CSC12107 – Information Systems for Business Intelligence

Chapter 4
ETL PROCESS

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Goals

- After complete this chapter, student will:
  - Define the ETL approach and architecture
  - Able to extract, transform and load data into a datawarehouse

Main topic

- **Introduction to ETL**
- ETL approach and architecture
- Extracting data
- Populating the DW

Discussion

- WHY WE HAND CODE
- WHY WE USE TOOLS
- *Are ETL systems only used to load data into the data warehouse?*

Introduction to ETL

- ETL is the process of retrieving and transforming data from the source system and putting it into the data warehouse.
- The most underestimated and time-consuming process in DW development ⍰
  - Often, 80% of development time is spent on ETL
- The ETL system is the foundation of the DW/BI project → its success makes or breaks the data warehouse.

Introduction to ETL

- ETL stands for Extract, Transform, and Load
  - **E**xtract
    - Extract relevant data from source system
  - **T**ransform
    - Transform data to DW format; deduce new data values, validate data checks
    - Data cleansing
    - …
  - **L**oad
    - loads the data into the DW

ETL - Fundamental principles

- Not to slow the source system down too much
- Be careful not to disturb the source system too much
- **The extraction to be as fast as possible**:
    - **Time**: such as five minutes if we can, not three hours
    - **Size**: as small as possible, such as 10MB per day, not 1GB per day.
    - **Frequency**: once a day if we can, not every five minutes

ETL - Fundamental principles

- The change in the source systems to be as minimal as possible
    - Should not creating triggers for capturing data changes in every single table.
- Should not have any **leakage**
- Can **recover** without data loss or damage

Main topic

- Introduction to ETL
- **ETL approach and architecture**
- Extracting data
- Populating the DW

ETL approach and architecture

- **Traditionall approach:**
  - To stage on disks or do transformation in memory
- **Alternative approaches based on**:
  1. where to perform the transformations
  2. who moves the data out of the source system
  3. Where to put ETL processes

ETL approach and architecture

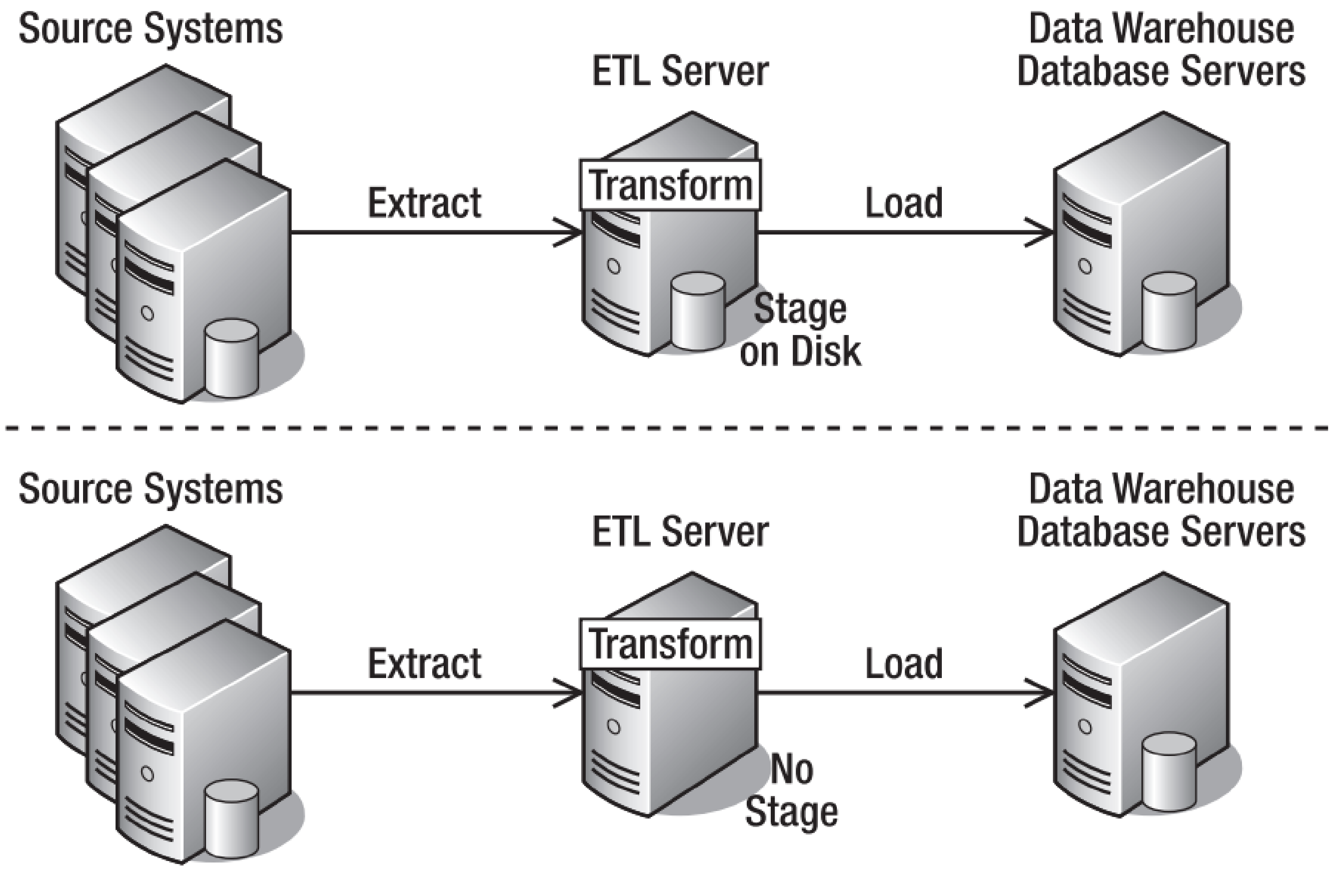
- **Traditional approach:**
  - Source system → ETL server (stage) → DW
  - Source system → ETL server (no staging, in memory) → DW

- The staging area is a physical database or files.
- Putting the data into the staging area means inserting it into the database or writing it in files.

ETL approach and architecture

Traditional approach:

- Transforming the data in memory is faster than putting it on disk first.
    - Small data?
    - Big data?



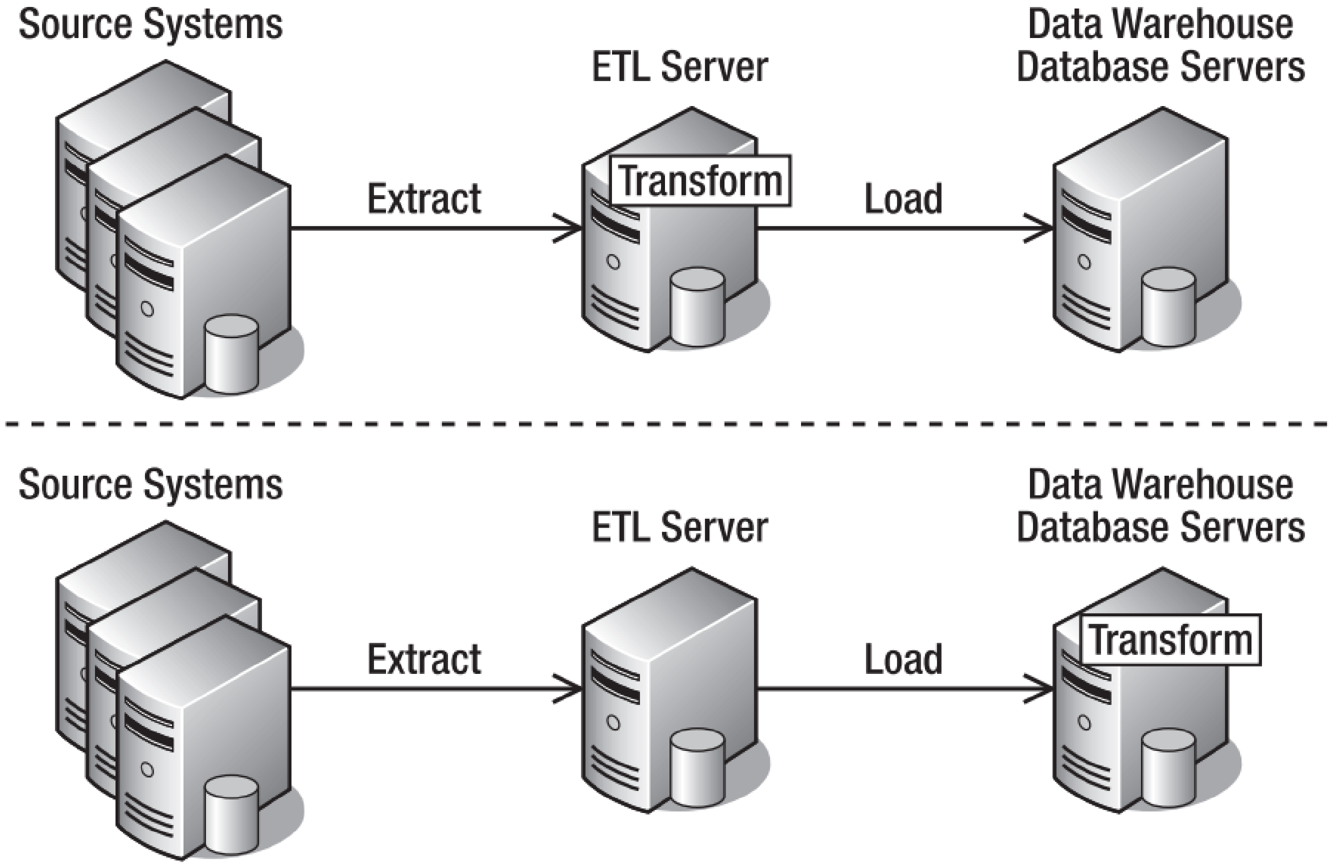
ETL approach and architecture

- **Traditionall approach:**
  - To stage on disks or do transformation in memory
- **Alternative approaches based on**:
  1. **where to perform the transformations**
  2. who moves the data out of the source system
  3. Where to put ETL processes

ETL approach and architecture

- **E-L-T**: (Extract – Load – Transform): copy the source system (OLTP) data into the data warehouse and transform it there:
    - Pull data from source system
    - Load it into DW
    - Apply the transformation by updating data in DW

ETL approach and architecture



Strong ETL server
Strong software

strong DW database system - Usually Massively parallel processing (MPP)

ETL approach and architecture

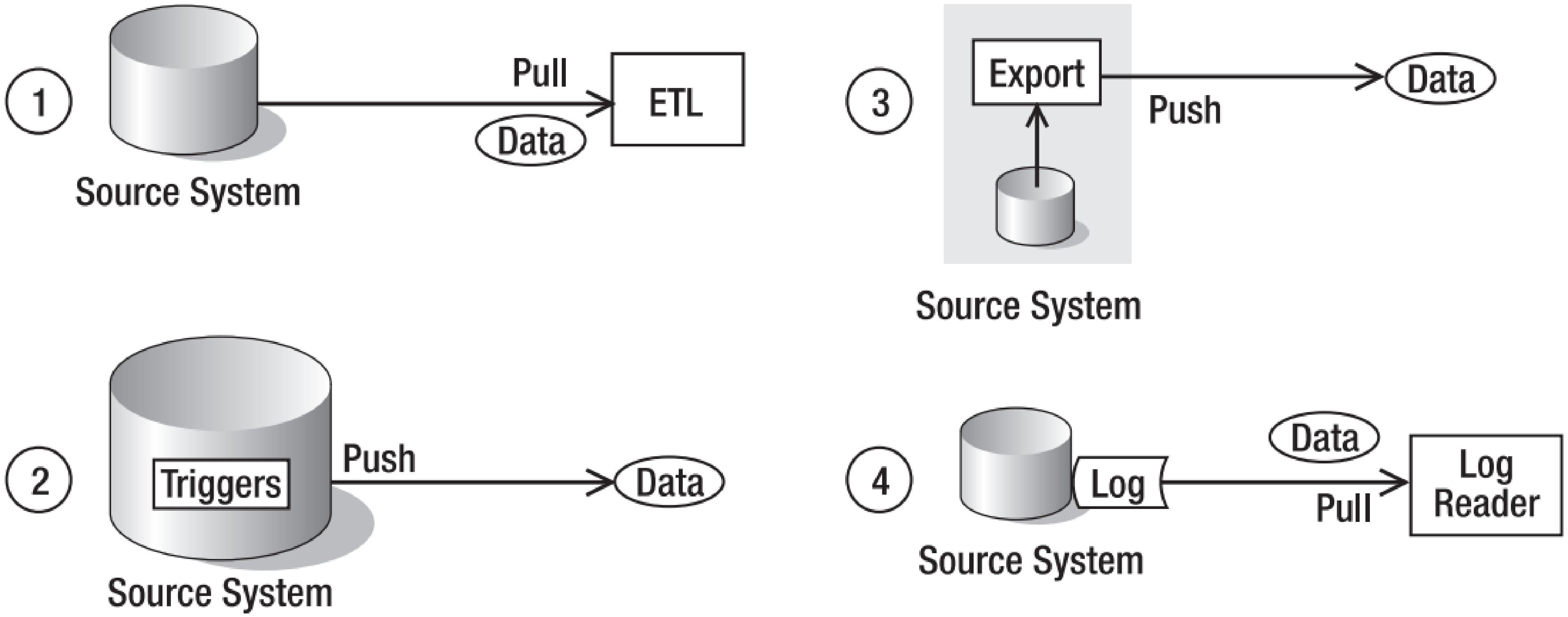
- **Traditionall approach:**
  - To stage on disks or do transformation in memory
- **Alternative approaches based on**:
  1. where to perform the transformations
  2. **who moves the data out of the source system**
  3. Where to put ETL processes

ETL approach and architecture

1. Pulls the data out by ***querying*** the source system database regularly
2. Implement a ***trigger*** in the source system database to push the data changes out
3. Install a ***schedule*** process within the source system to extract data periodically.
4. Implement a procedure to ***read*** the database ***logfiles*** of the DB source to discover every data change of the DB

ETL approach and architecture

- **4 method to execute the ETL process based on who moves the data out of the source system**



ETL approach and architecture

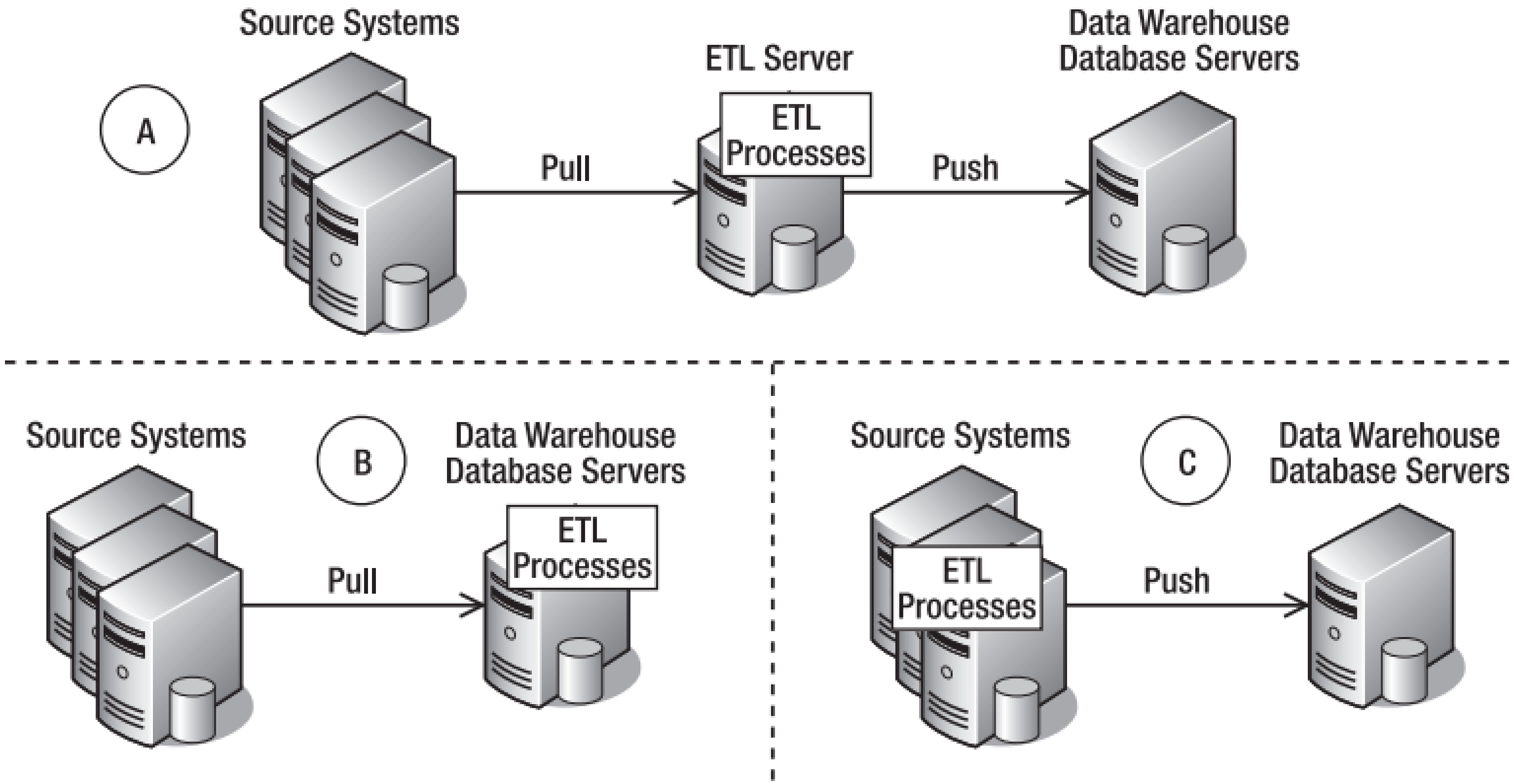
- **Traditionall approach:**
  - To stage on disks or do transformation in memory
- **Alternative approaches based on**:
  1. where to perform the transformations
  2. who moves the data out of the source system
  3. **Where to put ETL processes**

ETL approach and architecture

- **Three approaches based on where to put ETL processes**:
  - Execute the ETL processes in a separate ETL server that sits between the source system and the data warehouse server
  - Execute the ETL processes in the data warehouse server
  - Execute the ETL processes in the server that hosts the source system

ETL approach and architecture

- Three approaches based on where to put ETL processes:



Main topic

- Introduction to ETL
- ETL approach and architecture
- **Extracting data**
- Populating the DW

Extracting database

1. **Flat file**
2. Relational database
3. Others

Extraction from Flat files

- Example of flat file:

```
001|Nguyễn Ngọc Thảo|Accounting
002|Trần Thanh Toàn|Admin
003|Lê Thanh Nhi|Technical support
```

- Use bulk-insert in SQL command to load data from flat file
- Quick I/O, provide the best performance
  - Bulk insert table1 from 'file1' with (field terminator = '|')

Extraction from Flat files

- **Some remarks:**
  - Must know the flat file structure:
    - Field name
    - Delimiter
    - Type and length are not fixed
    - File name
  - Have access to the agreed-upon location (permission to delete/read files)
  - ….

Extracting database

1. **Flat file**
2. Relational database
3. Others

Extracting relational database

- **Three methods**:
  1. **Incremental extract**
  2. Fixed range
  3. Whole table every time

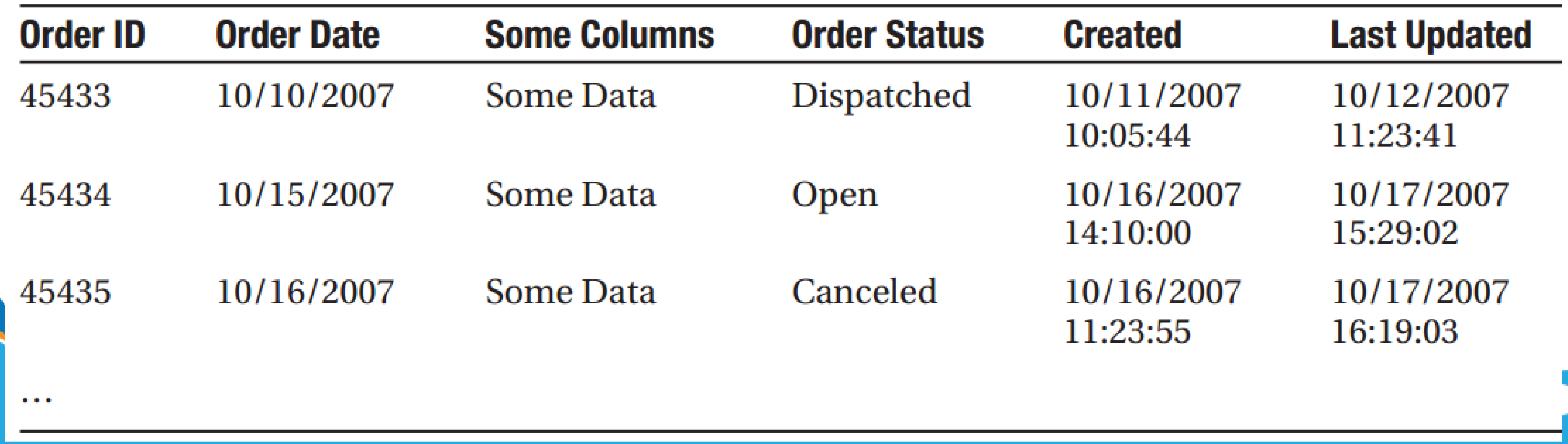
Incremental extract

- Download only the changed rows from the source system, not the whole table
  - New row
  - Newly deleted row
  - Newly updated row

❑**Based on**: **timestamp** columns, identity columns, transaction dates, **triggers**, or a combination of them

Incremental extract

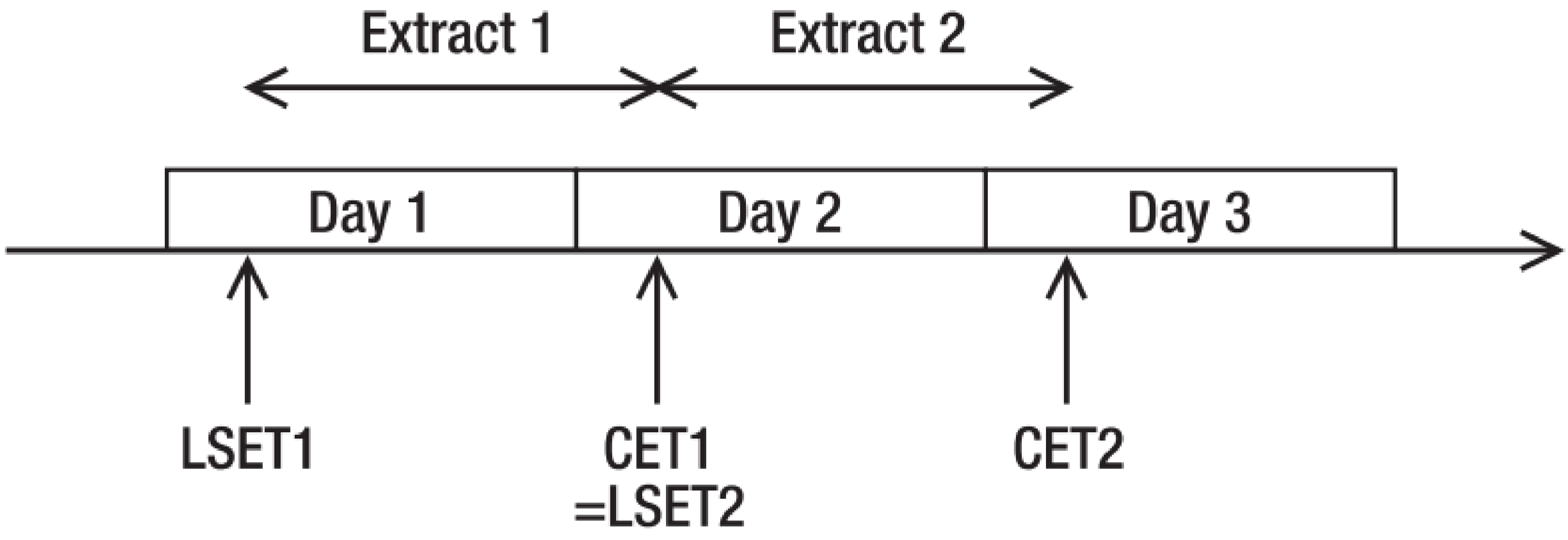
- Using a “created”/last timestamp column, updated/order date/incremental orderID
  - check whether the timestamp columns are reliable
    - contain dummy values such as 1900-01-01, Blank, null, Last updated < created date….
- Every time the row in the table changes (insert/update), the timestamp is updated



Order ID	Order Date	Some Columns	Order Status	Created	Last Updated
45433	10/10/2007	Some Data	Dispatched	10/11/2007 10:05:44	10/12/2007 11:23:41
45434	10/15/2007	Some Data	Open	10/16/2007 14:10:00	10/17/2007 15:29:02
45435	10/16/2007	Some Data	Canceled	10/16/2007 11:23:55	10/17/2007 16:19:03
…					

Incremental extract

- Incremental extraction logic using **LSET** and **CET**
  - LSET: the time when data was last extracted.
  - CET is the time the **ETL package** started, **not** when the current **task started**



Incremental extract

Procedure to extract

1. Retrieve the LSET from the metadata database
2. Get the CET, which is passed in by the top-level ETL package
3. Extract the data
    1. **select** * **from** order_header **where** (created >= LSET and created < CET) or (last_updated >= LSET and last_update < CET)
4. Update meta data: writing CET as the new LSET value.

Incremental extract

- Business rule:
  - the order happened last week but just entered into the system today (pastdated orders).
  - If we apply the previous logic to the order_datecolumn, we will miss past-dated orders.
  - if you try to put the order date as 29 days ago → generate an error message.
  - ***select*** ** **from** order_header **where** order_date >= (LSET – 28 days) and created < CET*

Incremental extract

Another way of doing incremental extract is to use the order ID:

- Retrieve the Last Successfully Extracted ID (LSEI) from the metadata database.
- Select max(order_id) from order_header
- Set CEI = max
- Select * from order_header where order_id >= LSEI and order_id < CEI.
- Update meta data: LSEI = CEI.

Remarks

- Incremental Extract logic is fault tolerant
- if ETL doesn’t run or it failed to run, the return result will:
  - no risk of missing the data
  - Not loading data that we loaded earlier

- **How about deletion?**
  - How do we know which orders have been deleted?

Discussion

- How about deletion?
  - soft delete, don’t physically delete the record in the table
  - physically deleted
    - comparing the PK between the source table and the warehouse table
    - Using deletion trigger
      - A trigger is the most reliable approach in ETL
      - Can create separate triggers for delete, update, and insert
      - **Drawback**:

Fixed range

- Periodically extract a certain number of records or a certain period of time based on business constraint.
  - no reliable incremental identity column
  - no timestamp columns
  - timestamp columns are not reliable
  - …..
- EX: by the end of each month, extract the data of that month

Whole table

When:

- Deals with tables of small size
- No timestamp or identity column
- Neither incremental attribute
- No business constraint

Extracting database

1. Flat file
2. Relational database
3. **Others**

Extracting Other Source Types

- XML
- spreadsheet files (Excel)
- Web logs
- Binary file
- Webservice
- Emails
- ……

Main topic

- Introduction to ETL
- ETL approach and architecture
- Extracting data
- **Populating the DW**

Populating the DW

- ❑Loading the stage
- ❑Creating the data firewall
- ❑Populating a normalized data store (NDS)
- ❑Populating dimension data store (DDS)
  - ❑Populating dimension tables
  - ❑Populating fact tables

Stage loading (source → stage → NDS → DDS)

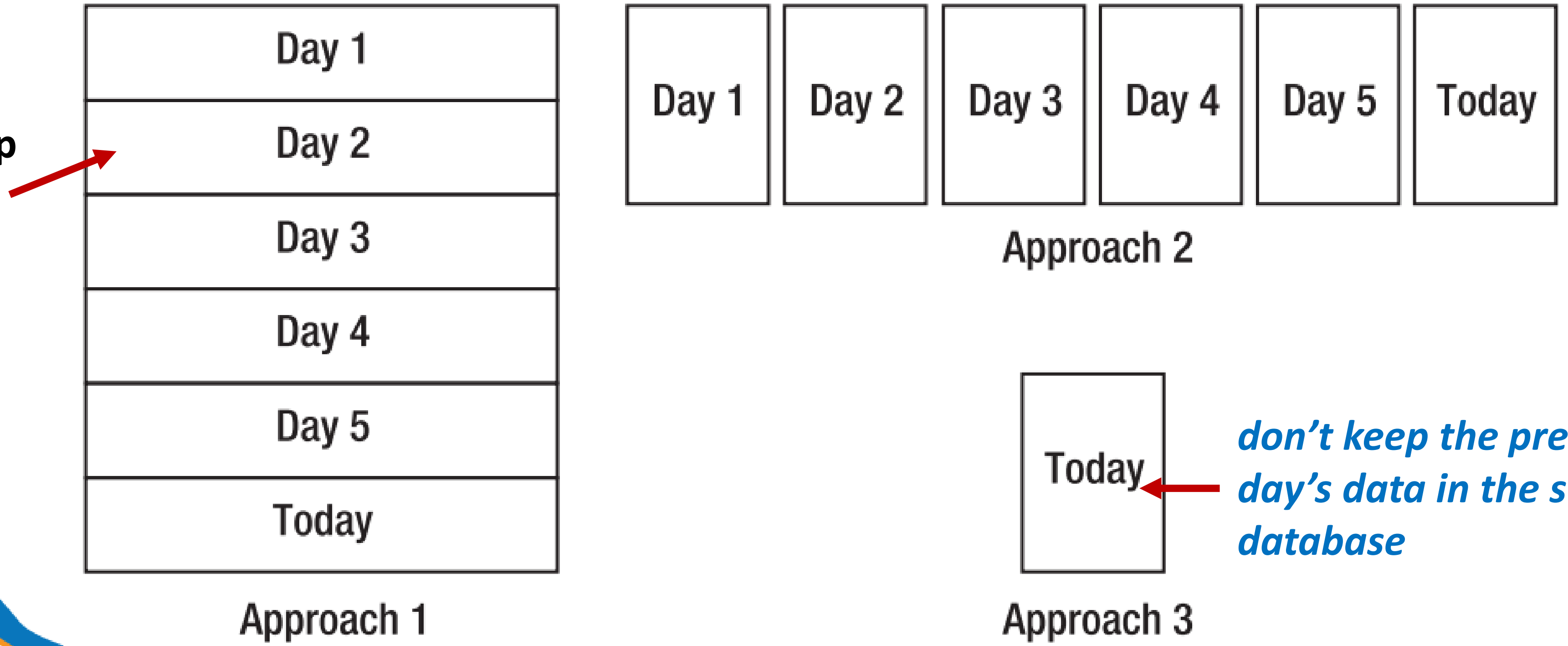
- Load the source system data into the stage
- Extract the data as soon as possible without doing too much transformation
  - the structure of the stage tables is similar to the source system tables
- It is better not to put any indexes or constraints in the stage database
  - to capture and report the “bad data”in the data quality process

Stage loading

- Three different approaches of how stage tables are structured:
  1. Keeps the previous day’s data in the same table
  2. Keeps each day in a separate table
  3. Uses Just one table and truncate the table every time before loading

Stage loading

- Three different approaches of how stage tables are structured:



Loaded timestamp column

don’t keep the previous day’s data in the stage database

Data firewall

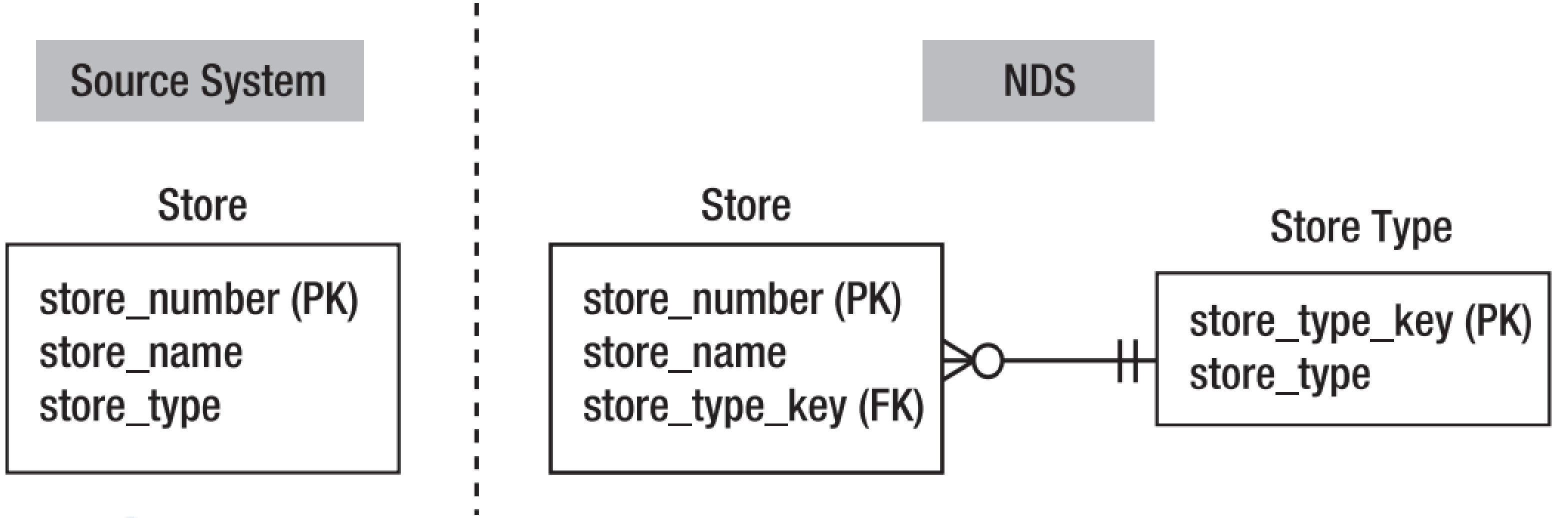
- The data firewall is a program that checks the incoming data, similar to the firewall concept in networking → ensures data quality
    - Physically, it is an SSIS package or a stored procedure
    - Place a data firewall between the stage and the
        - **reject** the data (not load it into the DW),
        - **allow** the data (load it into the DW)
        - **fix** the data (correct the data before loading it into the DW)

Populating NDS (source→ stage→ NDS→ DDS)

- Extract data then load it into the NDS database:
  - From the stage table
  - From the source system
- **Some remarks**
  - In the NDS, the tables are normalized
  - External data
  - Data conversion
  - Key management
  - Consider insert/ update issues

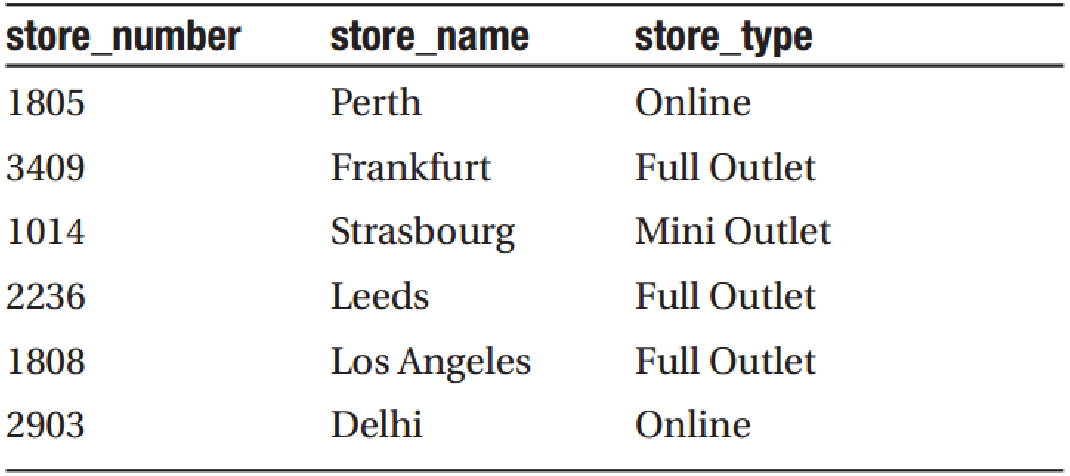
Normalization

- Normalization is a process of removing data redundancy by implementing normalization rules (1NF, 2NF, 3 NF, BCF…)
- A normalized data store is usually in third normal form or higher



EX

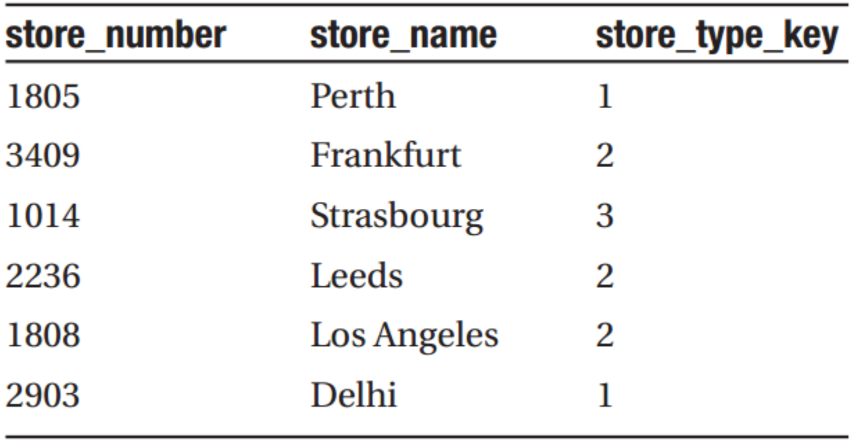
Store



store_number	store_name	store_type
1805	Perth	Online
3409	Frankfurt	Full Outlet
1014	Strasbourg	Mini Outlet
2236	Leeds	Full Outlet
1808	Los Angeles	Full Outlet
2903	Delhi	Online

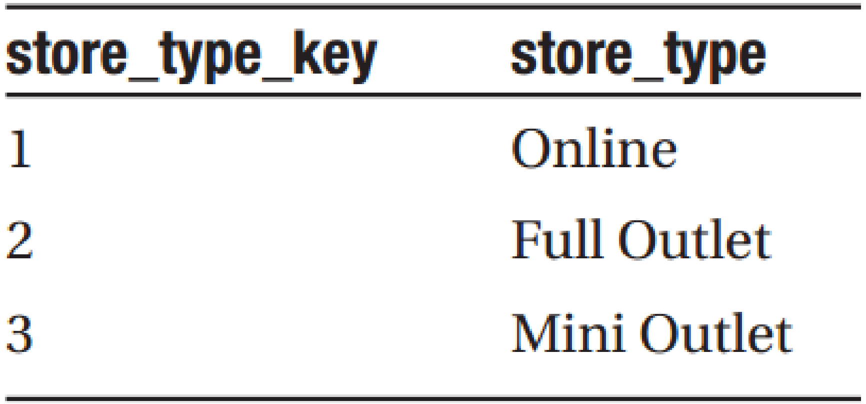
Normalized

N_Store



store_number	store_name	store_type_key
1805	Perth	1
3409	Frankfurt	2
1014	Strasbourg	3
2236	Leeds	2
1808	Los Angeles	2
2903	Delhi	1

Store_Type



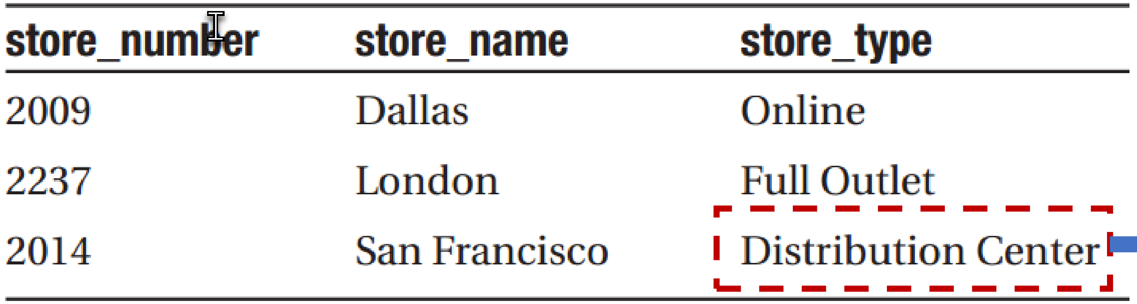
store_type_key	store_type
1	Online
2	Full Outlet
3	Mini Outlet

Each store has one store type

Each store type relates to zero or many stores

Normalization

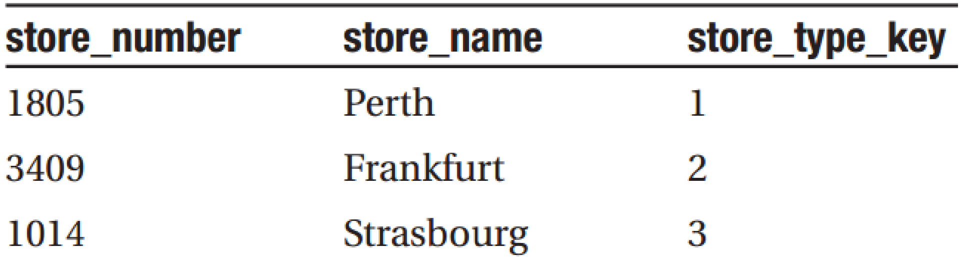
- Data from source



store_number	store_name	store_type
2009	Dallas	Online
2237	London	Full Outlet
2014	San Francisco	Distribution Center

not exists in

Store_NDS



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1805	Perth	1
3409	Frankfurt	2
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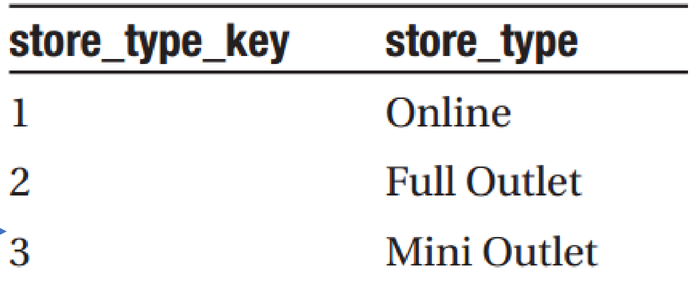
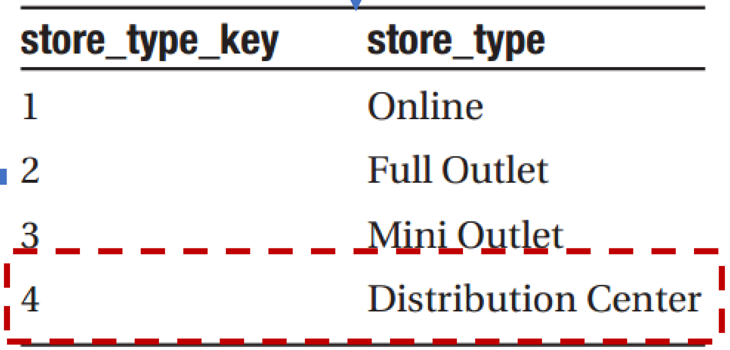
StoreType_NDS

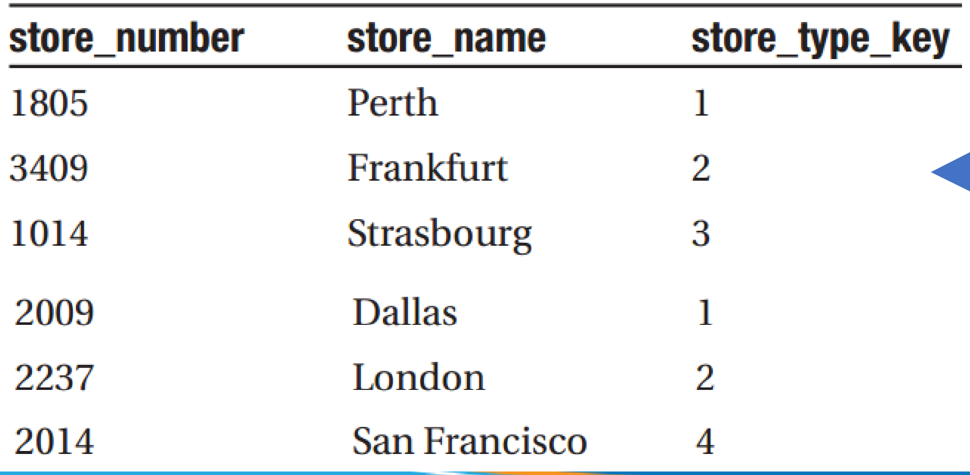


store_type_key	store_type
1	Online
2	Full Outlet
3	Mini Outlet



store_type_key	store_type
1	Online
2	Full Outlet
3	Mini Outlet
4	Distribution Center

Store_NDS



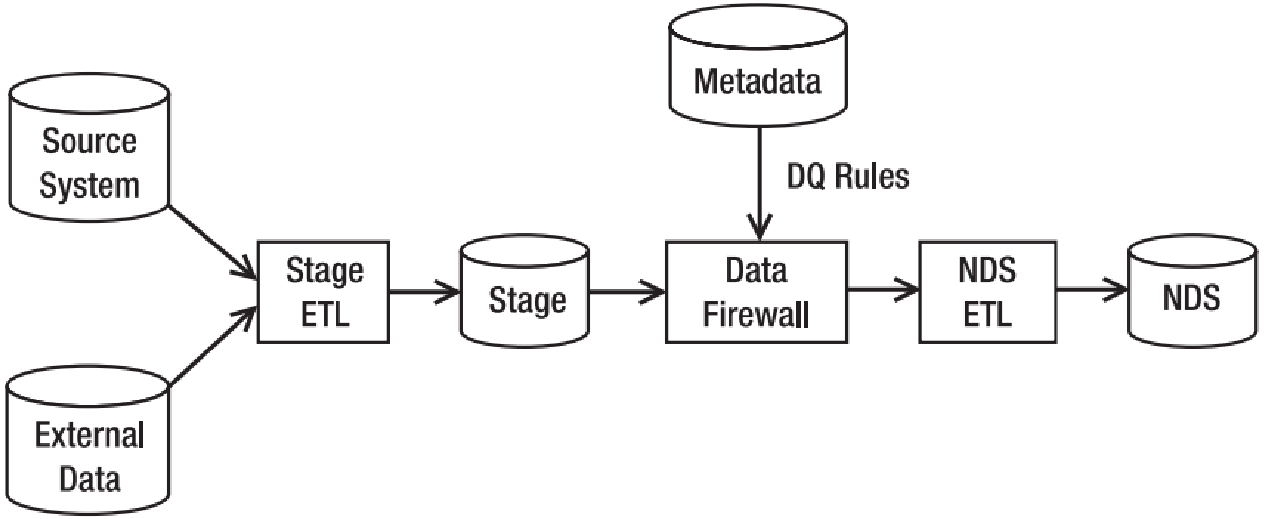
store_number	store_name	store_type_key
1805	Perth	1
3409	Frankfurt	2
1014	Strasbourg	3
2009	Dallas	1
2237	London	2
2014	San Francisco	4

External data

- Customer from Source system: Congo (Zaire)
- Customer from external data: Congo

➔ should we ***create*** “Congo (Zaire)” as a new row?

Or ***replace*** “Congo (Zaire)” with “Congo”?



External data

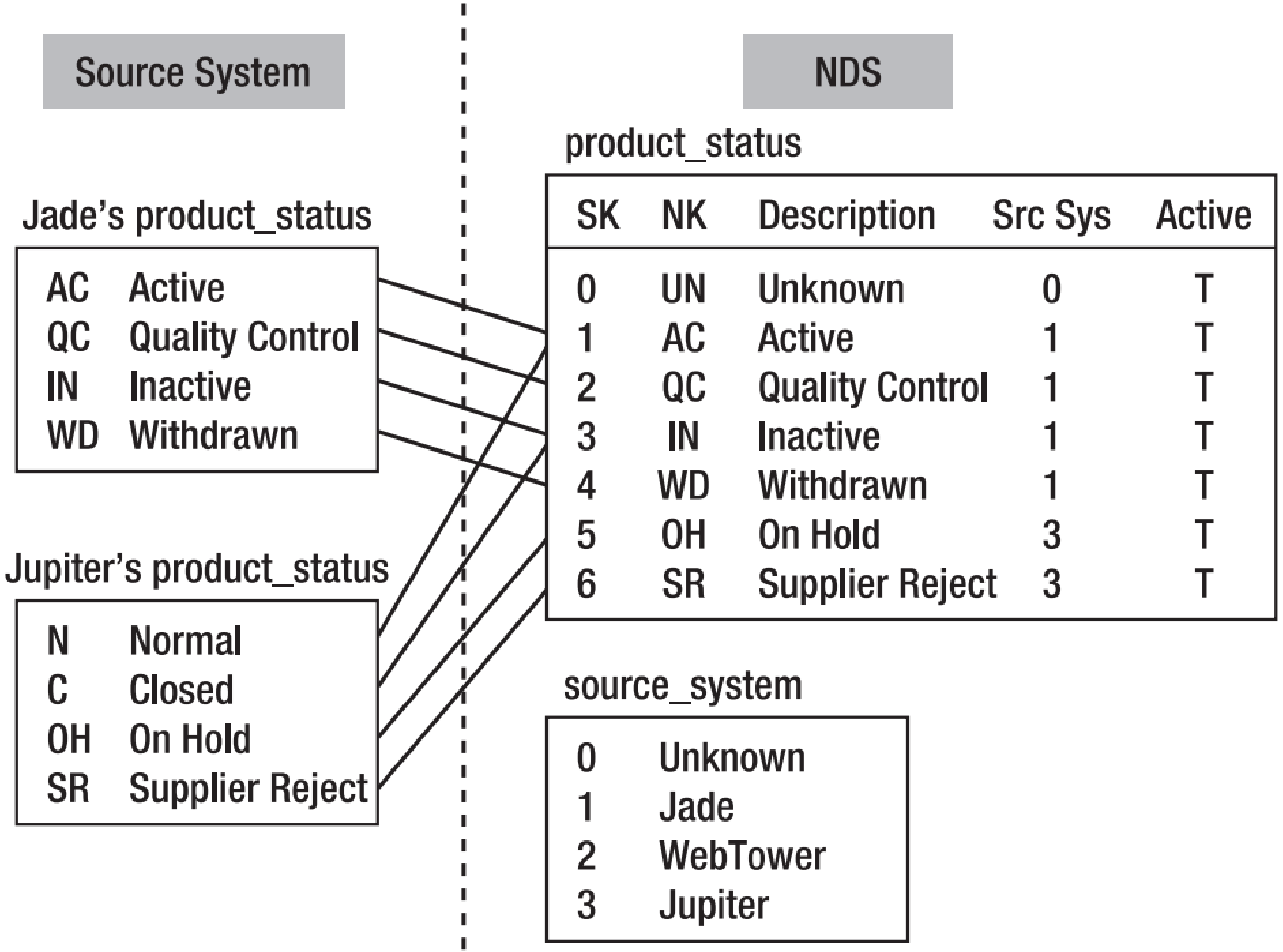
- **TIPS: to prevent the ETL from creating duplicate entries in the NDS country table**
  - Create a rule in the data quality routine to replace “Congo (Zaire)”
  - Then the NDS ETL looks up “Congo” in the NDS country table

Key management

- To be able to adapt the key changes in the source system(s).
- The data warehouse key is known as a surrogate key (SK) → enables the integration of several source systems
- The source system key is known as a natural key (NK)

Key management

- The mapping for the product_status table between the source systems and the NDS



Jade’s product_status

AC	Active
QC	Quality Control
IN	Inactive
WD	Withdrawn

Jupiter’s product_status

N	Normal
C	Closed
OH	On Hold
SR	Supplier Reject

product_status

SK	NK	Description	Src Sys	Active
0	UN	Unknown	0	T
1	AC	Active	1	T
2	QC	Quality Control	1	T
3	IN	Inactive	1	T
4	WD	Withdrawn	1	T
5	OH	On Hold	3	T
6	SR	Supplier Reject	3	T

source_system

0	Unknown
1	Jade
2	WebTower
3	Jupiter

Populating DDS - Dimension Tables

- DDS tables: **fact** tables and **dimension** tables
- The dimension tables in the DDS are ***denormalized***
- Like populating NDS, do an **UPSERT** operation to update or insert the source row depending on whether it exists in the target
- ***Several issues need to be considered:***
    - Incremental loading,
    - Key management,
    - Denormalization,
    - Slowly changing dimension (SCD)

Populating DDS - Dimension Tables

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  - Denormalization,
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In the NDS everything is timestamped → load only the NDS rows that changed since the last ETL run

Populating DDS - Dimension Tables

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The Surrogate key (SK) are managed in the NDS
➔ can guarantee that all DDSs use the same SK.

Populating DDS - Dimension Tables

- The dimension tables in the DDS are ***denormalized***
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- ***Several issues need to be considered:***
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  - Key management,
  - **Denormalization,**
  - Slowly changing dimensi

To load the store dimension in the DDS, in the NDS we need to join the storetable with the store_type table

Populating DDS - Dimension Tables

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  - Key management,
  - Denormalization,
  - **Slowly changing dimension (SCD)**

SCD type 1(overwrite),
SCD type 2 (rows),
SCD type 3 (column)

Populating DDS - Fact Tables

- Fact tables are normally large tables
- Table partitioning can speed up the update operation significantly when correctly applied to a fact table
- The dimensional key index is required to find the row that we want to update

Assuring Data Quality

- when building a DW, it is important to think about data quality **as early as possible**
- The data quality process includes the activities to make sure the data in the DW is correct and complete
  - ❑set up rules that define what “bad data”
  - ❑Reporting
  - ❑Monitoring
  - ❑Cleaning/ Correcting

Assuring Data Quality

- Example: customers can purchase a product, or they can subscribe to a package
  - first subscription date > last cancellation date → invalid condition
  - Question:
    - The last cancellation date is wrong
    - The first subscription date is wrong
    - or both??

Assuring Data Quality

❑Data Cleansing and Matching

❑Cross-checking with External Sources

❑Data Quality Rules

Data Cleansing and Matching

- **Data cleansing**, or data scrubbing is the process of *identifying* and *correcting* **dirty data**
  - Dirty data means incomplete, wrong, duplicate, or out-of-date data
- **Ex**:
  - Checking stores' tables to make sure the store names, store numbers, store types, and store addresses are all correct
  - Making sure that there are no duplicate customer records → **data matching**
    - **use = for matching numeric data. For example, "if A = B, then…."**
    - **is 5.029 the same as 5.03?**
    - **03/01/2008 the same as 01/03/2008?**

SQL server matching

- Three types of matching logic:
  - **Exact**: all characters are the same, for example “Los Angeles” and “Los Angeles.”
  - ➔ using a **Lookup** transformation
  - **fuzzy** (approximate): finds how similar a set of data is to another set of data
    - using the Fuzzy Lookup
    - “You can’t hurry love” and “You cannot hurry love” have a similarity score of 0.81666672 and a confidence level of 0.59414238
  - **rule based**: use certain rules and data to identify a match
    - In product names “movie”is the same as “film”. → implemented with Script Component
    - “For product code, omit the spaces when comparing”so that “KL 7923 M” is the same as “KL7923M.”