Lecture 10

Building the DW

Summary – last week

- OLAP Operations:
  - Roll-up: hierarchical, dimensional
  - Drill-down: You can't drill if you don't have the data
  - Slice, dice, Pivot
- Operations affect data through query languages OLAP Query languages: SQL 99
  - SQL99:
    - Grouping Set, Roll-up, Cube operators

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This week

Building the DW

1. The DW Project
2. Data Extract/Transform/Load (ETL)
3. Metadata

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The DW Project

- Building a DW, is a complex IT project
  - A middle size DW-project contains 500-1000 activities
- DW-Project organization
  - Project roles and corresponding tasks, e.g.:

Roles	Tasks
DW-PM	Project Management
DW-Architect	Methods, Concepts, Modeling
DW-Miner	Concepts, Analyze(non-standard)
Domain Expert	Domain Knowledge
DW-System Developer	System- and metadata-management, ETL
DW User	Analyze (standard)

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The DW Project (cont'd.)

- Software choice
  - Database system for the DW
    - Usually the choice is to use the same technology provider as for the operational data
    - MDB vs. RDB
  - ETL tools
    - Differentiate by the data cleansing needs
  - Analysis tools
    - Varying from data mining to OLAP products, with a focus on reporting functionality
  - Repository
    - Not very oft used
    - Helpful for metadata management

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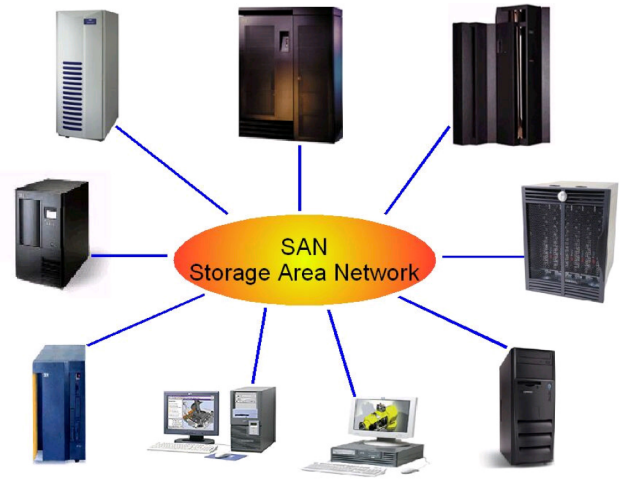
The DW Project (cont'd.)

- Hardware choice
  - Data storage
    - RAID systems, SAN's, NAS's
  - Processing
    - Multi-CPU systems, SMP, Clusters
  - Failure tolerance
    - Data replication, mirroring RAID, backup strategies
  - Other factors
    - Data access times, transfer rates, memory bandwidth, network throughput and latency



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The DW Project (cont'd.)

- Project **Timelines**, depends on the development methodology, but usually
  - Phase I – **Proof of Concept**
    - Establish Technical Infrastructure
    - Prototype Data Extraction/Transformation/Load
    - Prototype Analysis & Reporting
  - Phase II – **Controlled Release**
    - Iterative Process of Building Subject Oriented Data Marts
  - Phase III – **General Availability**
    - On going operations, support and training, maintenance and growth
- The most important part of the DW building project is defining the **ETL** process

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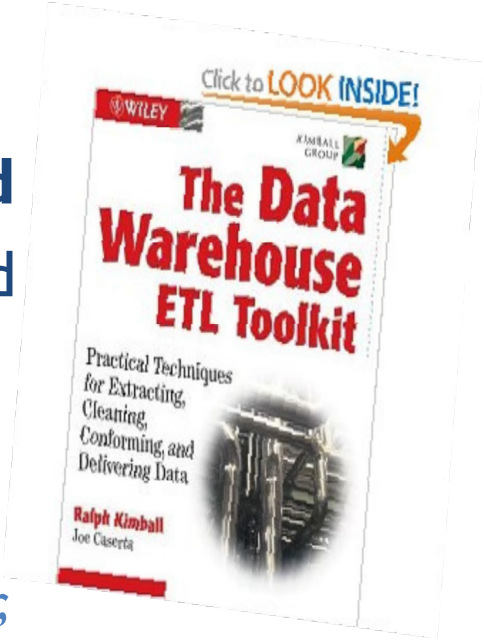
ETL

- What is ETL?
  - Short for **extract**, **transform**, and **load**
  - Three database functions that are combined into one tool to **pull data out** of productive databases and place it into the DW
    - **Migrate data** from one database to another, to form data marts and data warehouses
    - **Convert** databases from one format or type to another



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ETL (cont'd.)

- **When** should we ETL?
  - Periodically (e.g., every night, every week) or after significant events
  - Refresh policy set by administrator based on user needs and traffic
  - Possibly different policies for different sources
  - Rarely, on every update (real-time DW)
    - Not warranted unless warehouse data require current data (up to the minute stock quotes)

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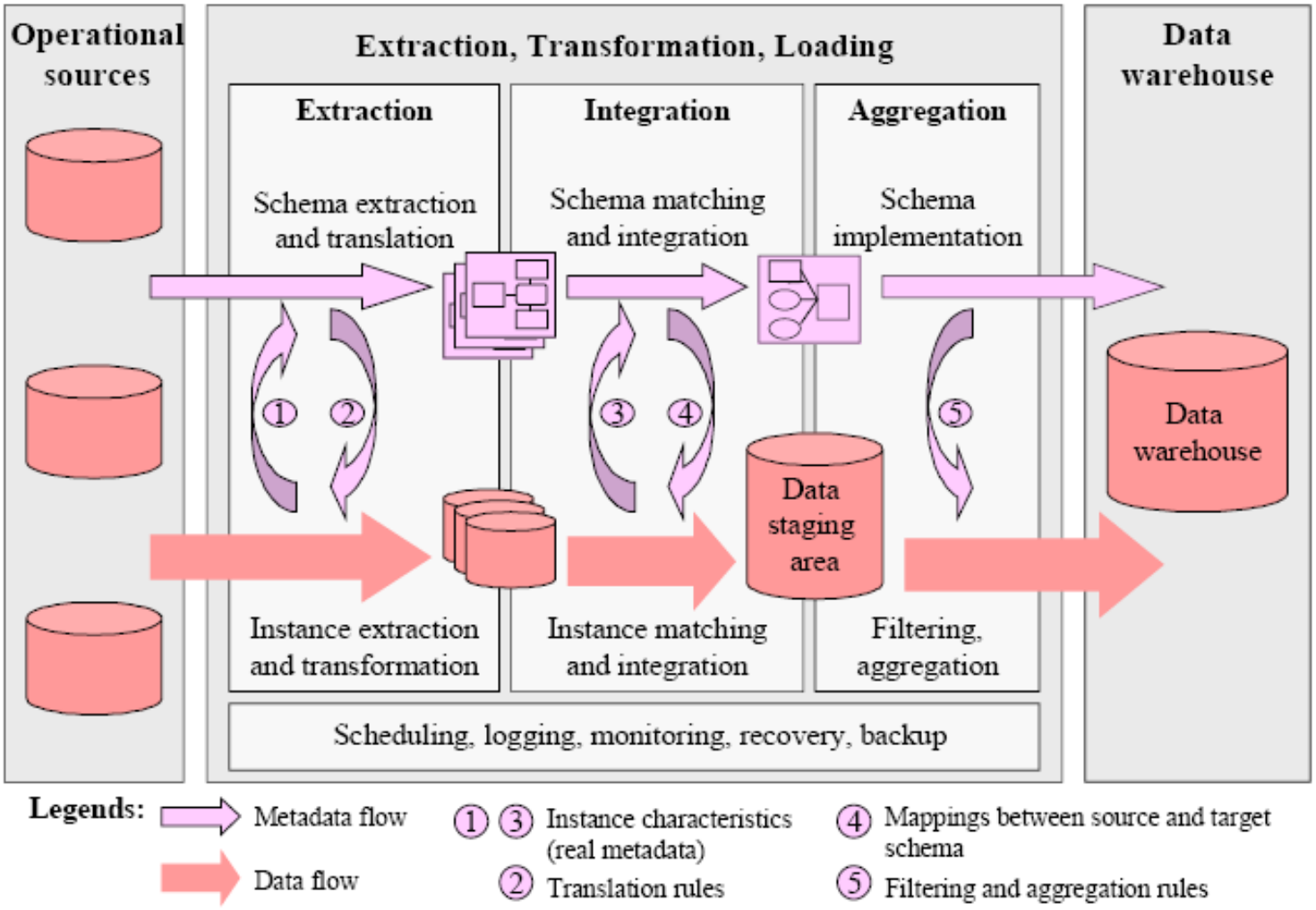
ETL (cont'd.)



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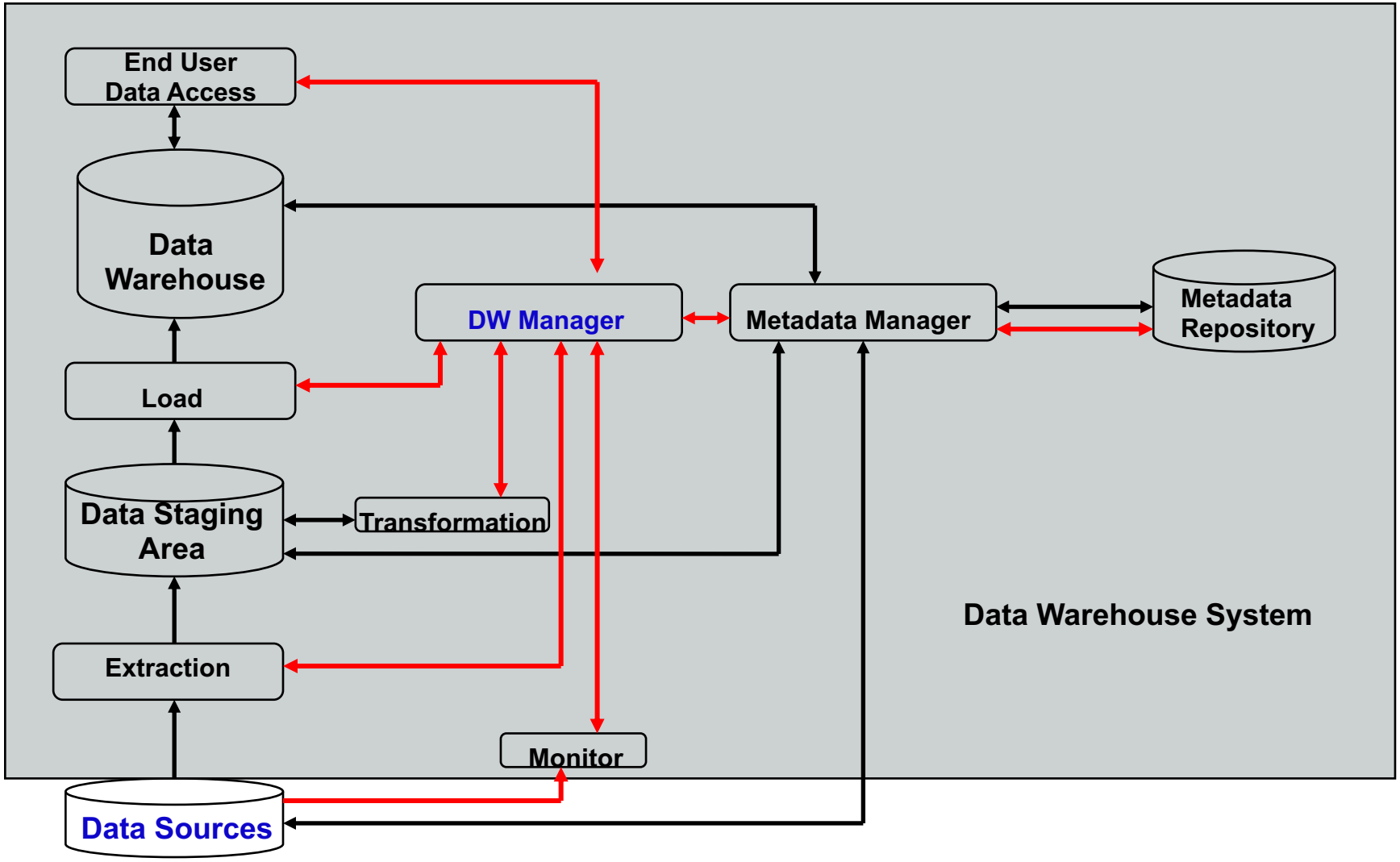
ETL (cont'd.)



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Data Extraction

- **Data Extraction**
  - Data needs to be taken from a data source so that it can be put into the DW
    - Internal scripts/tools at the data source, which **export** the data to be used
    - External programs, which **extract** the data from the source
  - If the data is exported, it is typically exported into a **text file** that can then be brought into an intermediary database
  - If the data is extracted from the source, it is typically transferred directly into an **intermediary database**

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Data Extraction (cont'd.)

- **Steps** in data extraction
  - Initial extraction
    - Preparing the **logical map**
    - First time data extraction
  - Ongoing extraction
    - Just **new** data
    - **Changed** data
    - Or even **deleted** data

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Data Extraction (cont'd.)

- **Logical map** connects the original source data to the final data
- **Building the logical map**: first identify the data sources
  - Data discovery phase
    - Collecting and documenting source systems: databases, tables, relations, cardinality, keys, data types, etc.
  - Anomaly detection phase
    - NULL values can destroy any ETL process, e.g., if a foreign key is NULL, joining tables on a NULL column results in data loss, because in RDB NULL ≠ NULL in DW

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Data Extraction (cont'd.)

- Example of solving NULL anomalies
  - If NULL on **foreign key** then use **outer joins**
  - If NULL on other columns then create a **business rule** to replace NULLs while loading data in DW
- Ongoing Extraction
  - Data needs to be **maintained** in the DW also after the initial load
    - Extraction is performed on a regular basis
    - Only changes are extracted after the first time
- **How do we detect changes?**

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Ongoing Extraction

- Detecting changes (new/changed data)
  - Using audit columns
  - Database log scraping or sniffing
  - Process of elimination
- Using **audit columns**
  - Store the date and time a record has been added or modified at
  - Detect changes based on **date stamps higher than the last extraction date**

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Detecting Changes

- **Log scraping**
  - Takes a snapshot of the database **redo log** at a certain time (e.g., midnight) and finds the transactions affecting the tables ETL is interested in
  - It can be problematic when the redo log gets full and is emptied by the DBA
- **Log Sniffing**
  - Pooling the redo log at small time granularity, capturing the transactions on the fly
  - The better choice: suitable also for real-time ETL

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Detecting Changes

- **Process of Elimination**
  - Preserves exactly one copy of each previous extraction
  - During next run, it compares the entire source tables against the extraction copy
  - Only differences are sent to the DW
  - Advantages
    - Because the process makes row by row comparisons, it is **impossible to miss data**
    - **It can also detect deleted rows**

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Detecting Changes

- Detecting deleted or overwritten fact records
  - If records or incorrect values are inserted by mistake, records in ODS get deleted or overwritten
  - If the mistakes have already been loaded in the DW, corrections have to be made
  - In such cases the solution is not to modify or delete data in the DW, but inserting an additional record which **corrects** or even **cancels** the mistake by negating it

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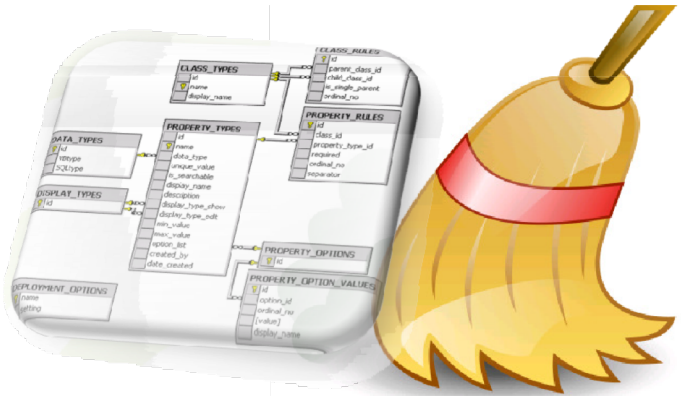
Data Transformation

- **Data transformation**
  - Uses **rules**, **lookup tables**, or combinations with other data (master data), to convert source data to the desired state
- 2 major steps
  - Data Cleaning
    - Mostly involves manual work
    - Assisted by artificial intelligence algorithms and pattern recognition
  - Data Integration
    - Also involves manual work



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Data Cleaning

- Extracted data can be dirty. How does clean data look like?
- **Data Quality** characteristics:
  - **Correct**: values and descriptions in data represent their associated objects truthfully
    - E.g., if the city in which store A is located is Braunschweig, then the address should not report Paris
  - **Unambiguous**: the values and descriptions in data can be taken to have only one meaning

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Cleaning Engine

- **Core** of the data cleaning engine
  - Break data into atomic units
    - E.g., breaking the address into street, number, city, zip and country
  - Standardizing
    - E.g., encoding of the sex: 0/1, M/F, m/f, male/female
  - Verification
    - E.g., does zip code 38106 belong to Braunschweig?
  - Matching

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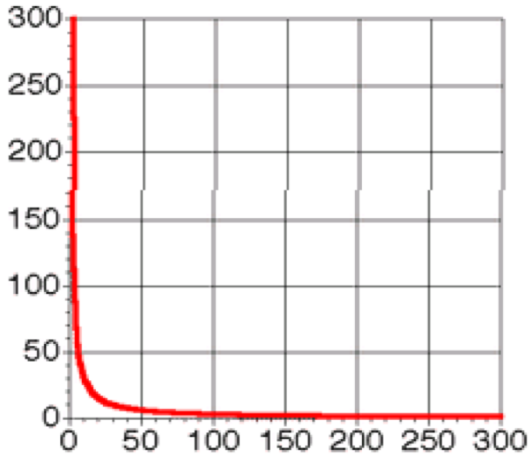
Data Quality (cont'd.)

- Data profiling
  - Pay closer look to strange values
  - Observe data distribution pattern
- Data distribution
  - Flat distribution
    - Identifiers distributions (keys)
  - Zipfian distribution
    - Some values appear more often than others
      - In sales, more cheap goods are sold than expensive ones



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Data Quality Checks

- Types of enforcement
  - Column property enforcement
    - Ensures that incoming data contains expected values
    - No NULL values in required columns
    - No numeric values outside the expected high/low ranges
    - No columns whose lengths are unexpectedly short or long
    - No columns that contain values outside of valid value sets
    - Spell-checker rejects

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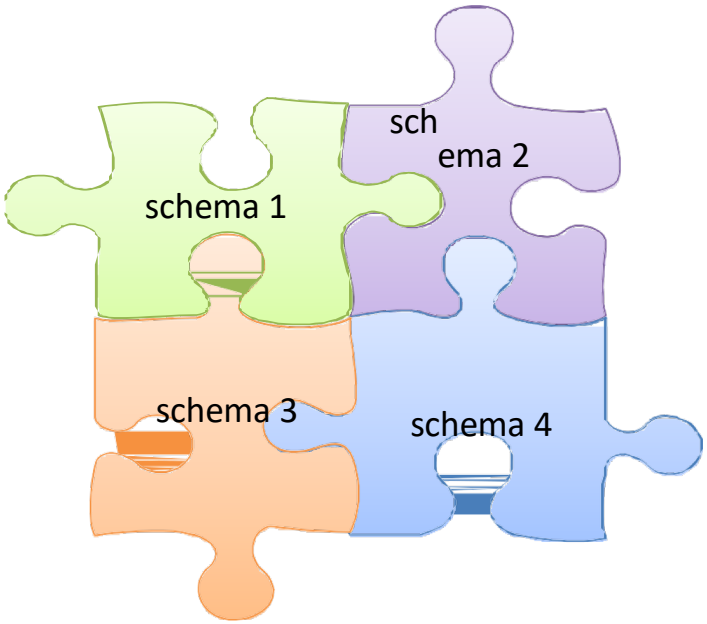
Data Integration

- Data integration
  - Several conceptual schemas need to be combined into a unified global schema
  - All differences in perspective and terminology have to be resolved
  - All redundancy has to be removed



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Data Integration (cont'd.)

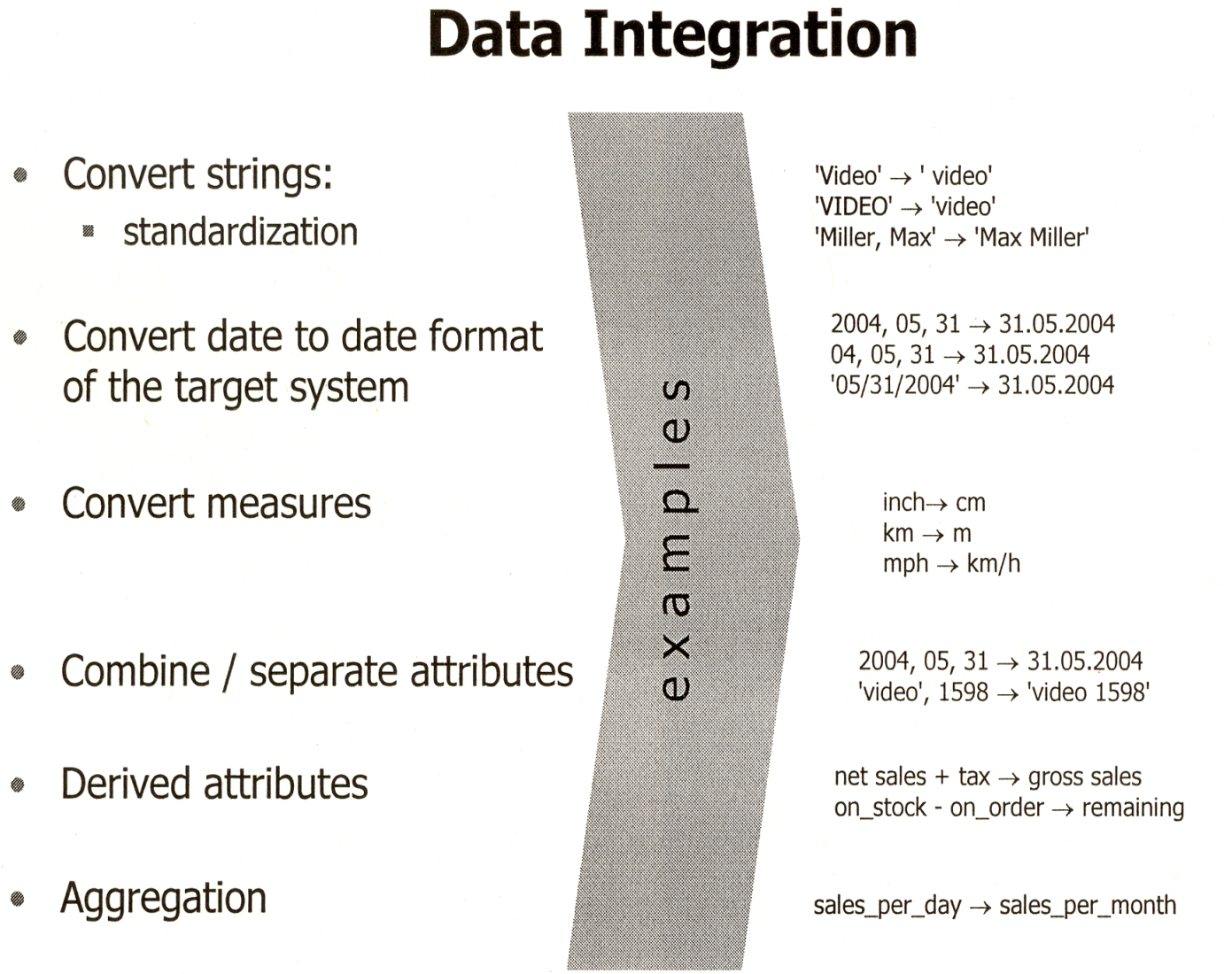
customer

system	local key	global key
1	107	5400345
1	109	5401340
2	107	4900342
2	214	5401340

character→ date
character → integer
'MM-DD-YYYY' → 'DD.MM.YYYY'

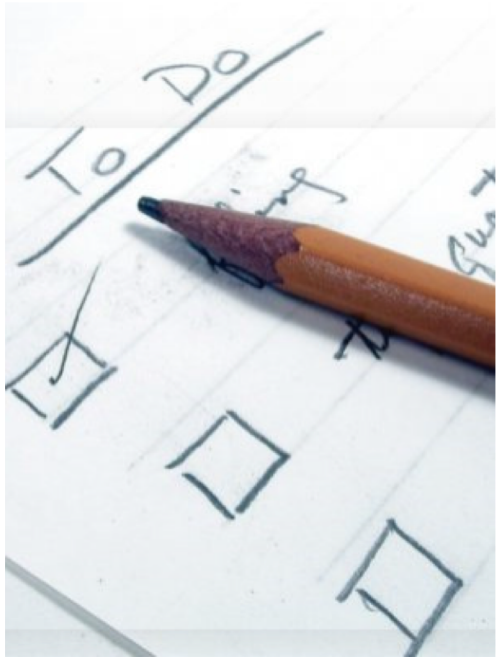
gross sales → 1
net sales → 2
3 → price
2 → GS

Data Integration (cont'd.)



Schema Integration

- There are **four basic steps** needed for conceptual schema integration
  1. Preintegration analysis
  2. Comparison of schemas
  3. Conformation of schemas
  4. Merging and restructuring of schemas
- The integration process needs continual refinement and reevaluation



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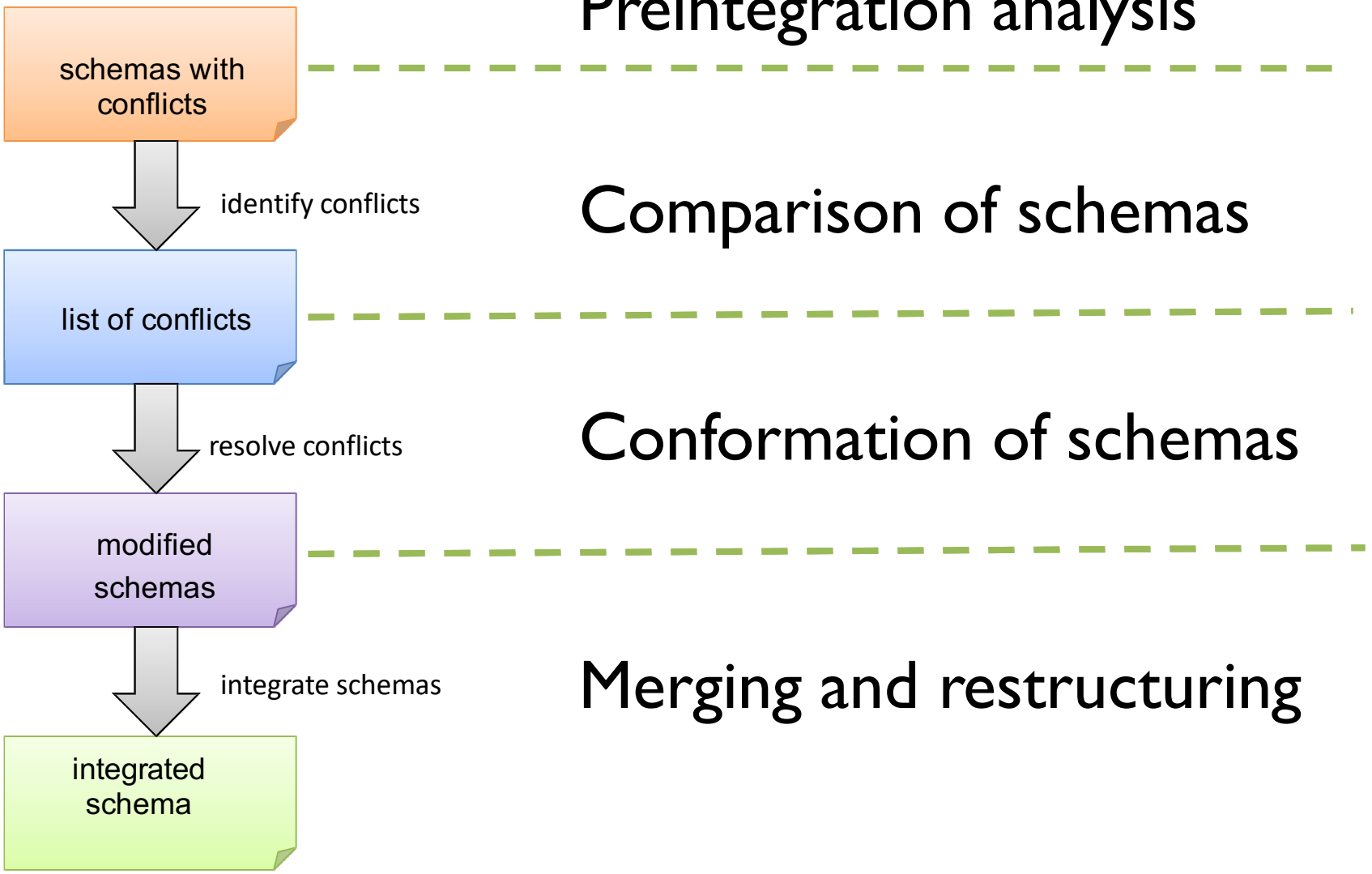
Schema Integration (cont'd.)



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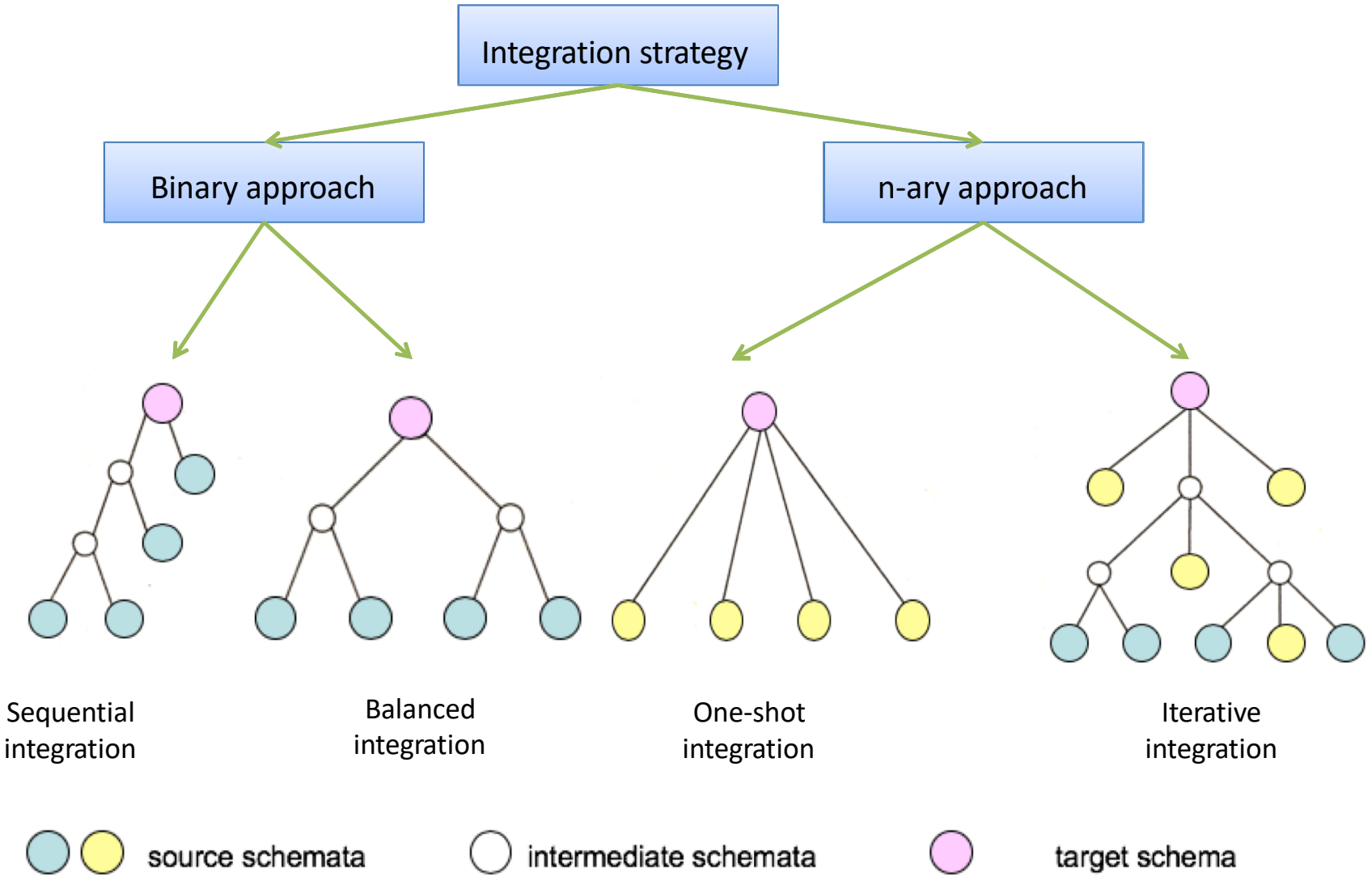
Schema Integration (cont'd.)

- **Preintegration analysis** needs a close look on the individual conceptual schemas to decide for an **adequate integration strategy**
  - Is it really sensible/possible to integrate all schemas? e.g. no need to load attribute TransactionID into DW.

Schema Integration (cont'd.)



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Schema Integration (cont'd.)

- **Schema conflicts**
  - Table/Table conflicts
    - Table naming e.g., synonyms
    - Structure conflicts e.g., missing attributes
    - Conflicting integrity conditions
  - Attribute/Attribute conflicts
    - Naming e.g., synonyms
    - Default value conflicts
    - Conflicting integrity conditions e.g., different data types or boundary limitations
  - Table/Attribute conflicts

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Schema Integration (cont'd.)

- The basic goal is to make schemas **compatible** for integration
- Conformation usually needs **manual** interaction
  - Conflicts need to be **resolved semantically**
  - Rename entities/attributes
  - Convert differing types, e.g., convert an entity to an attribute or a relationship
  - Align cardinalities/functionalities
  - Align different datatypes

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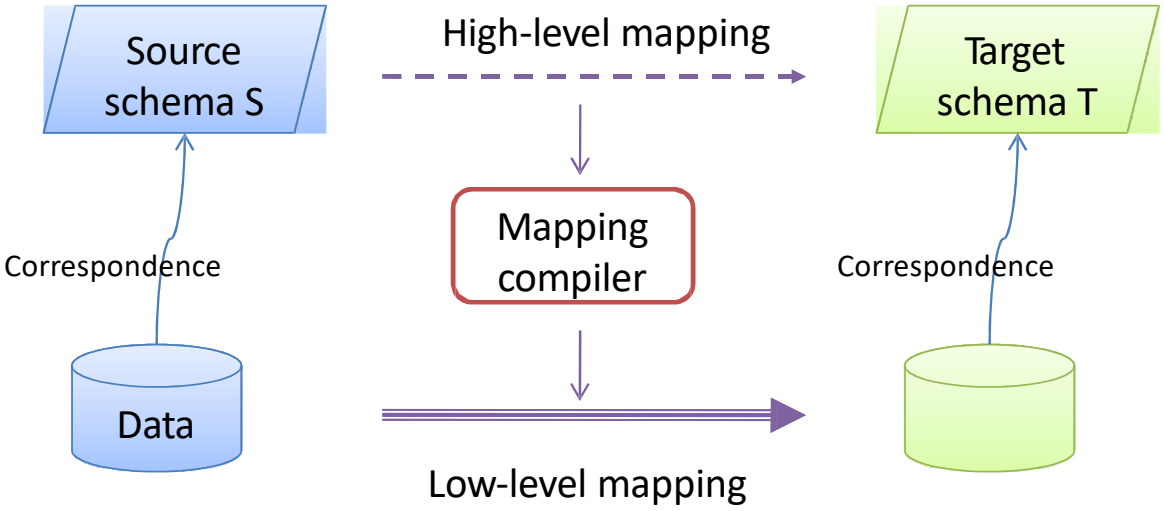
Schema Integration (cont'd.)

- Mapping from one or more source schemas to a target schema



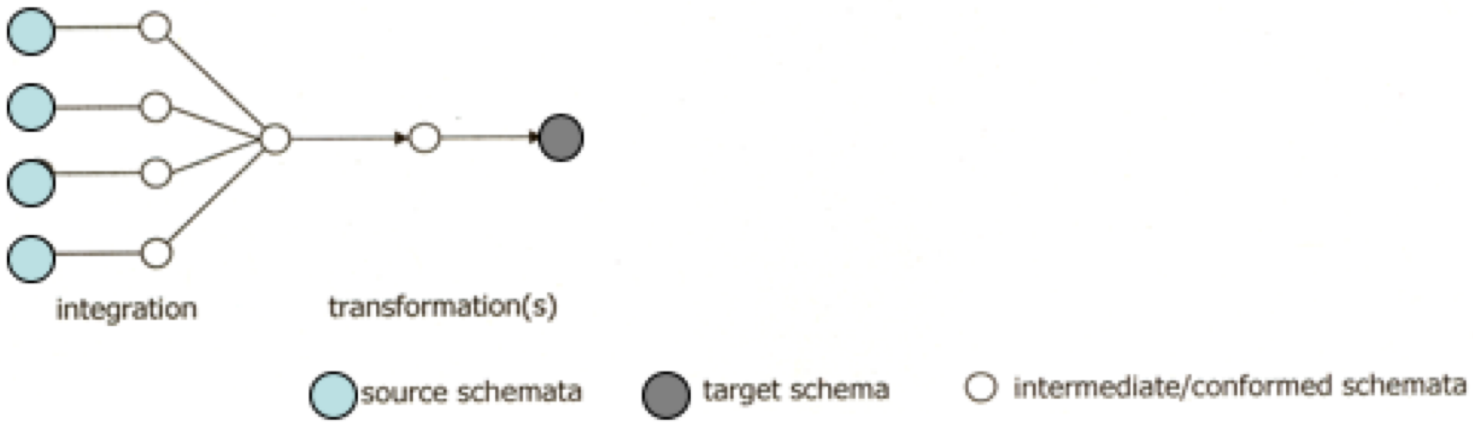
Schema Integration (cont'd.)

- Schema Mapping
  - Abstracting from the actual labels, regarding element types, depths in hierarchies, number and type of relationships, etc.

Product
ID: Decimal
Product: VARCHAR(50)
GroupID:Decimal

→

Product
ProdID: Decimal
Product: VARCHAR(50)
Group: VARCHAR(50)
Categ: VARCHAR(50)



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Loading

- The **loading** process can be broken down into 2 different types:
  - Initial load
  - Continuous load (loading over time)

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Loading (cont'd.)

- **Issues**
  - Huge volumes of data to be loaded
  - Small time window available when warehouse can be taken off line (usually nights)
  - When to build index and aggregated tables
  - Allow system administrators to monitor, cancel, resume, change load rates
  - **Recover gracefully** - restart after failure from where you were and without loss of data integrity

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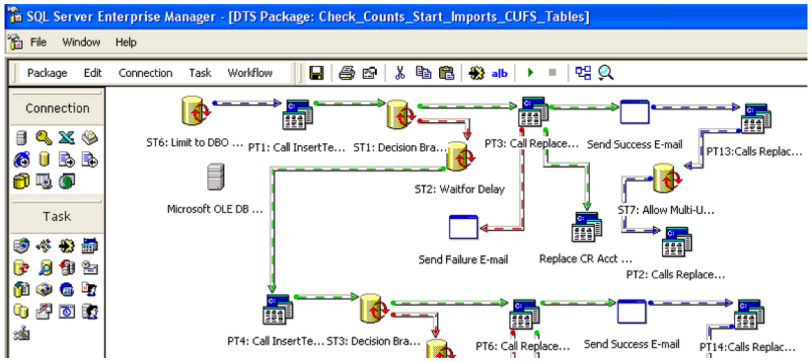
Loading (cont'd.)

- **Initial Load**
  - Deliver dimensions tables
    - Create and assign surrogate **keys**, each time a new cleaned and conformed dimension record has to be loaded
    - Write dimensions to disk as physical tables, in the **proper dimensional format**
  - Deliver fact tables
    - Utilize bulk-load utilities
    - Load in parallel
  - Tools
    - DTS – DataTransformation Services (set of tools)
    - bcp utility – batch copy
    - SQL* Loader



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Loading (cont'd.)

- **Continuous load** (loading over time)
  - Must be scheduled and processed in a specific order to maintain integrity, completeness, and a satisfactory level of trust.
  - Should be the most carefully planned step in data warehousing or can lead to:
    - Error duplication
    - Exaggeration of inconsistencies in data

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Loading (cont'd.)

- Continuous load of **facts**
  - Separate updates from inserts
  - Drop any indexes not required to support updates
  - Load updates
  - Drop all remaining indexes
  - Load inserts through bulk loaders
  - Rebuild indexes

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Loading (cont'd.)

MERGE INTO

- Transaction table cust_napier contains updates to existing rows in DW and/or new rows that should be inserted
- MERGE statement of SQL 2003 allows us to:
  - Update (address in) rows that have a matching counterpart in the target table
  - Insert rows that do not have a matching counterpart in the target table

```
MERGE INTO customer as c1
USING (  SELECT key, name, addr, …
         FROM cust_napier
         WHERE …) as c2
ON (c1.key = c2.key)
WHEN MATCHED THEN
         UPDATE SET c1.addr = c2.addr
WHEN NOT MATCHED THEN
         INSERT (key, name addr, …
         VALUES (key, name, addr, …)
```

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Loading (cont'd.)

Multi-table INSERT

- Insert rows into several target tables
- Insert the same row into several target tables

Conditional Insert

- Can define conditions to select target table

Unconditional INSERT

```
INSERT ALL
    INTO customer
    VALUES (key, name, addr,…)
    INTO location
        VALUES (addr, 'Napier')
SELECT * FROM cust_napier
WHERE …
```

Conditional INSERT

```
INSERT ALL
WHEN KEY < 100
    INTO customer
    VALUES (key, name, addr,…)
WHEN KEY < 1000
    INTO location
     VALUES (addr, 'Napier')
SELECT * FROM cust_napier
WHERE …
```

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Metadata

- **Metadata** - data about data
  - In DW, metadata describe the contents of a data warehouse and how to use it
    - What information exists in a data warehouse, what the information means, how it was derived, from what source systems it comes, when it was created, what pre-built reports and analyses exist for manipulating the information, etc.

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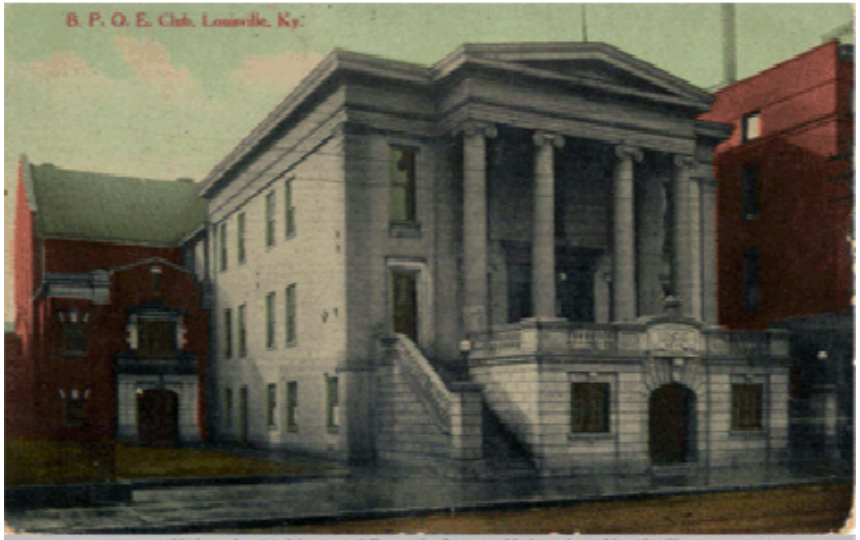
Metadata (Cont'd.)

- **Types** of metadata in DW
  - Source system metadata
  - Data staging metadata
  - DBMS metadata



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Location Depicted	Louisville (Ky.)
Date Original	1910?
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Summary

- How to build a DW
  - The DW Project: usual tasks, hardware, software, timeline (phases)
  - Data Extract/Transform/Load (ETL):
    - Data storage structures, extraction strategies (e.g., scraping, sniffing)
    - Transformation: data quality, integration
    - Loading: issues, and strategies, (bulk loading for fact data is a must)
  - Metadata:
    - Describes the contents of a DW, comprises all the intermediate products of ETL,
    - Helps for understanding how to use the DW

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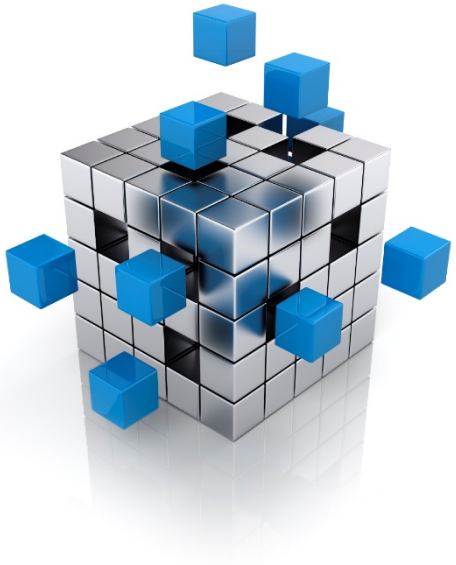
Next Lecture

- Real-time Data Warehousing
  - Real-time Data Processing Challenges
  - Real-time Join Algorithms



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