Advanced Data Management Technologies

Unit 8 — Extract, Transform, Load

J. Gamper

Free University of Bozen-Bolzano
Faculty of Computer Science
IDSE

Acknowledgements: I am indebted to M. Böhlen for providing me the lecture notes.

Outline

1. The ETL Process

2. Extract

3. Transform

4. Load

5. Other Issues

Outline

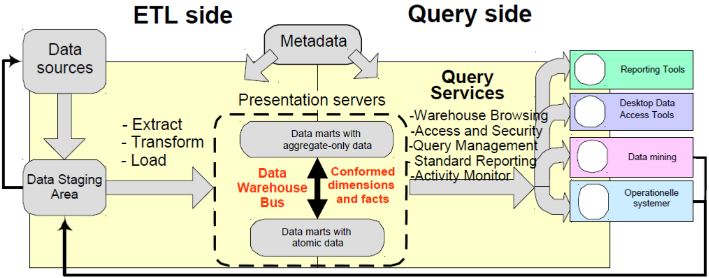
1. The ETL Process
2. Extract
3. Transform
4. Load
5. Other Issues

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.

- The ETL system is the foundation of the DW/BI project
  - its success makes or breaks the data warehouse.
- The most underestimated and time-consuming process in DW development
  - Often, 80% of development time is spent on ETL

ETL – Big Picture



Data Staging Area

- **Data staging area** (DSA) is a transit storage for data underway in the ETL process.
    - Transformations/cleansing done here
- No user queries (some do it)
- Sequential operations (few) on large data volumes
    - Performed by central ETL logic
    - Easily restarted
    - No need for locking, logging, etc.
    - RDBMS or flat files? (DBMSs have become better at this)
- Finished dimension and fact data copied from DSA to relevant data marts.

The 34 ETL Subsystems

- Kimball et al. report 34 subsystems to compose the ETL system
  - Extracting
    - Gathering raw data from the source systems and usually writing it to disk in the ETL environment.
    - 3 subsystems
  - Cleaning and conforming
    - Sending source data through a series of processing steps in the ETL system to improve the quality of the data and merging data.
    - 4 subsystems
  - Delivering
    - Physically structuring and loading the data into the dimensional model.
    - 13 subsystems
  - Managing (usually considered a separate component)
    - Managing the related systems and processes of the ETL environment.
    - 13 subsystems

ETL Construction Process

- Plan
  - Make high-level diagram of source-destination flow.
  - Test, choose and implement ETL tool.
  - Outline complex transformations, key generation and job sequence for every destination table.
- Construction of dimensions
  - Construct and test building static dimension.
  - Construct and test change mechanisms for one dimension.
  - Construct and test remaining dimension builds.
- Construction of fact tables and automation
  - Construct and test initial fact table build.
  - Construct and test incremental update.
  - Construct and test aggregate build (will be done later).
  - Design, construct, and test ETL automation.

Building Dimension Tables

- Static dimension table
  - Relatively easy
  - Assignment of production keys to DW keys using a mapping table.
  - Combination of data sources: find common key.
  - Check one-one and one-many relationships (using sorting).
- Handling dimension changes
  - Find newest DW key for a given production key.
  - Table for mapping production keys to DW keys must be updated.
- Load of dimensions
  - Small dimensions: replace
  - Large dimensions: load only changes

Building Fact Tables

- Two types of load are distinguished
  - Initial load
    - ETL for all data up till now.
    - Done when DW is started the first time.
    - Often problematic to get correct historical data.
    - Very heavy – large data volumes
  - Incremental update
    - Move only changes since last load.
    - Done periodically (. . . /month/week/day/hour/. . .) after DW start.
    - Less heavy – smaller data volumes.
- Dimensions must be updated **before** facts.
  - The relevant dimension rows for new facts must be in place.
  - Special key considerations if initial load must be performed again.

Outline

1. The ETL Process
2. Extract
3. Transform
4. Load
5. Other Issues

Extract

- Goal: fast extract of relevant data
  - Extract from source systems can take a long time.
- Different types of extraction methods
  - Extract applications (SQL): co-existence with other applications.
  - DB unload tools: much faster than SQL-based extracts.
  - Extract applications sometimes the only solution.
- Often too time consuming to ETL all data at each load.
  - Extracts can take days/weeks.
  - Drain on the operational systems.
  - Drain on DW systems.
- Alternative: Extract/ETL only changes since last load (delta).

Computing Deltas

- Much faster to only "ETL" changes since last load
  - A number of methods can be used.
- Store sorted total extracts in DSA
  - Delta can easily be computed from current+last extract

  + Always possible
  + Handles deletions
  – Does not reduce extract time
- Put update timestamp on all rows to reduce extract time
  - Updated by DB trigger
  - Extract only where "timestamp > time for last extract"

  + Reduces extract time
  + Less operational overhead
  – Deletions cannot be handled (alone)
  – Source system must be changed, e.g., change of DB schema

Capturing Changed Data

- Messages
    - Applications insert messages in a “queue” at updates

  + Works for all types of updates and systems
  – Operational applications must be changed+operational overhead
- DB triggers
    - Triggers execute actions on INSERT/UPDATE/DELETE

  + Operational applications need not be changed
  + Enables real-time update of DW
  – Operational overhead
- Replication based on DB log
    - Find changes directly in DB log which is written anyway

  + Operational applications need not be changed
  + No operational overhead
  – Not possible in some DBMS (SQL Server, Oracle, DB2 can do it)

Data Quality

- Data almost **never** has decent quality
- Data in DW must be
  - Precise
    - DW data must match known numbers – or explanation needed!
  - Complete
    - DW has all relevant data and the users know.
  - Consistent
    - No contradictory data: aggregates fit with detail data.
  - Unique
    - The same things is called the same and has the same key (customers).
  - Timely
    - Data is updated “frequently enough” and the users know when.

Outline

1. The ETL Process
2. Extract
3. **Transform**
4. Load
5. Other Issues

Data Transformations

- Data type conversions
  - EBCDIC → ASCII/UniCode
  - String manipulations
  - Date/time format conversions
- Normalization/denormalization
  - To the desired DW format
  - Depending on source format
- Building keys
  - Table that maps production keys to surrogate DW keys.
  - Observe correct handling of history – especially for total reload.

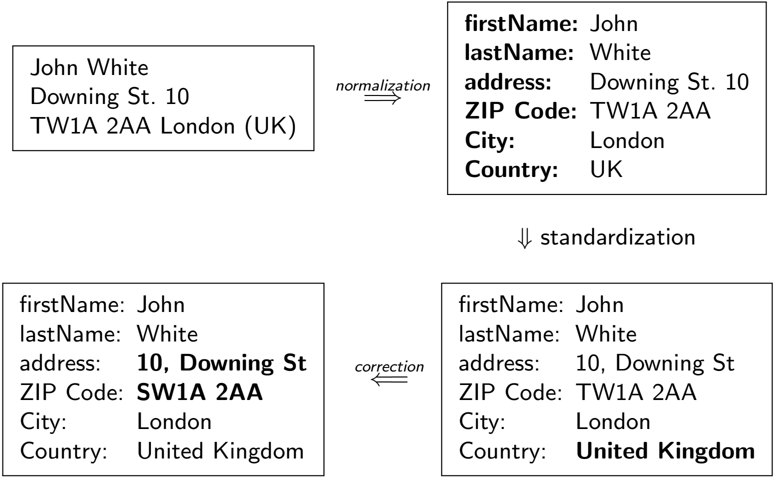
Cleansing/1

- BI does not work on "raw" data.
  - Pre-processing necessary for good results.
  - Can "disturb" BI analyses if not handled (e.g., duplicates).
- Handle inconsistent data formats.
  - Spellings, codings, . . .
- Remove unneeded attributes
  - Production keys, comments, . . .
- Replace codes with text
  - City name instead of ZIP code, 0/1 by Yes/No, . . .
- Combine data from multiple sources with common key
  - Customer data, . . .
- Find attributes with several uses
  - Extra values used for "programmer hacks".

Cleansing/2

- Mark facts with data status dimension
  - Normal, abnormal, outside bounds, impossible,
  - Facts can be taken in/out of analyses
- Recognize random or noise values
  - Can disturb BI tools
  - Replace with NULLs (or estimates)
- Uniform treatment of NULL
  - Use explicit NULL value rather than "normal" value (0, -1, . . .)
  - Use NULLs only for measure values (estimates instead?)
  - Use special dimension keys for NULL dimension values
- Aggregate fact data?
  - Performance
  - Statistical significance only for higher levels

Data Cleansing Example



John White
Downing St. 10
TW1A 2AA London (UK)

normalization ⟹

firstName:	John
lastName:	White
address:	Downing St. 10
ZIP Code:	TW1A 2AA
City:	London
Country:	UK

⇓ standardization

firstName:	John
lastName:	White
address:	10, Downing St
ZIP Code:	TW1A 2AA
City:	London
Country:	**United Kingdom**

correction ⟸

firstName:	John
lastName:	White
address:	**10, Downing St**
ZIP Code:	**SW1A 2AA**
City:	London
Country:	United Kingdom

Data Mining Transformations

- Can often **not** be done generally for the whole DW.
- Divide data into training, test, and evaluation sets.
  - Training: used to train model.
  - Test: used to check the model's generality (overfitting).
  - Evaluation: model uses evaluation set to find "real" clusters, . . .
- Add computed attributes as inputs or "targets"
  - Derived attributes often more interesting for mining (profit,. . .)
  - Means more possibilities for data mining
- Mappings
  - Continuous values to intervals, textual values to numerical
- Normalization of values between 0 and 1
  - Demanded by some tools (neural nets)
- Emphasizing the rare case
  - Duplicate rare elements in training set

Improving Data Quality

- Appoint “data stewards” – responsible for data quality
  - A given steward has the responsibility for certain tables
  - Includes manual inspections and corrections!
- DW-controlled improvement
  - Default values
  - “Not yet assigned 157” note to data steward
- Source-controlled improvements
  - The optimal solution, but not feasible in most cases.
- Construct programs to automatically check data quality
  - Are totals as expected?
  - Do results agree with alternative source?
- Do not fix **all** problems with data quality
  - Allow management to see “weird” data in their reports.

Outline

1 The ETL Process

2 Extract

3 Transform

4 **Load**

5 Other Issues

Load/1

- Goal: fast loading into DW.
  - Loading deltas is much faster than total load.
- SQL-based update is slow
  - Large overhead (optimization, locking, etc.) for every SQL call.
- DB load tools are much faster.
  - Some load tools can also perform UPDATEs.
- Index on tables slows load a lot.
  - Drop index and rebuild after load.
  - Can be done per partition.
- Parallelization
  - Dimensions can be loaded concurrently.
  - Fact tables can be loaded concurrently.
  - Partitions can be loaded concurrently.

Load/2

- Relationships in the data
  - Referential integrity must be ensured.
  - Can be done by loader.
- Aggregates
  - Must be built and loaded at the same time as the detail data.
  - Today, RDBMSs can often do this.
- Load tuning
  - Load without log
  - Sort load file first
  - Make only simple transformations in loader
  - Use loader facilities for building aggregates
  - Use loader within the same database
- Should DW be on-line 24*7?
  - Use partitions or several sets of tables

Outline

1 The ETL Process

2 Extract

3 Transform

4 Load

5 Other Issues

ETL Tools

- ETL tools from the big vendors
  - Oracle Warehouse Builder/Oracle Data Integrator
  - IBM DB2 Warehouse Manager
  - Microsoft Data Transformation Services
- Offer much functionality at a reasonable price
  - Data modeling
  - ETL code generation
  - Scheduling DW jobs
  - ...
- Many others
  - Hundreds of tools
  - Often specialized tools for certain jobs (insurance cleansing, ...)
- The "best" tool does not exist.
  - Choose based on your own needs.
  - Check first if the "standard tools" from the big vendors are ok.

Other ETL Issues

- Files versus streams/pipes?
  - Streams/pipes: no disk overhead, fast throughput
  - Files: easier restart, often only possibility
- ETL tool or not?
  - Code: easy start, co-existence with IT infrastructure
  - Tool: better productivity on subsequent projects
- Load frequency?
  - ETL time depends on data volumes
  - Daily load is much faster than monthly
  - Applies to all steps in the ETL process

A Few Hints on ETL Design

- Do **not** try to implement all transformations in one step!
- Do **one** (or just a few) thing(s) at the time
  - Copy source data one-one to DSA
  - Compute deltas
    - Only if doing incremental load
  - Handle versions and DW keys
    - Versions only if handling slowly changing dimensions
  - Implement complex transformations
  - Load dimensions
  - Load facts

Summary

- ETL is very time consuming (80% of entire DW project).
  - Not a single-step process, but needs to be implemented as a sequence of many small steps.
  - Data quality plays a crucial role in ETL.
  - Data has almost never good quality, which need to be fixed in ETL.
- Extraction of data from source systems might be very time consuming.
  - Incremental approach is suggested.
- Transformation into DW format includes many steps, such as
  - building key, cleansing the data, handle inconsistent/duplicate data, etc.
- Load includes the loading of the data in the DW, updating indexes and pre-aggregates, etc.
- ETL tools are available from big vendors, but also many other (open source) tools
  - Offer good functionality at a reasonable price
  - “Best tool” does not exist