

# OLTP and OLAP

DATABASE DESIGN



Lis Sulmont

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Our motivating question:

## How should we organize and manage data?

- **Schemas:** *How should my data be logically organized?*
- **Normalization:** *Should my data have minimal dependency and redundancy?*
- **Views:** *What joins will be done most often?*
- **Access control:** *Should all users of the data have the same level of access*
- **DBMS:** *How do I pick between all the SQL and noSQL options?*
- and more!

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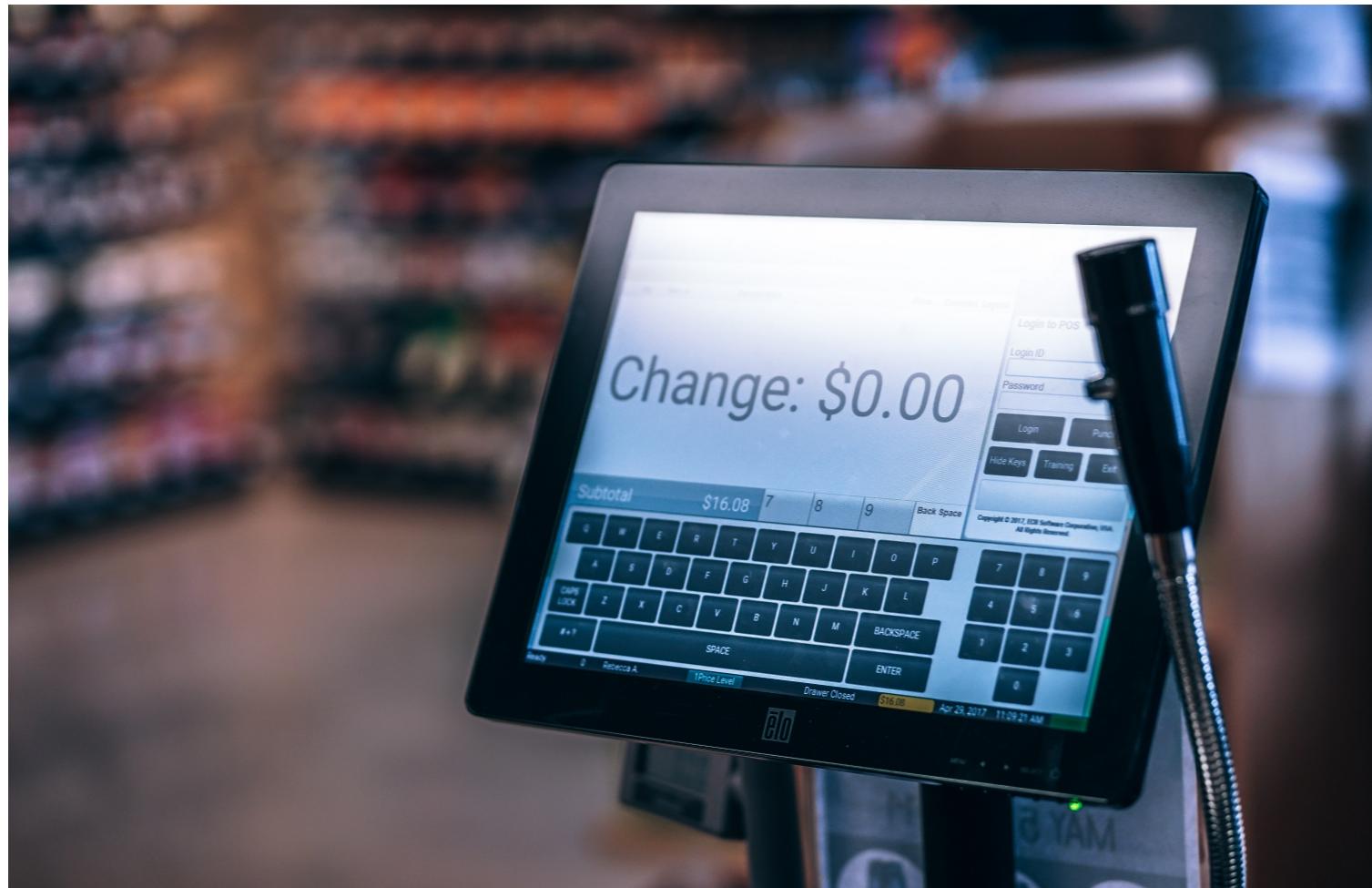
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- and more!

**It depends on the intended use of the data.**

# Approaches to processing data

## OLTP

Online Transaction Processing



## OLAP

Online Analytical Processing



# Some concrete examples

## OLTP tasks

- Find the price of a book
- Update latest customer transaction
- Keep track of employee hours

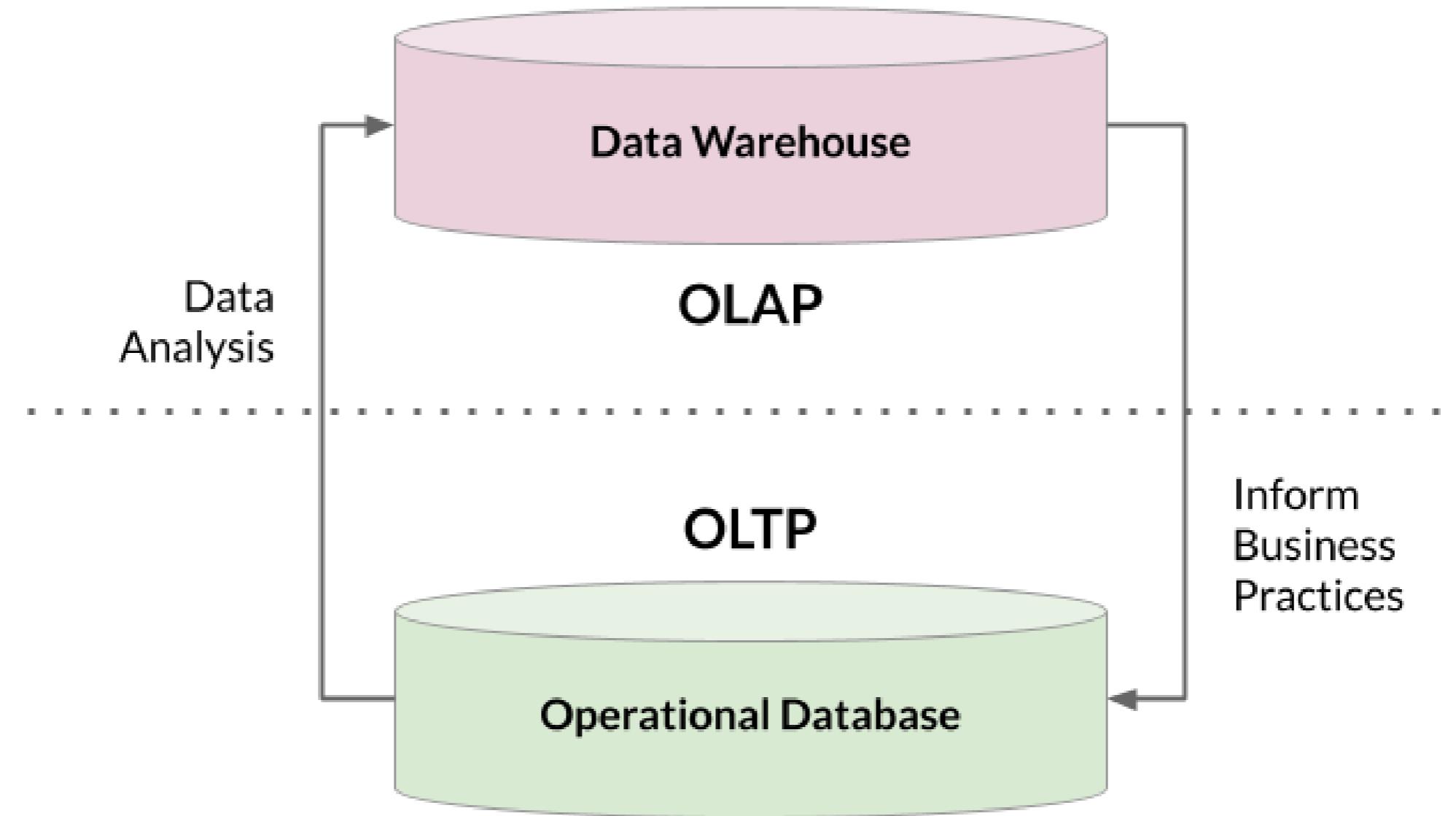
## OLAP tasks

- Calculate books with best profit margin
- Find most loyal customers
- Decide employee of the month

# OLAP vs. OLTP

|         | OLTP                                   | OLAP   |
|---------|--|--|
| Purpose | support daily transactions             | report and analyze data                      |
| Design  | application-oriented                   | subject-oriented                             |
| Data    | up-to-date, operational                | consolidated, historical                     |
| Size    | snapshot, gigabytes                    | archive, terabytes                           |
| Queries | simple transactions & frequent updates | complex, aggregate queries & limited updates |
| Users   | thousands                              | hundreds                                     |

# Working together



# Takeaways

- Step back and figure out business requirements
- Difference between OLAP and OLTP
- OLAP? OLTP? Or something else?

# Let's practice!

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# Storing data

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# Structuring data

## 1. Structured data

- Follows a schema
- Defined data types & relationships

e.g., SQL, tables in a relational database

## 3. Semi-structured data

- Does not follow larger schema
- Self-describing structure

e.g., NoSQL, XML, JSON

## 2. Unstructured data

- Schemaless
- Makes up most of data in the world

e.g., photos, chat logs, MP3

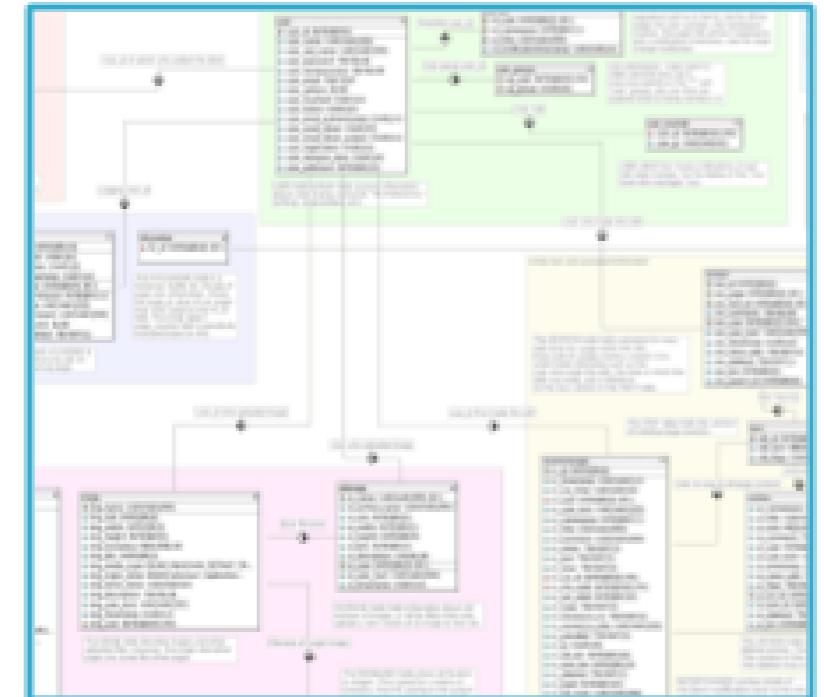
```
# Example of a JSON file
"user": {
    "profile_use_background_image": true,
    "statuses_count": 31,
    "profile_background_color": "C0DEED",
    "followers_count": 3066,
    ...
}
```

# Structuring data

Easier to Analyze



```
<?xml version="1.0"
      encoding="iso-8859-1" ?>
<languages>
  <language id="fr">
    <name lang="fr">Français</name>
    <name lang="en">French</name>
    <name lang="es">Frances</name>
    <name lang="de">Französisch</name>
    <name lang="eo">Franca</name>
  </language>
```



More Flexibility and Scalability

<sup>1</sup> [https://commons.wikimedia.org/wiki/File:Flower\\_jtca001.jpg](https://commons.wikimedia.org/wiki/File:Flower_jtca001.jpg) <sup>2</sup> [https://commons.wikimedia.org/wiki/File:Languages\\_xml.png](https://commons.wikimedia.org/wiki/File:Languages_xml.png) <sup>3</sup>

# Storing data beyond traditional databases

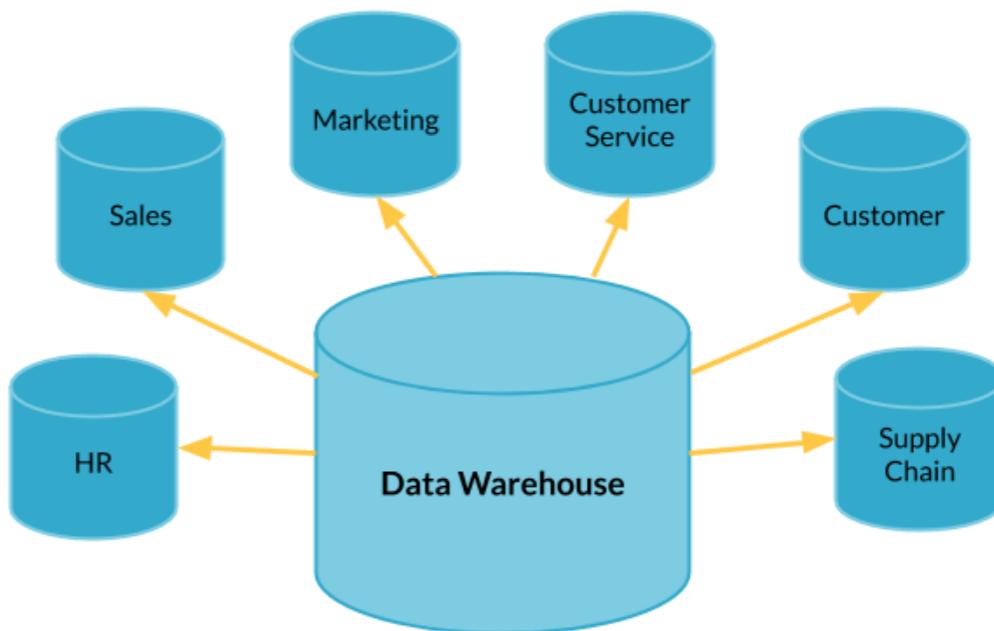
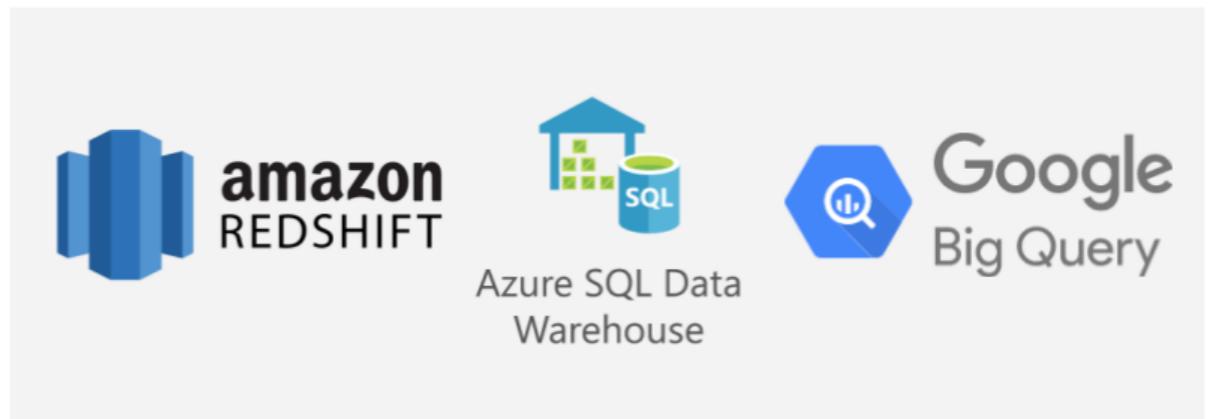
- Traditional databases
  - For storing real-time relational structured data ? **OLTP**
- Data warehouses
  - For analyzing archived structured data ? **OLAP**
- Data lakes
  - For storing data of all structures = flexibility and scalability
  - For analyzing **big data**

# Data warehouses

- Optimized for analytics - **OLAP**
  - Organized for reading & aggregating data
  - Usually read-only
- Contains data from multiple sources
- Massively Parallel Processing (MPP)
- Typically uses a denormalized schema and dimensional modeling

## Data marts

- Subset of data warehouses
- Dedicated to a specific topic

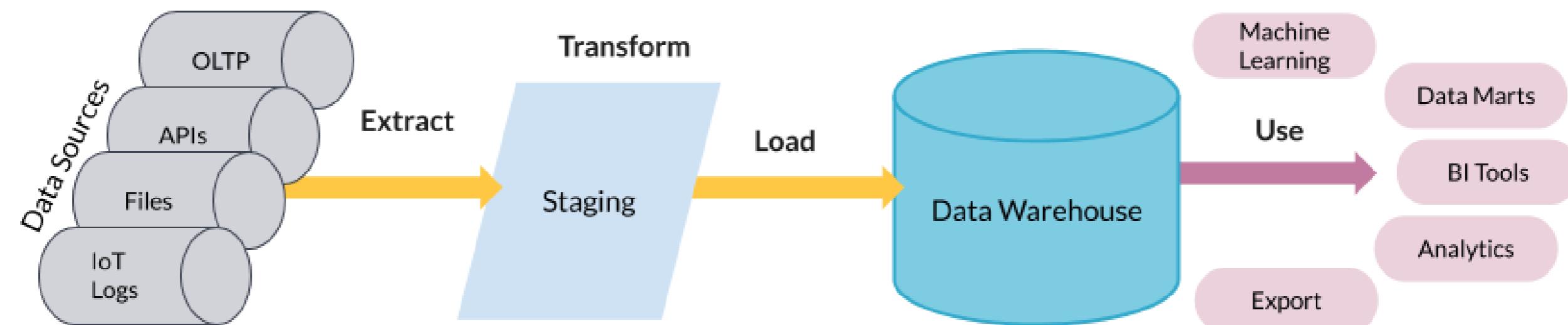


# Data lakes

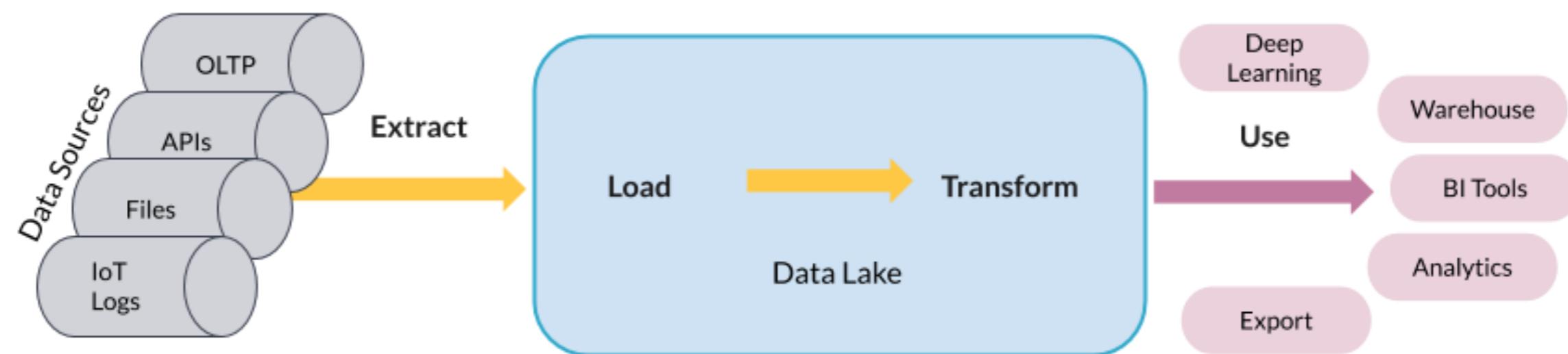
- Store *all* types of data at *a lower cost*:
  - e.g., raw, operational databases, IoT device logs, real-time, relational and non-relational
- Retains all data and can take up petabytes
- Schema-on-read as opposed to schema-on-write
- Need to catalog data otherwise becomes a **data swamp**
- Run **big data analytics** using services such as **Apache Spark** and **Hadoop**
  - Useful for deep learning and data discovery because activities require so much data



# ETL



# ELT



# Let's practice!

DATABASE DESIGN

# Database design

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# What is database design?

- Determines how data is logically stored
  - How is data going to be read and updated?
- Uses **database models**: high-level specifications for database structure
  - Most popular: relational model
  - Some other options: NoSQL models, object-oriented model, network model
- Uses **schemas**: blueprint of the database
  - Defines tables, fields, relationships, indexes, and views
  - When inserting data in relational databases, schemas must be respected

# Data modeling

Process of creating a *data model* for the data to be stored

**1. Conceptual data model:** describes entities, relationships, and attributes

- *Tools:* data structure diagrams, e.g., entity-relational diagrams and UML diagrams

**2. Logical data model:** defines tables, columns, relationships

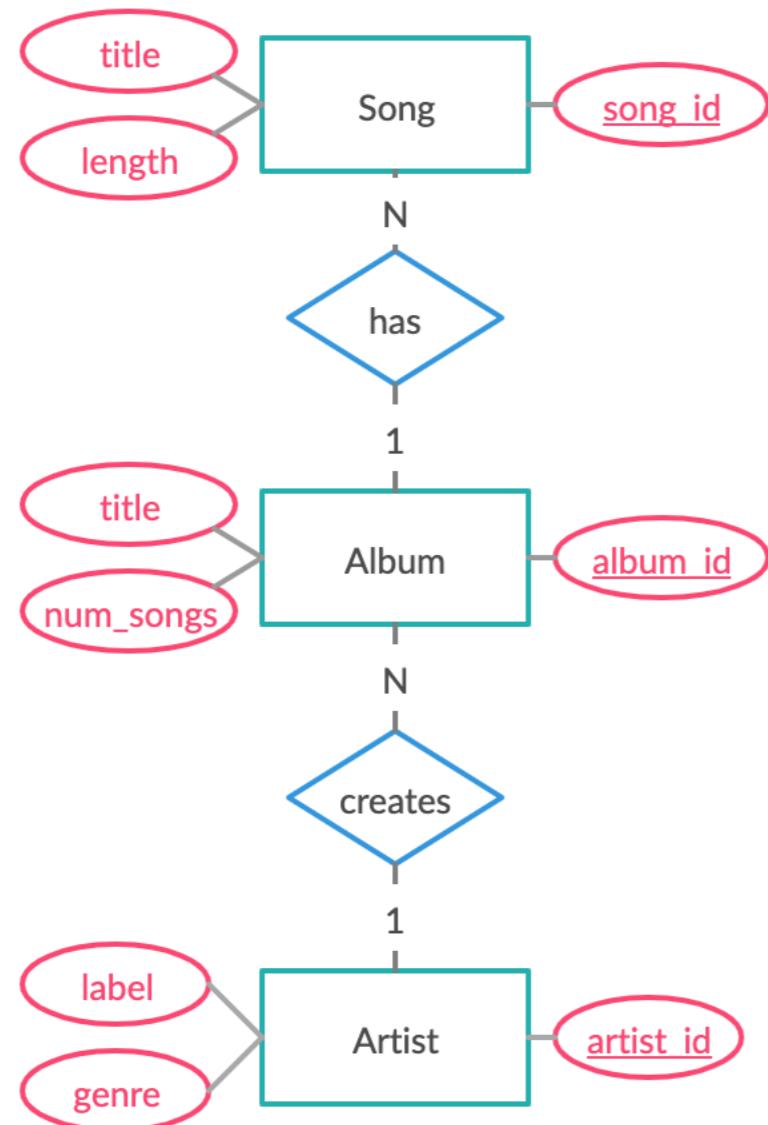
- *Tools:* database models and schemas, e.g., relational model and star schema

**3. Physical data model:** describes physical storage

- *Tools:* partitions, CPUs, indexes, backup systems and tablespaces

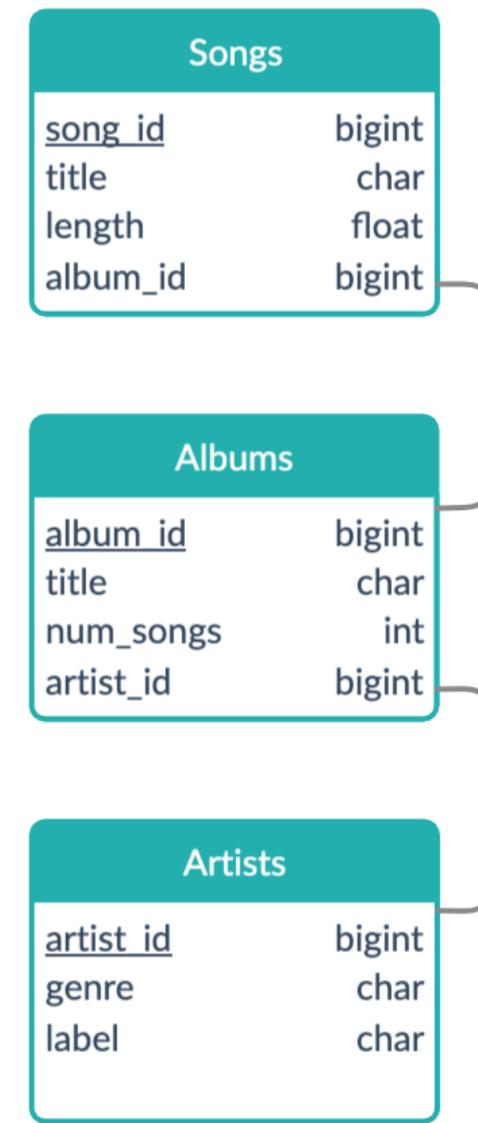
<sup>1</sup> [https://en.wikipedia.org/wiki/Data\\_model](https://en.wikipedia.org/wiki/Data_model)

# Conceptual - ER diagram



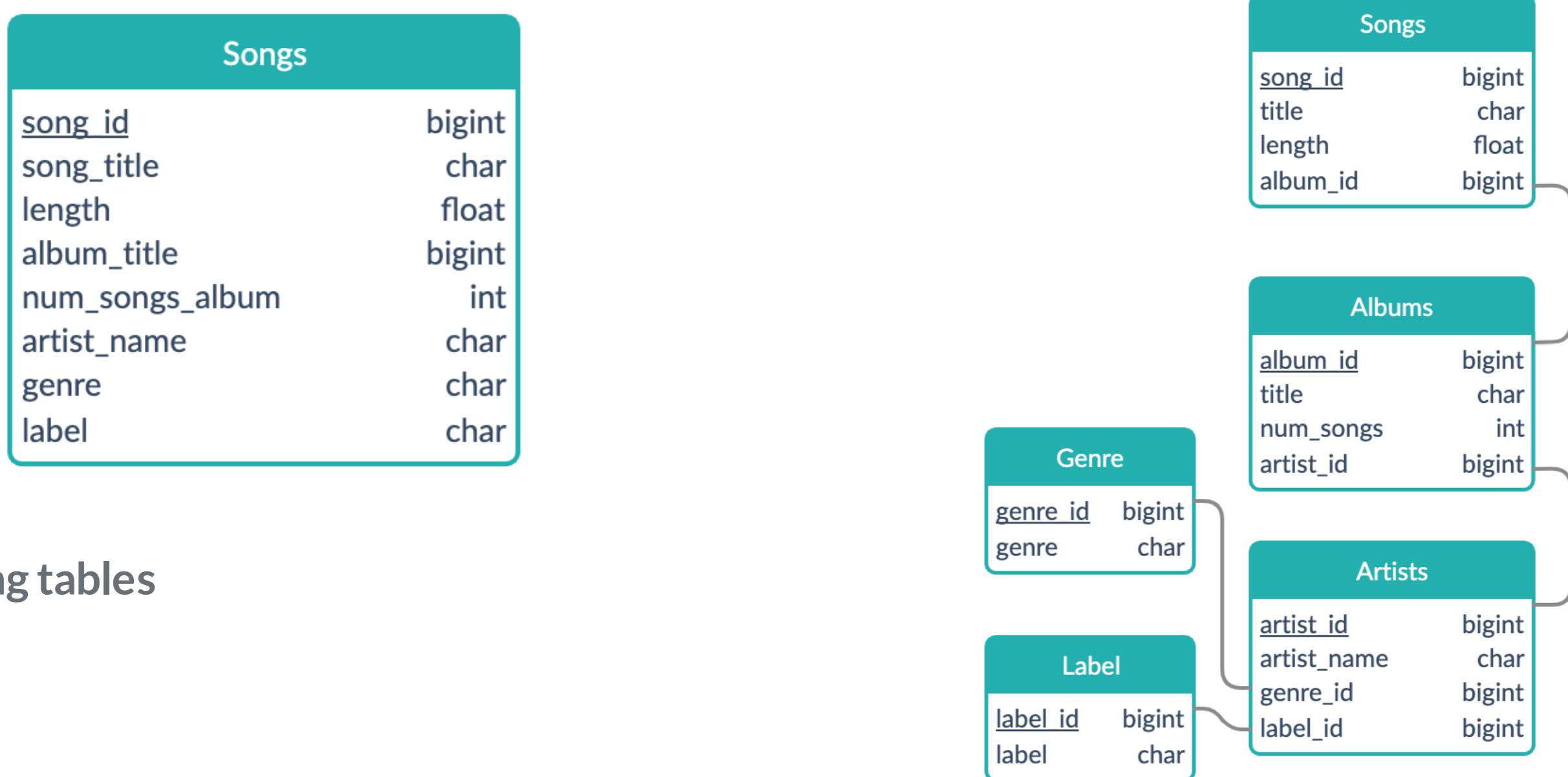
Entities, relationships, and attributes

# Logical - schema



Fastest conversion: entities become the tables

# Other database design options



Determining tables

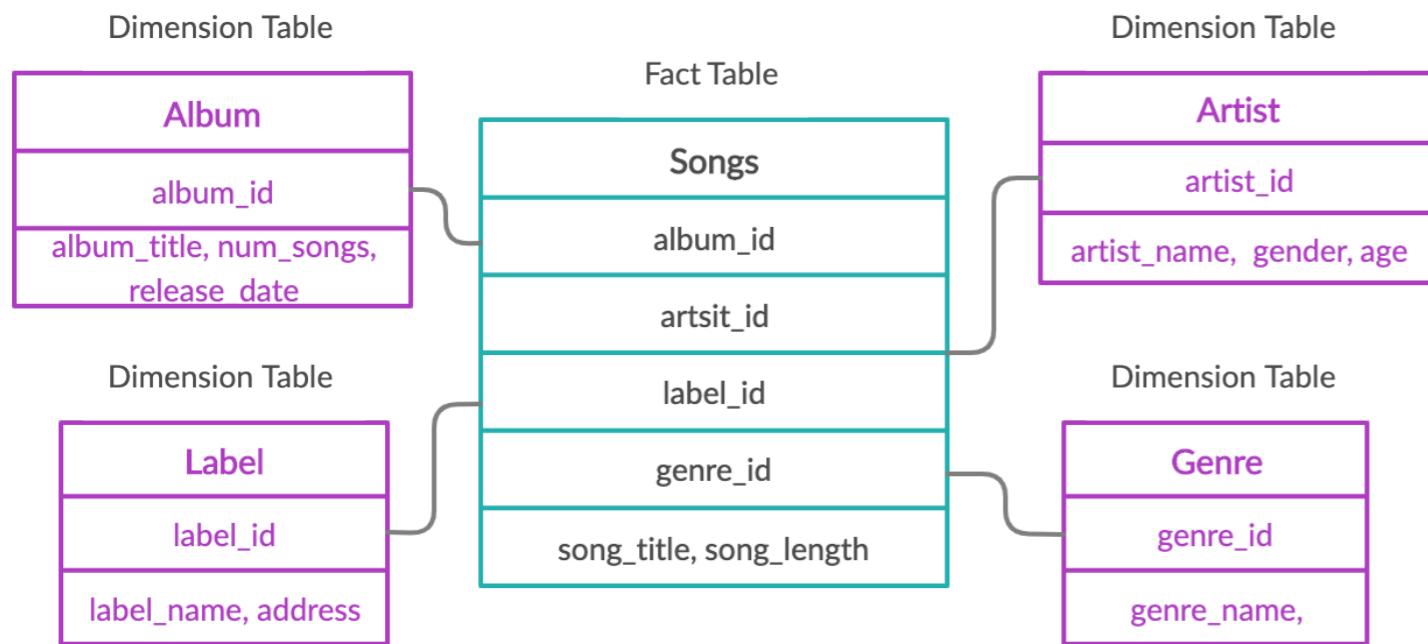
# Beyond the relational model

## Dimensional modeling

Adaptation of the relational model for data warehouse design

- Optimized for **OLAP** queries: aggregate data, not updating (OLTP)
- Built using the star schema
- Easy to interpret and extend schema

# Elements of dimensional modeling



## Organize by:

- What is being analyzed?
- How often do entities change?

## Fact tables

- Decided by business use-case
- Holds records of a metric
- Changes regularly
- Connects to dimensions via foreign keys

## Dimension tables

- Holds descriptions of attributes
- Does not change as often

# Let's practice!

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