey,us_phone,us_acctbal'

-- Option to use replicated JOIN for the supplier name lookup.
--   use it
%DECLARE USE_REP_JOIN 'USING \'REPLICATED\'' ;
--   don't use it
-- %DECLARE USE_REP_JOIN ' ' ;

-- tag in end-date fieldstop signify an active records
%DECLARE OPEN_REC '12/31/9999'

-- tags for start/end date fields
%DECLARE TODAY_REC `date +%m/%d/%Y`
%DECLARE YESTE_REC `date --date="1 days ago" +%m/%d/%Y`

IMPORT 'uc1_macros.pig';
```

```
-----------------
-----------------

-- supplier, new history

supplier = update_history('$IN_S_UPDATES', '$IN_S_HISTORY', '$UP_S_FIELDS',
'$HI_S_FIELDS');
STORE supplier INTO '$OUT_S_HISTORY' USING PigStorage('|');

-- part, new history

part = update_history('$IN_P_UPDATES', '$IN_P_HISTORY', '$UP_P_FIELDS', '$HI_P_FIELDS');
STORE part INTO '$OUT_P_HISTORY' USING PigStorage('|');

-- orders, new history

orders = update_history('$IN_O_UPDATES', '$IN_O_HISTORY', '$UP_O_FIELDS',
'$HI_O_FIELDS');
STORE orders INTO '$OUT_O_HISTORY' USING PigStorage('|');

-----------------------------------------------
-----------------------------------------------

-- drop expired records

supplier = FILTER supplier BY h_enddate == '$OPEN_REC';
part     = FILTER part     BY h_enddate == '$OPEN_REC';
orders   = FILTER orders   BY h_enddate == '$OPEN_REC';

-- data for fact table

lineitem = lOAD '$IN_LINEITEM' USING PigStorage('|') AS (
   l_orderkey,l_partkey,l_suppkey,
   l_linenumber,l_quantity,l_extendedprice,l_discount,l_tax,l_returnflag,
   l_linestatus,l_shipdate,l_commitdate,
l_receiptdate,l_shipinstruct,l_shipmode,l_comment
);

-- dereference supplier and save required keys (drop l_suppkey)

lineitem = JOIN lineitem by l_suppkey LEFT OUTER, supplier by h_key;
lineitem = FOREACH lineitem GENERATE
   l_orderkey,l_partkey,
   hs_name,hs_nationkey,hs_acctbal,supplier::h_startdate,l_linenumber .. l_comment;

-- dereference part and save required keys (drop l_partkey)

lineitem = JOIN lineitem by l_partkey LEFT OUTER, part by h_key;
lineitem = FOREACH lineitem GENERATE
   l_orderkey,
   hp_name,hp_mfgr,hp_brand,hp_type,hp_retailprice,part::h_startdate,hs_name ..
l_comment;


-- dereference orders and save required keys (drop l_orderkey)
```

```
lineitem = JOIN lineitem by l_orderkey LEFT OUTER, orders by h_key;
lineitem = FOREACH lineitem GENERATE
   ho_custkey,ho_orderstatus,ho_totalprice,ho_orderdate,orders::h_startdate,hp_name ..
l_comment;

-----------------------------------------------
-----------------------------------------------

STORE lineitem INTO '$OUT_FACT' USING PigStorage('|');
```

uc1_macros.pig

```
DEFINE update_history(in_updates, in_history, update_fields, history_fields) RETURNS
history {
  -- update tables
  updates = LOAD '$in_updates' USING PigStorage('|') AS (
     u_key, $update_fields, u_comment
  );
  -- historical tables
  historical = LOAD '$in_history' USING PigStorage('|') AS (
     h_key, $history_fields, h_comment, h_startdate:chararray,h_enddate:chararray
  );
  -- remove expired records from the historical data and save for final table
  SPLIT historical INTO
     in_unexpired IF (h_enddate matches '^$OPEN_REC$'),
     in_expired OTHERWISE;
  -- full join by primary key to determine matches and left/right uniques
  joined = JOIN
     updates   by u_key FULL OUTER,
     in_unexpired by h_key;
  SPLIT joined INTO
     new IF h_key IS NULL,     -- totally new entry from updates
     old IF u_key IS NULL,     -- unmatched historical entry
     matched OTHERWISE;        -- match primary key: either redundant or updated entry
  -- format new and old entries for output
  new = FOREACH new GENERATE u_key .. u_comment, '$TODAY_REC', '$OPEN_REC';
  old = FOREACH old GENERATE h_key .. h_enddate;
  -- find updated entries
  SPLIT matched INTO
     updates IF ( TOTUPLE($update_fields, u_comment) != TOTUPLE($history_fields,
h_comment) ),
     redundant OTHERWISE;
  -- format redundant entries for output
  redundant = FOREACH redundant GENERATE h_key .. h_enddate;
  -- updated entry: expire historical; tag update
  modified = FOREACH updates GENERATE u_key .. u_comment, '$TODAY_REC', '$OPEN_REC';
  expired  = FOREACH updates GENERATE h_key .. h_startdate, '$YESTE_REC';
  -- combine the record classes
  $history = UNION in_expired, new, old, redundant, modified, expired;
};
```

Use case 2: Data validation and pre-processing

```
set pig.maxCombinedSplitSize 1610612736
set pig.exec.mapPartAgg true

------------------------------
------------------------------
-- parameter and constants definitions

-- input and output files
%DECLARE IN_LINEITEM_VENDOR '/UC2/200/Source/lineitem_vendorx.tbl'
%DECLARE IN_SUPPLIER        '/UC2/200/Source/supplier.tbl'
%DECLARE OUT_GOOD           '/DIY/200/UC2/lineitem_validated'
%DECLARE OUT_BAD            '/DIY/200/UC2/lineitem_errors'

-- Option to use replicated JOIN for the supplier name lookup.
--   use it
%DECLARE USE_REP_JOIN 'USING \'REPLICATED\'' ;
--   don't use it
-- %DECLARE USE_REP_JOIN ' ' ;

-- REGEX to match valid Gregorian dates in the form yyyy-mm-dd for
--  years 0000 to 9999 (as a mathematical concept, not political).
%DECLARE VALID_DATE '^(?:\\\\d{4}-(?:(?:0[1-9]|1[0-2])-(?:0[1-9]|1\\\\d|2[0-8])|(?:0[13-
9]|1[0-2])-(?:29|30)|(?:0[13578]|1[02])-
31)|(?:\\\\d{2}(?:[02468][48]|[13579][26]|[2468]0)|(?:[02468][048]|[13579][26])00)-02-
29)$'

-- header for invalid data error message field and other nerror messages
%DECLARE ERR_MSG_HEAD 'ERROR(S) in LINEITEM source record:'
%DECLARE ORD_ERR ' invalid L_ORDERKEY value;'
%DECLARE PAR_ERR ' invalid L_PARTKEY value;'
%DECLARE SUP_ERR ' invalid L_SUPPKEY value;'
%DECLARE LIN_ERR ' invalid L_LINENUMBER value;'
%DECLARE QUN_ERR ' invalid L_QUANTITY value;'
%DECLARE DIS_ERR ' invalid L_DISCOUNT value;'
%DECLARE TAX_ERR ' invalid L_TAX value;'
%DECLARE RET_ERR ' L_RETURNFLAG must be one of A,N,R;'
%DECLARE LIS_ERR ' L_LINESTATUS must be one of O,F;'
%DECLARE SHI_ERR ' L_SHIPMODE must be one of AIR,FOB,MAIL,RAIL,REG AIR,SHIP,TRUCK;'
%DECLARE NAM_ERR ' supplier lookup failed;'
%DECLARE COD_ERR ' invalid L_COMMITDATE;'
%DECLARE SHD_ERR ' invalid L_SHIPDATE;'
%DECLARE RED_ERR ' invalid L_RECEIPTDATE;'
%DECLARE SRD_ERR ' L_SHIPDATE after L_RECEIPTDATE;'

------------------------------
------------------------------
-- start of the main program

-- data to be validated

lineitem = LOAD '$IN_LINEITEM_VENDOR' USING PigStorage('|') AS (
    l_orderkey:int, l_partkey:int, l_suppkey:int, l_linenumber:int, l_quantity:int,
    l_extendedprice:float, l_discount:float, l_tax:float,
    l_returnflag:chararray, l_linestatus:chararray,
    l_shipdate:chararray, l_commitdate:chararray, l_receiptdate:chararray,
```

```
    l_shipinstruct:chararray, l_shipmode:chararray,
    l_comment);

-- lookup table for supplier name and validation
--   only first two columns from supplier

suppnames = LOAD '$IN_SUPPLIER' USING PigStorage('|') AS (
    s_suppkey:int, s_name:chararray);

-- anti join idiom (completed below) for the supplier lookup (i.e., null is if unmatched)
--   We use known cardinality of TPC-H tables (supplier is small; lineitem is
--   huge) to choose JOIN type. For example, when the TPC-H SF is 1000, the entire
--   supplier table is about 1.4GB and 10,000,000 rows. So, we know the supplier table
--   with two fields will fit (partitioned or not) in RAM -- so replicated JOIN

good1 = JOIN lineitem BY l_suppkey LEFT OUTER, suppnames BY s_suppkey $USE_REP_JOIN ;

good2 = FOREACH good1 GENERATE
--
-- start of error message
    CONCAT('$ERR_MSG_HEAD',                  CONCAT(
    (l_orderkey > 0     ? '' : '$ORD_ERR'), CONCAT(
    (l_partkey > 0      ? '' : '$PAR_ERR'), CONCAT(
    (l_suppkey > 0      ? '' : '$SUP_ERR'), CONCAT(
    (l_linenumber > 0   ? '' : '$LIN_ERR'), CONCAT(
    (l_quantity > 0     ? '' : '$QUN_ERR'), CONCAT(
   ((l_discount >= 0.0F AND l_discount <= 1.0F)
                        ? '' : '$DIS_ERR'), CONCAT(
    (l_tax >= 0.0F      ? '' : '$TAX_ERR'), CONCAT(
    (l_returnflag IN ('A','N','R')
                        ? '' : '$RET_ERR'), CONCAT(
    (l_linestatus IN ('F','O')
                        ? '' : '$LIS_ERR'), CONCAT(
    (l_shipmode IN ('AIR','FOB','MAIL','RAIL','REG AIR','SHIP','TRUCK')
                        ? '' : '$SHI_ERR'), CONCAT(
    (s_name is NOT NULL ? '' : '$NAM_ERR'), CONCAT(
    (l_commitdate matches  '$VALID_DATE'
                        ? '' : '$COD_ERR'), CONCAT(
    (l_shipdate matches    '$VALID_DATE'
                        ? '' : '$SHD_ERR'), CONCAT(
    (l_receiptdate matches '$VALID_DATE'
                        ? '' : '$RED_ERR'), -- last CONCAT
   ((l_shipdate matches '$VALID_DATE' AND l_receiptdate matches '$VALID_DATE')
                        ?  ((DaysBetween(ToDate(l_receiptdate,'yyyy-MM-
dd'),ToDate(l_shipdate, 'yyyy-MM-dd')) >= 0)
                                  ? '' : '$SRD_ERR' )
                             : '')
     ))))))))))))))) AS err_message,
-- end of error message
--
 l_orderkey .. l_suppkey, s_name, l_linenumber .. l_shipmode,
--
-- start of shipping time and rating as a TUPLE
   ((l_shipdate matches '$VALID_DATE' AND l_receiptdate matches '$VALID_DATE')
                       ?  TOTUPLE((int)DaysBetween(ToDate(l_receiptdate,'yyyy-MM-
dd'),ToDate(l_shipdate, 'yyyy-MM-dd')),
```

```
                            (CASE (int)DaysBetween(ToDate(l_receiptdate,'yyyy-MM-
dd'),ToDate(l_shipdate, 'yyyy-MM-dd'))
                                        WHEN 0 THEN 'A' WHEN 1 THEN 'A' WHEN 2 THEN 'A'
WHEN 3 THEN 'A'
                                        WHEN 4 THEN 'B' WHEN 5 THEN 'B' WHEN 6 THEN 'B'
WHEN 7 THEN 'B'
                                        WHEN 8 THEN 'C' WHEN 9 THEN 'C' WHEN 10 THEN 'C'
WHEN 11 THEN 'C' WHEN 12 THEN 'C' WHEN 13 THEN 'C'
                                        ELSE 'D' END ) )
                       : TOTUPLE( 999, 'Z')) AS t1:tuple(shippingtime_days:int,
shipping_ratingi:chararray),
-- end of shipping time and rating as a TUPLE
--
 l_comment;

SPLIT good2 INTO
  good IF ENDSWITH(err_message, ':'),
  bad OTHERWISE;

good = FOREACH good GENERATE l_orderkey .. l_shipmode, FLATTEN(t1), l_comment;
bad  = FOREACH bad  GENERATE err_message .. l_suppkey, l_linenumber .. l_shipmode,
l_comment;

STORE good into '$OUT_GOOD' USING PigStorage('|');
STORE bad  into '$OUT_BAD'  USING PigStorage('|');
```

Use case 3: Vendor mainframe file integration

```
set pig.maxCombinedSplitSize 2147483648
set pig.exec.mapPartAgg true

-- uc3
-- djs, 13 july 2015

-----------------
-----------------
-- parameters and constants

-- input and output files
%DECLARE IN_ORDERITEM '/UC3/200/Source/ORDRITEM'
%DECLARE OUT_ORDERS   '/DIY/200/UC3/orders'
%DECLARE OUT_LINEITEM '/DIY/200/UC3/lineitem'

-----------------
-----------------
-- job parameterrs
-- set the property for fixed-lengthed records; unsure which it is
set mapreduce.input.fixedlengthinputformat.record.length 178;
set mapreduce.lib.input.fixedlengthinputformat.record.length 178;
set fixedlengthinputformat.record.length 178;

-- UDF loader: fixed-length reads and ebscdic decoing
register myudfs.jar;

-----------------
-----------------

-- this UDF loader reads fixed-length records (178 bytes), and performs
--  EBCDIC conversion on the string and formats the fields, using the fixed
--  copybook format for this table. A loader that works for
--  general-purpose copybooks is out of scope, but could be done with the
--  Jrecord classes.

cobol = LOAD '$IN_ORDERITEM' USING myudfs.SimpleFixedLengthLoader;

SPLIT cobol INTO
   orders   if (chararray)$0 == 'O',
   lineitem if (chararray)$0 == 'L';

-- remove record-type field
orders   = FOREACH orders   GENERATE $1 .. ;
lineitem = FOREACH lineitem GENERATE $1 .. ;

store orders   into '$OUT_ORDERS' USING PigStorage('|');
store lineitem into '$OUT_LINEITEM' USING PigStorage('|');


SimpleFixedLengthLoader.java

package myudfs;
/* compile with, for example,
  CP=/opt/cloudera/parcels/CDH-5.4.3-1.cdh5.4.3.p0.6/lib/pig/pig-0.12.0-cdh5.4.3.jar
  export PATH=$PATH:/usr/java/jdk1.7.0_67-cloudera/bin
```

```
  export JAVA_HOME=/usr/java/jdk1.7.0_67-cloudera
  javac -cp $CP SimpleFixedLengthLoader.java
*/
import java.io.IOException;
import java.util.List;
import java.util.ArrayList;
import java.util.Arrays;

import org.apache.hadoop.mapreduce.InputFormat;
import org.apache.hadoop.mapreduce.Job;
import org.apache.hadoop.mapreduce.RecordReader;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.input.FixedLengthInputFormat;
import org.apache.hadoop.io.BytesWritable;
import org.apache.pig.FileInputLoadFunc;
import org.apache.pig.LoadFunc;
import org.apache.pig.PigException;
import org.apache.pig.backend.executionengine.ExecException;
import org.apache.pig.backend.hadoop.executionengine.mapReduceLayer.PigSplit;
import org.apache.pig.data.DataByteArray;
import org.apache.pig.data.Tuple;
import org.apache.pig.data.TupleFactory;
import org.apache.hadoop.classification.InterfaceAudience;

public class SimpleFixedLengthLoader extends LoadFunc {
      protected RecordReader in = null;
      private ArrayList<Object> mTuple = null;
      private TupleFactory mTupleFactory = TupleFactory.getInstance();

      public SimpleFixedLengthLoader() {
      }

      @Override
      public Tuple getNext()
      throws IOException {
            mTuple = new ArrayList<Object>();

            try {
                  if (!in.nextKeyValue()) {
                        return null;
                  }
                  BytesWritable val = (BytesWritable) in.getCurrentValue();
                        byte[] buf = val.getBytes();
                  String str = new String(buf, 0, 178, "Cp037");

                  addTupleValue(mTuple, doSingle(str, 0));    // record type
                  switch ( str.charAt(0) ) {
                  case 'O':
                        addTupleValue(mTuple, cleanL(str, 1, 13));    // orderkey
                        addTupleValue(mTuple, cleanL(str, 13, 25));    // custkey
                        addTupleValue(mTuple, doSingle(str, 25));    // orderstatus
                        addTupleValue(mTuple, unpackBCD(buf, 26, 34));    // totalprice
                        addTupleValue(mTuple, doDate(str, 34));        // orderdate
                        addTupleValue(mTuple, cleanR(str, 42, 57));    // orderpriority
                        addTupleValue(mTuple, cleanR(str, 57, 72));    // clerk
                        addTupleValue(mTuple, doSingle(str, 72));    // shippriority
                        addTupleValue(mTuple, cleanR(str, 73, 152));    // comment
```

```
                        break;
                  case 'L':
                        addTupleValue(mTuple, cleanL(str, 1, 13));   // orderkey
                        addTupleValue(mTuple, cleanL(str, 13, 25));   // partkey
                        addTupleValue(mTuple, cleanL(str, 25, 37));   // suppkey
                        addTupleValue(mTuple, cleanL(str, 37, 41));   // linenumber
                        addTupleValue(mTuple, unpackBCD(buf, 41, 49));   // quantity
                        addTupleValue(mTuple, unpackBCD(buf, 49, 57));   // extendedprice
                        addTupleValue(mTuple, unpackBCD(buf, 57, 65));   // discount
                        addTupleValue(mTuple, unpackBCD(buf, 65, 73));   // tax
                        addTupleValue(mTuple, doSingle(str, 73));   // returnflag
                        addTupleValue(mTuple, doSingle(str, 74));   // linestatus
                        addTupleValue(mTuple, doDate(str,75));        // shipdate
                        addTupleValue(mTuple, doDate(str,83));        // commitdate
                        addTupleValue(mTuple, doDate(str,91));        // receiptdate
                        addTupleValue(mTuple, cleanR(str, 99, 124));   // shipinstruct
                        addTupleValue(mTuple, cleanR(str,124, 134));   // shipmode
                        addTupleValue(mTuple, cleanR(str,134, 178));   // comment
                        break;
                  default:
                        String unr = "Error: unknown record type";
                        addTupleValue(mTuple, unr);                // error message
                        break;
                  }

                  Tuple tt =  mTupleFactory.newTupleNoCopy(mTuple);
                  return tt;

            } catch (InterruptedException e) {
                  int errCode = 6018;
                  String errMsg = "Error while reading input";
                  throw new ExecException(errMsg, errCode,
                  PigException.REMOTE_ENVIRONMENT, e);
            }
      }

      private String unpackBCD(byte[] buf, int start, int end) {
            StringBuffer sb = new StringBuffer();
      byte bcd, high, low;
          for (int i = start; i < end-1; i++) {
                bcd = buf[i];
            high = (byte) (bcd & 0xf0);
            high >>>= (byte) 4;
            high = (byte) (high & 0x0f);
            low = (byte) (bcd & 0x0f);

            sb.append(high);
            sb.append(low);
}
            bcd = buf[end-1];
            high = (byte) (bcd & 0xf0);
            high >>>= (byte) 4;
            high = (byte) (high & 0x0f);
            low = (byte) (bcd & 0x0f);
            sb.append(high);
// add decimal -- no check for length
            sb.insert(sb.length()-2, '.');
```

```
// add sign
            if ( low == 0x0d ) sb.insert(0, '-');
            return (sb.toString()).replaceFirst("^(-?)0+(?!\\.)","$1");
      }
      private String doSingle(String str, int start) {
            return str.substring(start, start+1);
        }
      private String cleanR(String str, int start, int end) {
            return str.substring(start, end).replaceFirst("\\s+$", "");
        }
      private String cleanL(String str, int start, int end) {
            return str.substring(start, end).replaceFirst("^0+(?!$)", "");
        }
      private String doDate(String str, int start) {
            return str.substring(start,start+4) + '-' + str.substring(start+4,start+6) +
'-' + str.substring(start+6,start+8);
        }
      private void addTupleValue(ArrayList<Object> tuple, String buf) {
            tuple.add(new DataByteArray(buf));
      }

      @Override
      public InputFormat getInputFormat() {
            return new FixedLengthInputFormat();
      }

      @Override
      public void prepareToRead(RecordReader reader, PigSplit split) {
            in = reader;
      }

      @Override
      public void setLocation(String location, Job job)
      throws IOException {
            FileInputFormat.setInputPaths(job, location);
      }
}
```

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

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Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.