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Document History

Date	Course Version No.	Software Version No.	Developer / SME	Change Record Remarks
June 2011	0.1D	NA	Vandana Mistry	Content Creation

Course Goals and Non Goals

➤ Course Goals

- At the end of this program, participants gain an understanding of basic concepts in ETL.

➤ Course Non Goals

- Implementation of ETL tools.



Pre-requisites

- Fair knowledge of DW concepts

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Intended Audience

- Software Engineers and Senior Software Engineers



Day Wise Schedule

➤ Day 1

Lesson 1: Basic Concepts

Lesson 2: ETL Process

Lesson 3: Operational considerations

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- 1.1: Data warehouse
- 1.2: Data warehousing strategies
- 1.3: Data warehouse architecture
- 1.4: ETL Meaning
- 1.5: Need for ETL

➤ Lesson 2: ETL process

- 2.1: Data extraction
- 2.2: Data transformation
- 2.3: Data Loading

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 - 3.1: Exceptional Handling
 - 3.2: Alerts and Notification
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 - 3.4: Job Scheduling and Monitoring

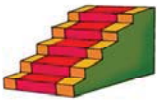
References

- **Student material:**
 - Class Book (presentation slides with notes)
- **Book:**
 - The Data Warehousing ETL Toolkit – Ralph Kimball
- **Web-site:**
 - <http://www.datawarehouse.org>
 - <http://etl-tools.info/>



Next Step Courses (if applicable)

- BI related tool training



Other Parallel Technology Areas

➤ NA


ETL Basics

Lesson 1: Basic Concepts

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Lesson Objectives

➤ On completion of this lesson on ETL basics, you will be able to:

- Understand Data warehousing strategies and architecture
- Know the meaning and need of ETL



Datawarehouse

- A single, complete and consistent store of data obtained from a variety of different sources made available to end users in a format that they can understand and use in a business context.

Datawarehousing Strategies

- Enterprise-wide warehouse, top down, the Inmon methodology
- Data mart, bottom up, the Kimball methodology
- When properly executed, both result in an enterprise-wide data warehouse

Inmon methodology - Top Down approach

- Bill Inmon saw a need to transfer data from diverse OLTP systems into a centralized place where the data could be used for analysis
- Inmon's philosophy recommends to start with building a large centralized enterprise-wide data warehouse, followed by several data-marts

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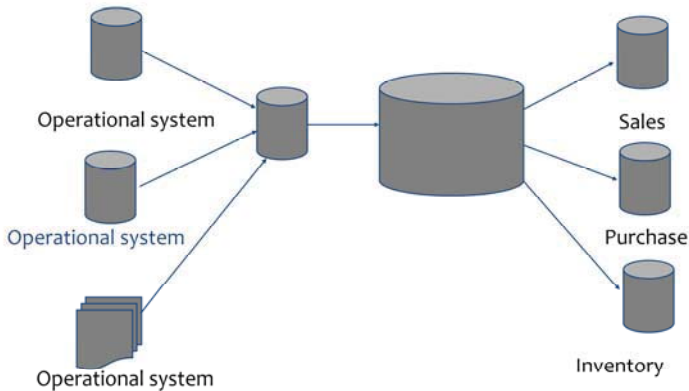
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The data marts are treated as sub sets of the data warehouse. Each data mart is built for an individual department and is optimized for analysis needs of the particular department for which it is created. The data flow in the top down OLAP environment begins with data extraction from the operational data sources. This data is loaded into the staging area and validated and consolidated. This data from the Staging area is then loaded in to the datawarehouse.

Top Down Approach

➤ Data Sources Staging Area Warehouse Data mart Topic



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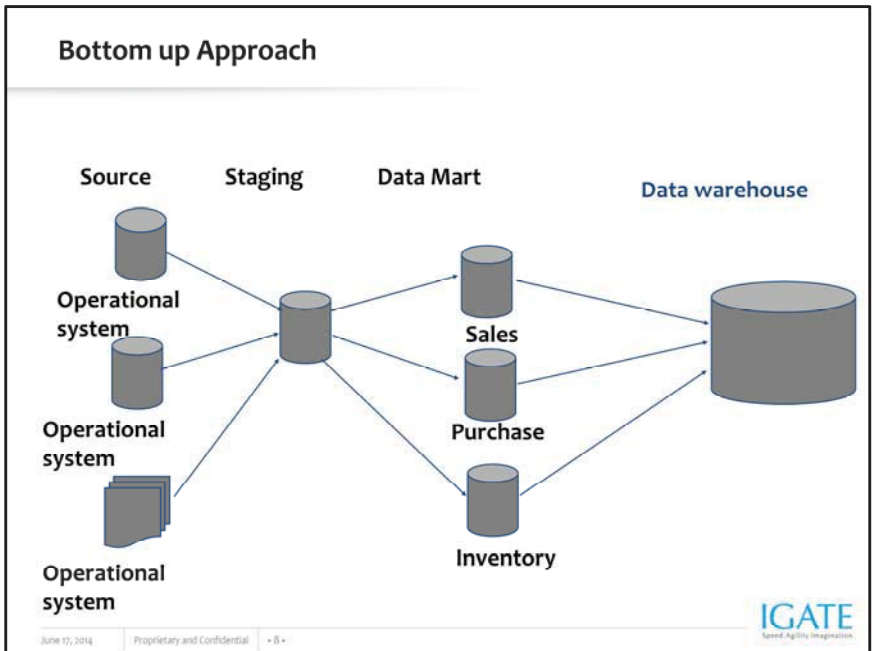
The data flow in the top down OLAP environment begins with data extraction from the operational data sources. This data is loaded into the staging area and validated and consolidated for ensuring a level of accuracy and then transferred to the Operational Data Store. (ODS). The ODS stage is sometimes skipped if it is a replication of the operational databases. Data is also loaded into the Data warehouse in a parallel process to avoid extracting it from the ODS.

Detailed data is regularly extracted from the ODS and temporarily hosted in the staging area for aggregation, summarization and then extracted and loaded into the Data warehouse. The need to have an ODS is determined by the needs of the business. If there is a need for detailed data in the Data warehouse then, the existence of an ODS is considered justified. Else organizations may do away with the ODS altogether. Once the Data warehouse aggregation and summarization processes are complete, the data mart refresh cycles will extract the data from the Data warehouse into the staging area and perform a new set of transformations on them. This will help organize the data in particular structures required by data marts. Then the data marts can be loaded with the data and the OLAP environment becomes available to the users.

The data in a data warehouse is time variant in nature as it contains historical data. Inmon proposes a top-down model approach to create a centralized Enterprise Data Warehouse using traditional database modeling techniques (ER Model), where the data is stored in 3NF. The data warehouse acts as data source for the new data marts

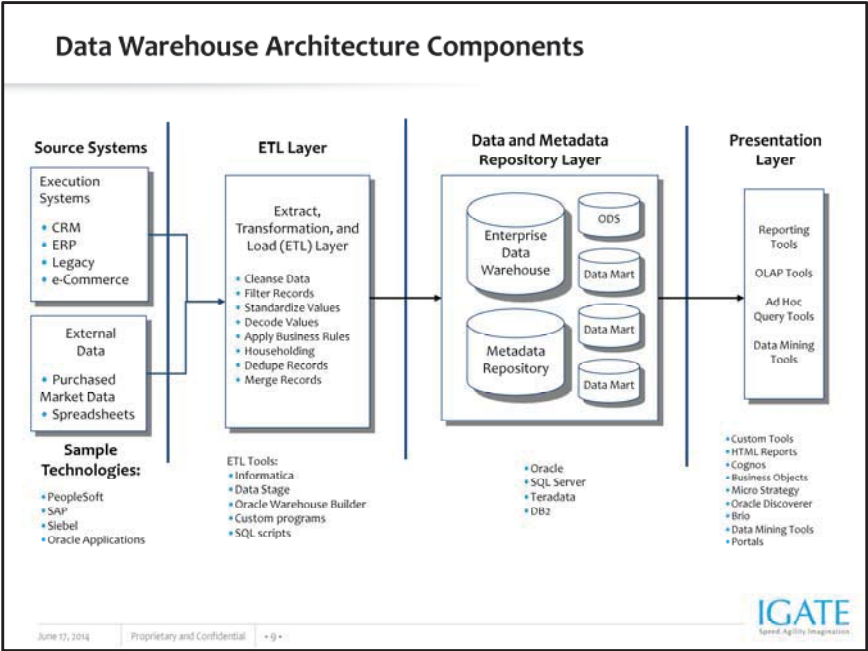
Kimball methodology – Bottom Up approach

- Kimball's philosophy recommends to start with building several data marts that serve the analytical needs of departments, followed by "virtually" integrating these data marts.



The bottom-up approach reverses the positions of the Data warehouse and the Data marts. Data marts are directly loaded with the data from the operational systems through the staging area. The ODS may or may not exist depending on the business requirements.

The data flow in the bottom up approach starts with extraction of data from operational databases into the staging area where it is processed and consolidated and then loaded into the ODS. The data in the ODS is appended to or replaced by the fresh data being loaded. After the ODS is refreshed the current data is once again extracted into the staging area and processed to fit into the Data mart structure. The data from the Data Mart, then is extracted to the staging area aggregated, summarized and so on and loaded into the Data Warehouse and made available to the end user for analysis.



What is ETL?

- ETL stands for Extract Transform & Load
- The process of updating the data warehouse
- ETL is the automated and auditable data acquisition process from source system that involves one or more sub processes of data extraction, data transportation, data transformation, data consolidation, data integration, data loading and data cleaning.

Need for ETL

- The process of ETL is required so that data from different heterogeneous sources can be combined and brought into one common source.
- The Advantage of having the process of ETL is that, as data from different sources can be brought together, highly complex and user friendly reports can be generated for decision making

Need for ETL

- Data stored in different formats in different types of databases
- Some data sources might be archives while others may be active operational systems
- Data extraction and cleansing - time-consuming and difficult
Aggregation of data

Summary

➤ In this module, you learned about the following:

- Datawarehousing strategies
- Datawarehousing architecture
- Need for ETL
- Meaning of ETL



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ETL Basics

Lesson 2: ETL Process

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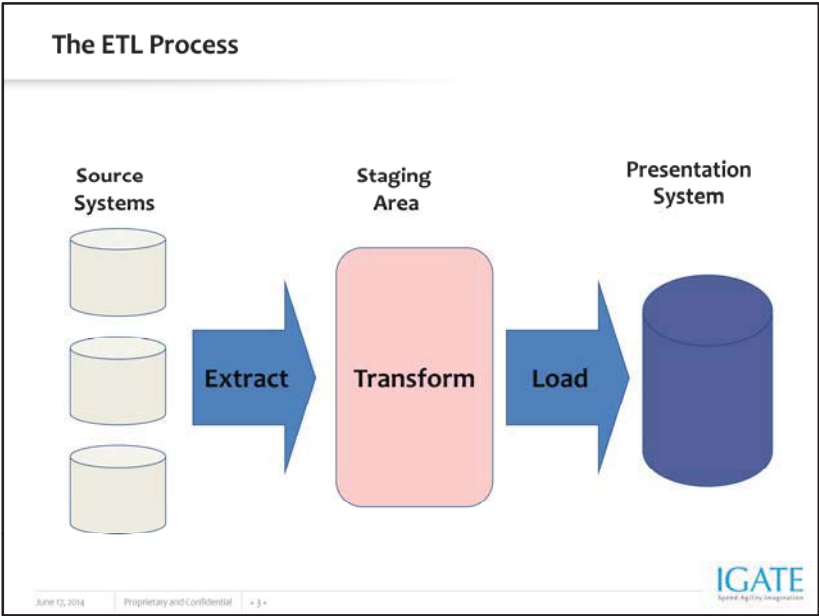

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Lesson Objectives

➤ On completion of this lesson on Data Modeling, you will be able to understand:

- The ETL process
- The steps in Data Cleansing





Change Data Capture

- Data warehousing involves the extraction and transportation of data from one or more databases into a target system or systems for analysis.
- But this involves the extraction and transportation of huge volumes of data and is very expensive in both resources and time.
- The ability to capture only the changed source data and to move it from a source to a target system(s) in real time is known as Change Data Capture (CDC).

- CDC helps identify the data in the source system that has changed since the last extraction.
- Set of software design patterns used to determine the data that has changed in a database.

Change Data Capture

- **Based on the Publisher/Subscriber model.**
- **Publisher**
 - Identifies the source tables from which the change data needs to be captured
 - Captures the change data and stores it in specially created change tables
 - Allows the subscribers controlled access to the change data

Change Data Capture

➤ Subscriber

- Subscriber needs to know what change data it is interested in
- It creates a subscriber view to access the change data to which it has been granted access by the publisher

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Data Staging

- Often used as an interim step between data extraction and later steps
- Accumulates data from asynchronous sources using native interfaces, flat files, FTP sessions, or other processes
- At a predefined cutoff time, data in the staging file is transformed and loaded to the warehouse
- There is usually no end user access to the staging file
- An operational data store may be used for data staging

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Data staging is used in cleansing, transforming, and integrating the data.

The ETL Process

- **Extract**
 - Extract relevant data
- **Transform**
 - Transform data to DW format
 - Build keys, etc.
 - Cleansing of data
- **Load**
 - Load data into DW
 - Build aggregates, etc

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Data Extraction

- Capture of data from Source Systems
- Important to decide the frequency of Extraction
- Sometimes source data is copied to the target database using the replication capabilities of standard RDBMS (not recommended because of “dirty data” in the source systems)

Reasons for “Dirty” Data

- Dummy Values
- Absence of Data
- Multipurpose Fields
- Cryptic Data
- Contradicting Data
- Inappropriate Use of Address Lines
- Violation of Business Rules
- Reused Primary Keys,
- Non-Unique Identifiers
- Data Integration Problems

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Data Transformation

- Transforms the data in accordance with the business rules and standards that have been established
- Example include: format changes, de-duplication, splitting up fields, replacement of codes, derived values, and aggregates

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Aggregates, such as sales totals, are often precalculated and stored in the warehouse to speed queries that require summary totals.

Data Transformation

➤ Validating

- Process of ensuring that the data captured is accurate and transformation process is correct
- E.g. Date of Birth of a Customer should not be more than today's date

Data Transformation

➤ Data Cleansing

- Source systems contain “dirty data” that must be cleansed
- ETL software contains rudimentary data cleansing capabilities
- Specialized data cleansing software is often used.
- Important for performing name and address correction and house holding functions
- Leading data cleansing vendors include Vality (Integrity), Harte-Hanks (Trillium), and Firstlogic (i.d.Centric)

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Data cleansing is critical to customer relationship management initiatives.

Data Transformation

▶ Steps in Data Cleansing

- Parsing
- Correcting
- Standardizing
- Matching
- Consolidating
- Conditioning
- Enrichment

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A good example to use is cleansing customer data. Most students can identify with receiving multiple copies of the same catalog because the company is not doing a good data cleansing job.

Data Transformation

➤ Parsing

- Parsing locates and identifies individual data elements in the source files and then isolates these data elements in the target files
- Examples include :
 - parsing the first, middle, and last name;
 - street number and street name; and city and state

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The record is broken down into atomic data elements.

Data Transformation

➤ Parsing

Input Data from Source File
Beth Christine Parker, SLS MGR
Regional Port Authority
Federal Building
12800 Lake Calumet
Hedgewisch, IL



Parsed Data in Target File
First Name: Beth
Middle Name: Christine
Last Name: Parker
Title: SLS MGR
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: Lake Calumet
City: Hedgewisch
State: IL

Data Transformation

➤ Correcting

- Corrects parsed individual data components using sophisticated data algorithms and secondary data sources.
- Example include replacing a vanity address and adding a zip code.

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External data, such as census data, is often used in this process.

Data Transformation

➤ Correcting

Parsed Data

First Name: Beth
Middle Name: Christine
Last Name: Parker
Title: SLS MGR
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: Lake Calumet
City: Hedgewisch
State: IL



Corrected Data

First Name: Beth
Middle Name: Christine
Last Name: Parker
Title: SLS MGR
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: South Butler Drive
City: Chicago
State: IL

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Data Transformation

➤ Standardizing

- Standardizing applies conversion routines to transform data into its preferred (and consistent) format using both standard and custom business rules.
- Examples include adding a pre name, replacing a nickname, and using a preferred street name.

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Companies decide on the standards that they want to use.

Data Transformation

Standardizing

Corrected Data

First Name: Beth
Middle Name: Christine
Last Name: Parker
Title: SLS MGR
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: South Butler Drive
City: Chicago
State: IL
Zip: 60633
Zip+Four: 2398



Corrected Data

Pre-name: Ms.
First Name: Beth
1st Name Match
Standards: Elizabeth, Bethany, Bethel
Middle Name: Christine
Last Name: Parker
Title: Sales Mgr.
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: S. Butler Dr.
City: Chicago
State: IL
Zip: 60633
Zip+Four: 2398

Data Transformation

➤ Matching

- Searching and matching records within and across the parsed, corrected and standardized data based on predefined business rules to eliminate duplications.
- Examples include identifying similar names and addresses.

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Commercial data cleansing software often uses AI techniques to match records.

Data Transformation

Matching

Corrected Data (Data Source #1)

Pre-name: Ms.
First Name: Beth
1st Name Match
Standards: Elizabeth, Bethany, Bethel
Middle Name: Christine
Last Name: Parker
Title: Sales Mgr.
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: S. Butler Dr.
City: Chicago
State: IL
Zip: 60633
Zip+Four: 2398



Corrected Data (Data Source #2)

Pre-name: Ms.
First Name: Elizabeth
1st Name Match
Standards: Beth, Bethany, Bethel
Middle Name: Christine
Last Name: Parker-Lewis
Title:
Firm: Regional Port Authority
Location: Federal Building
Number: 12800
Street: S. Butler Dr., Suite 2
City: Chicago
State: IL
Zip: 60633
Zip+Four: 2398
Phone: 708-555-1234
Fax: 708-555-5678



Data Transformation

- Consolidating
- Analyzing and identifying relationships between matched records and consolidating/merging them into ONE representation.

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All of the data are now combined in a standard format.

Data Transformation

Consolidating

Corrected Data (Data Source #1)

Corrected Data (Data Source #2)



Consolidated Data
Name: Ms. Beth (Elizabeth) Christine Parker-Lewis
Title: Sales Mgr.
Firm: Regional Port Authority
Location: Federal Building
Address: 12800 S. Butler Dr., Suite 2
Chicago, IL 60633-2398
Phone: 708-555-1234
Fax: 708-555-5678

Data Transformation

➤ Conditioning

- The conversion of data types from the source to the target data store (warehouse) -- always a relational database
- Eg. OLTP Date stored as text (DDMMYY); DW format is Oracle Date type

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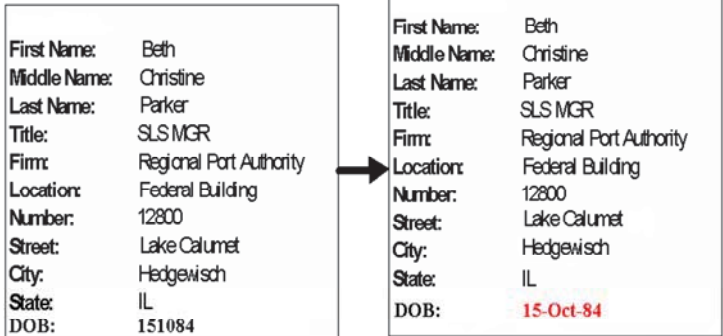
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Data Transformation

➤ Conditioning



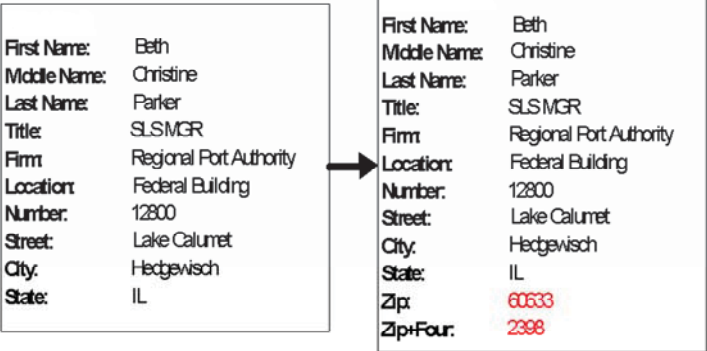
Data Transformation

➤ Enrichment

- Adding/combining external data values, rules to enrich the information already existing in the data
- E.g. If we can get a list that provides a relationship between Zip Code, City and State, then if a address field has Zip code 06905 it be safely assumed and address can be enriched by doing a lookup on this table to get Zip Code 06905 → City Stamford → State CT

Data Transformation

➤ Enrichment



Data Loading

- Data are physically moved to the data warehouse
- The loading takes place within a “load window”
- Loading the Extracted and Transformed data into the Staging Area or Data Warehouse.

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Most loads involve only change data rather than a bulk reloading of all of the data in the warehouse.

Data Loading

- First time bulk load to get the historical data into the Data Warehouse
- Periodic Incremental loads to bring in modified data
- The Loading window should be as small as possible
- Should be clubbed with strong Error Management process to capture the failures or rejections in the Loading process

Meta Data

- Data about data
- Needed by both information technology personnel and users
- IT personnel need to know data sources and targets; database, table and column names; refresh schedules; data usage measures; etc.
- Users need to know entity/attribute definitions; reports/query tools available; report distribution information; help desk contact information, etc.

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The importance of meta data is now realized, even though creating it is not glamorous work.

Feature of ETL Tools

- Support data extraction, cleansing, aggregation, reorganization, transformation, and load operations
- Generate and maintain centralized metadata
- Filter data, convert codes, calculate derived values, map source data fields to target data fields
- Automatic generation of ETL programs
- Closely integrated with RDBMS
- High speed loading of target data warehouses using Engine-driven ETL Tools

Advantages of using ETL Tools

- GUI based design of jobs – ease of development and maintenance
- Generation of directly executable code
- Engine driven technology is fast, efficient and multithreaded
- In-memory data streaming for high-speed data processing
- Products are easy to learn and require less training

Advantages of using ETL Tools

- Automatic generation and maintenance of open, extensible metadata
- Support for multiple data formats and platforms
- Large number of vendor supplied data transformation objects

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Example of ETL requirements

- **Integration of masters across different systems**
 - E.g. State code AP could mean Andhra Pradesh in one system while it could mean Arunachal Pradesh in another
- **De-duplication of data from different systems**
 - E.g. State Karnataka could be represented as KA in one system and KN in another system
- **Mapping of old codes to Data Warehouse codes**
- **Data Cleansing - Changing to upper case, assigning defaults to unavailable data elements**

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Sample ETL Tools

- Teradata Warehouse Builder from Teradata
- DataStage from IBM
- SAS System from SAS Institute
- Power Mart / Power Center from Informatica
- Sagent Solution from Sagent Software
- Hummingbird Genio Suite from Hummingbird Communications

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You might go to the vendors' web sites to find a good demo to show your students.

Summary

➤ In this module, you learned about the following:

- ETL process
- Cleansing steps



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ETL Basics

Lesson 3: Operational Considerations

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Lesson Objectives

- On completion of this lesson on ETL basics, you will be able to understand:
- Handling Exceptions in ETL
 - Notifications and Alerts in ETL
 - Recovery and Restartability



ETL Testing Considerations

- **UNIT Testing** (ensures that each component within the system successfully performs its individual responsibility when executed individually.)
 - Checking extraction rules
 - Transformation validation
 - Target system data integrity
 - Checking input data validation
 - Test the error-handling logic
 - Test slowly changing dimension implementation by checking the integrity of surrogate keys
 - Test Notifications/Warnings/Error messages
- **Integration Testing** (ensure seamless run of the entire process within an application, or a specific stage with an eye on the details of each of the steps/modules, capturing the responses as the data moves across the system.)

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ETL Testing Considerations (contd..)

- Successful extraction of data
- Order of Extraction
- Application and validation of transformation logic
- Order of precedence in which various algorithms are applied (phasing of ETL streams)
- Rejects based on applied algorithms
- Recovery and Restart
- Proper generation of the code
- Proper generation of surrogated keys in conjunction with processing the order of precedence
- Error handling
- Scheduling
- Job triggers
- Job dependencies
- Alerts and notification

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ETL Testing Considerations

➤ Integration Testing (Cont/-)

- Warnings and check point validations
- Data Auditing/Logs
- Metadata recording/deliver to internal/external repositories
- Perform delivery of the data, including format and layout
- Bulk load performance Checking extraction rules
- Transformation validation

➤ User Acceptance Testing (This testing should be for specific BI functions, including data transformation rules, and data correctness)

- Information Accuracy
- Source Data Rejections
- Data Transformation/Aggregation Rules
- Key performance metrics/reports

Exception Handling

- Exception Handling deals with any abnormal termination, unacceptable event or incorrect data that can impact the data flow or accuracy of data in the warehouse/mart.
- Exceptions in ETL could be classified as Data Related Exceptions and Infrastructure Related Exceptions.
- The process of recovering or gracefully exiting when an exception occurs is called exception handling.
- Data related exceptions are caused because of incorrect data format, incorrect value, incomplete data from the source system. This leads to Data validation exceptions and Data Rejects.
- The process of handling the Data Rejects is called Data Reprocessing.

Exception Handling

- Infrastructure related exceptions are caused because of issues in the Network , the Database and the Operating System.
- Common Infrastructure exceptions are FTP failure, Database connectivity failure, File system full etc.
- The data related exceptions are usually documented in the requirements, if not they must be because if the data related exceptions are not handled they lead to inaccurate data in the warehouse/mart.
- We also keep a threshold of maximum number of validation or reject failures allowed per load.
- Any value above the threshold would mean the data would be too inaccurate due to too many rejections.

Exception Handling

- **There is one more exception which is the presence of inaccurate or incorrect data in the warehouse. This could happen due to**
 - Incorrect requirement or missed, leading to incorrect ETL.
 - Incorrect interpretation of requirements leading to incorrect ETL.
 - Uncaught coding defects.
 - Incorrect data from source.
- **The process of Correction of the data already loaded in the warehouse involves fixing the data already loaded and also preventing the inaccuracy to persist in the future.**

Notification

➤ Methods of Notification

- Email
- Pager
- Front-End

➤ Phases of Notification

- Extraction – Start / End
- Transformation – Start / End
- Load – Start / End
- Error Messages
- Aborts

➤ Whom to Notify

- System Administrator,
- Business Users

Recovery & Restartability

➤ Design of Rollback and Recovery Procedures

- Rollback and Recovery Procedures define the strategy for handling load failures.
- This includes recommendations on whether milestone points and staging are required for restarts.
- The concept of rollback and recovery of ETL processes needs to be considered during the preliminary design stage as it affects all ETL jobs.
- For long ETL processing blocks such as a data warehouse load the end to end process may take hours or even days to run.
- It is important to have built in restartability to recover from fatal errors during the processing cycle.

Recovery & Restartability

➤ Milestone Recovery

- The simplest form of recovery is to introduce vertical bands into the ETL processing cycle.
- A vertical band is a set of jobs that run together and when complete they arrive at a milestone point.
- If the following block of jobs fail it can be restarted from this milestone.
- A milestone point requires some type of data staging, with the data being placed in temporary files or tables where they can be extracted by the next block.

Recovery & Restartability

- **The best practice for complex data loads is to have 3 vertical bands: Data Sourcing, Data Mediation & Quality/Transformation and Data Load.**
- Data Sourcing involves retrieving the data from sources and delivering it to files or tables with some type of time stamping to allow for time based processing.
 - This data undergoes as little transformation as possible and once delivered it is stable.
 - This milestone point means the Data Transformation block can be started and restarted without having the source data affected by user transactions.

Recovery & Restartability

- Data Mediation & Quality/Transformation covers a large area of data conversion, cleansing, enrichment, aggregation, etc.
- This step benefits from having ETL patterns that describe common transformations as shown in the sections below.

Recovery & Restartability

- **Data Load involves delivering the final data to the target database.**
 - This band holds as little of the transformation logic as possible.
 - It is focused on achieving a robust database update by controlling transaction sizing and trapping database rejects.
 - Database updates are the most volatile part of the process due to the complexity of RDBMS communications and the difficulty most ETL engines have with correctly rolling back and restarting a failed update.

Recovery & Restartability

➤ Individual Job Recovery

- In many instances it is possible to recover from a fatal error by restarting the job that failed and continuing the ETL cycle from that point.
- Many ETL and scheduling tools provide the functionality to automate this process.
- It may be necessary for production support to first investigate the problem and fix it before the automated recovery begins.
- This is a short cut to restarting from previous milestone points.

Recovery & Restartability

➤ Individual Job Recovery

- It is usually easy to do job recovery on the Sourcing and Transformation bands as these typically stage the data to temporary files or tables.
- Restarting an individual job recreates the target output of these jobs without rollback problems.
- In these cases the ETL scheduling tool can be used to restart the sequence from the correct point.

Recovery & Restartability

➤ Individual Job Recovery

- The Data Load band is the most difficult for rollback and recovery as a job may fail in the process of updating a database.
- If the update is an insert, or an update to an aggregated table then it is difficult to determine how many rows of stage data have already been processed.
- A simple job restart may result in duplicate rows or duplicate increases to aggregate results.
- For a Data Load job it may be possible to restart the job or it may be necessary to build full table rollback into a job restart.
- It is worth considering enhancing the design to assist with rollback – for example, a batch number could be added to transaction tables to facilitate deletion of partial or erroneous insertions.

Restartability Matrix

Issue	Steps to Mitigate Impact on Restartability	Party Responsible for Ensuring Steps are Completed
Data in source table changes frequently	Append source data with a timestamp, and store a snapshot of source data in a backup schema until the session has completed successfully	Database Administrator (creates backup schema in repository) Data Integration Developer (ensures that session calls backup schema when session recovery is performed)
Mappings in certain sessions are dependent on data produced by mappings in other sessions	Arrange sessions in a sequential batch; configure sessions to run only if previous sessions are completed successfully	Data Integration Developer
Session uses the Bulk Loading parameter	If sessions fail frequently due to external problems (e.g., network downtime), reconfigure the session to normal load. Bulk loading bypasses the database log, making session unrecoverable	Data Integration Developer
Only the Informatica Administrator can recover or restart sessions	Configure the session to send an email to the Informatica administrator when a session fails	Data Integration Developer
Multiple sessions within a concurrent batch fail	Work with database administrator to determine when failed sessions should be recovered, and when targets should be truncated and entire session run again.	Data Integration Developer Database Administrator

ETL Job Scheduling

- **ETL Job Scheduling is an operational process which is required to determine the sequence and time of execution of the various data flows (Jobs/Mappings).**
- **ETL schedule is dependent on the following**
 - Load Order
 - Order in which target data will be populated.
 - External Dependencies like
 - Timeframe of the source data availability.
 - Warehouse/Mart database Maintenance, like database backup time.
 - Operating System Maintenance, like file system backup time.
 - ETL's inter process flow dependencies like conformed dimensions ETL before the subject area specific dimension ETL, Dimension table ETL before the Fact Table ETL etc.

ETL Job Scheduling

- **Load Window**
 - Time frame in which target should be populated.
- **Scheduling Tools**
 - Scheduling the workflow / ETL jobs
- **Job Triggering**
 - Event based / Time based

ETL Job Monitoring

➤ Monitoring in ETL System

- ETL monitoring takes many aspects of the process into consideration.
- Resources outside the scope of the ETL system such as hardware and infrastructure administration and usage, as well as the source and target environments, play crucial parts in the overall efficiency of the ETL system.

ETL Job Monitoring

➤ Measuring ETL Specific Performance Indicators

- Duration in seconds.
- Rows processed per second.
- Rows read per second.
- Rows written per second.
- Throughput.

Summary

➤ In this module, you learned about the following:

- Exception handling
- Alerts and Notifications
- Process restart-ability
- Job scheduling and Monitoring



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