# Databases, Data Stores, & additional terminology

# NoSQL – Not only SQL (structured query language)

NoSQL term coined by Carlo Strozzi in 1998 to describe his relational database that did not expose Structured Query Language to users.

**What we mean by NoSQL is different** (non-relational database), and that term came into use for that meaning around 2009.

## Four main types

1. **Key-Value Store**
   - Riak, Amazon S3 (Dynamo), Redis, Voldemort, Apache Ignite, Dynamo, etc.
2. **Document Store**
   - Apache CouchDB, Couchbase, RethinkDB, IBM Domino, CosmosDB, MongoDB, etc.
3. **Column Store**
   - Hbase, Cassandra, BigTable, Vertica, Accumulo, Druid, etc.
4. **Graph**
   - Neo4J, Apache Giraph, AllegroGraph, Virtuoso, InfiniteGraph, FlockDB, etc.

| Data Model | Performance | Scalability | Flexibility | Complexity | Functionality |
|---|---|---|---|---|---|
| Key–Value Store | high | high | high | none | variable (none) |
| Column-Oriented Store | high | high | moderate | low | minimal |
| Document-Oriented Store | high | variable (high) | high | low | variable (low) |
| Graph Database | variable | variable | high | high | graph theory |
| Relational Database | variable | variable | low | moderate | relational algebra |

**Key-Value Store**

- Riak, Amazon S3 (Dynamo), Redis, Voldemort, Apache Ignite, Dynamo, etc.
- Data is represented as a collection of key-value pairs, with each key appearing only once in a collection
- Computationally powerful Key-Value stores may keep keys in lexicographic order, enabling faster retrieval.

| Key | Value |
|---|---|
| Title:How to X | by Jane Doe. Categories: foo, bar. So you want to X? Here's ... |
| Title:X Y About Z | by John Doe. Here's a list of Y about Z... |
| Title:Why X Instead of Z | by Jane Doe. Categories: foo. Some people think Z, but... |

Image: https://readwrite.com/2011/08/12/from-big-data-to-nosql-the-rea-2/

**Document Store**

- Apache CouchDB , MongoDB, Couchbase, RethinkDB, IBM Domino, CosmosDB, etc.
- Data is represented as a map
- Like a key-value store, but the value is a document (XML, JSON, BSON, etc.)
- Documents are self-describing and hierarchical trees

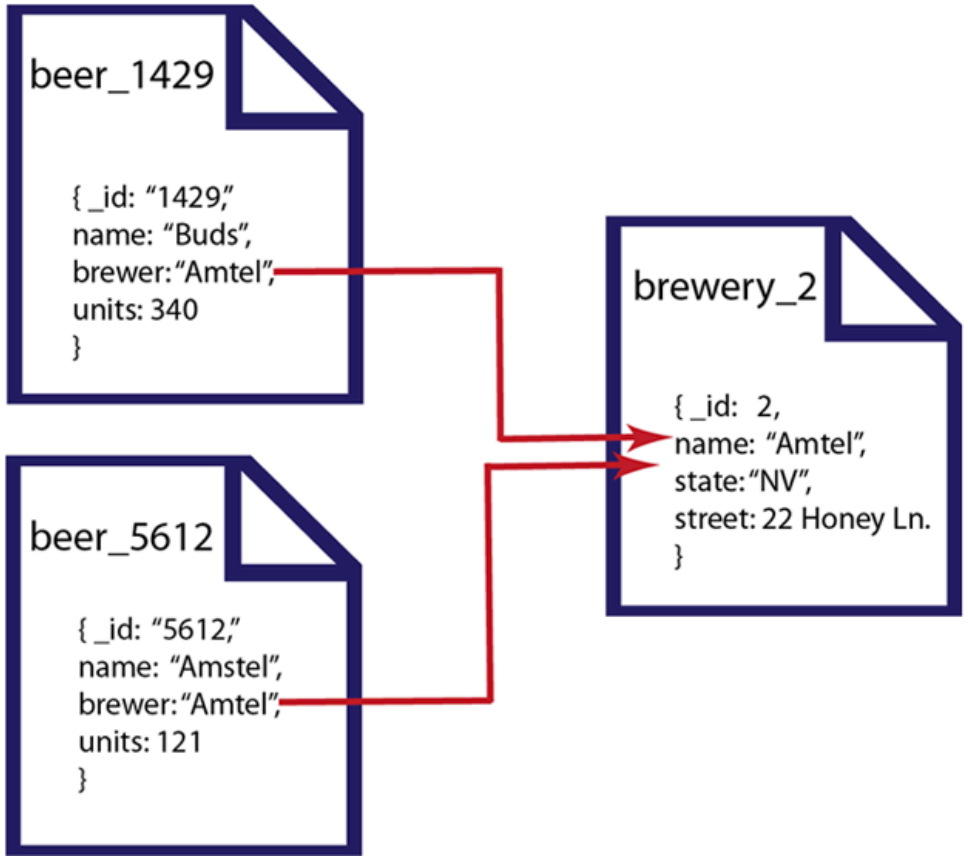


Image: http://amanbinny.blogspot.com/2014/11/introduction-about-nosql-data-models.html

**Column Store**

- Hbase, Cassandra, MariaDB, BigTable, Vertica, Accumulo, Druid, etc.
- All cells corresponding to a column are stored as a continuous disk entry, making the search/access faster.
- Optimized for reads (not so much for create, update, or delete)

## Row-Oriented vs Column-Oriented

Row-oriented: rows stored sequentially in a file

| Key | Fname | Lname | State | Zip | Phone | Age | Sales |
|---|---|---|---|---|---|---|---|
| 1 | Bugs | Bunny | NY | 11217 | (123) 938-3235 | 34 | 100 |
| 2 | Yosemite | Sam | CA | 95389 | (234) 375-6572 | 52 | 500 |
| 3 | Daffy | Duck | NY | 10013 | (345) 227-1810 | 35 | 200 |
| 4 | Elmer | Fudd | CA | 04578 | (456) 882-7323 | 43 | 10 |
| 5 | Witch | Hazel | CA | 01970 | (567) 744-0991 | 57 | 250 |

Column-oriented: each column is stored in a separate file
Each column for a given row is at the same offset.

| Key |
|---|
| 1 |
| 2 |
| 3 |
| 4 |
| 5 |

| Fname |
|---|
| Bugs |
| Yosemite |
| Daffy |
| Elmer |
| Witch |

| Lname |
|---|
| Bunny |
| Sam |
| Duck |
| Fudd |
| Hazel |

| State |
|---|
| NY |
| CA |
| NY |
| CA |
| CA |

| Zip |
|---|
| 11217 |
| 95389 |
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| Age |
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| Sales |
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| 100 |
| 500 |
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| 250 |

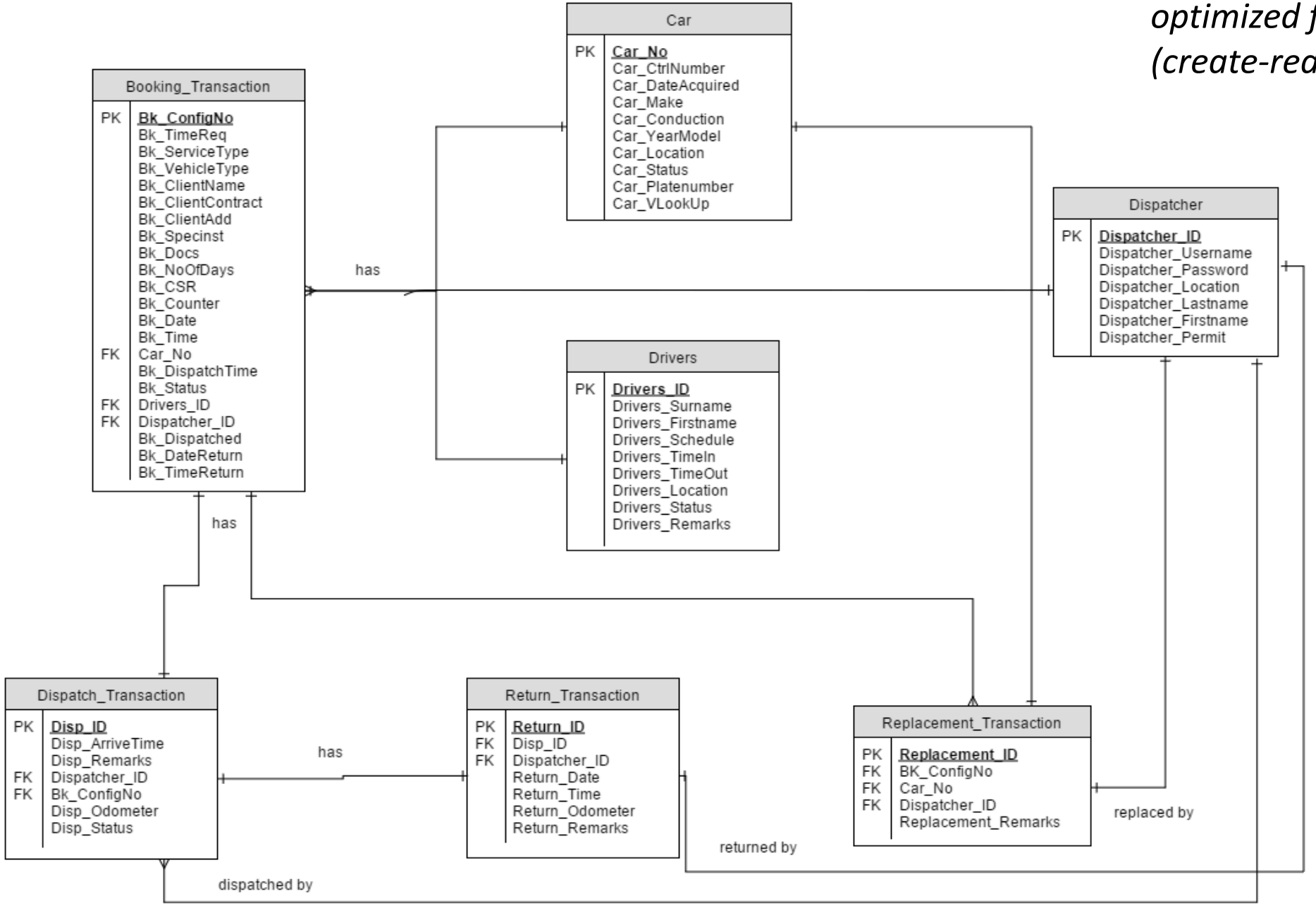
Image: https://mariadb.com/resources/blog/why-columnstore-important

# OLTP: OnLine Transactional Processing (database optimized for software applications)

- Should respond immediately to requests
- High throughput and insert/update intensive
- Used by many users concurrently
- Key goals: availability, speed, concurrency, and recoverability

**normalized relational database**

*optimized for CRUD transactions (create-read-update-delete)*




**Referential integrity**

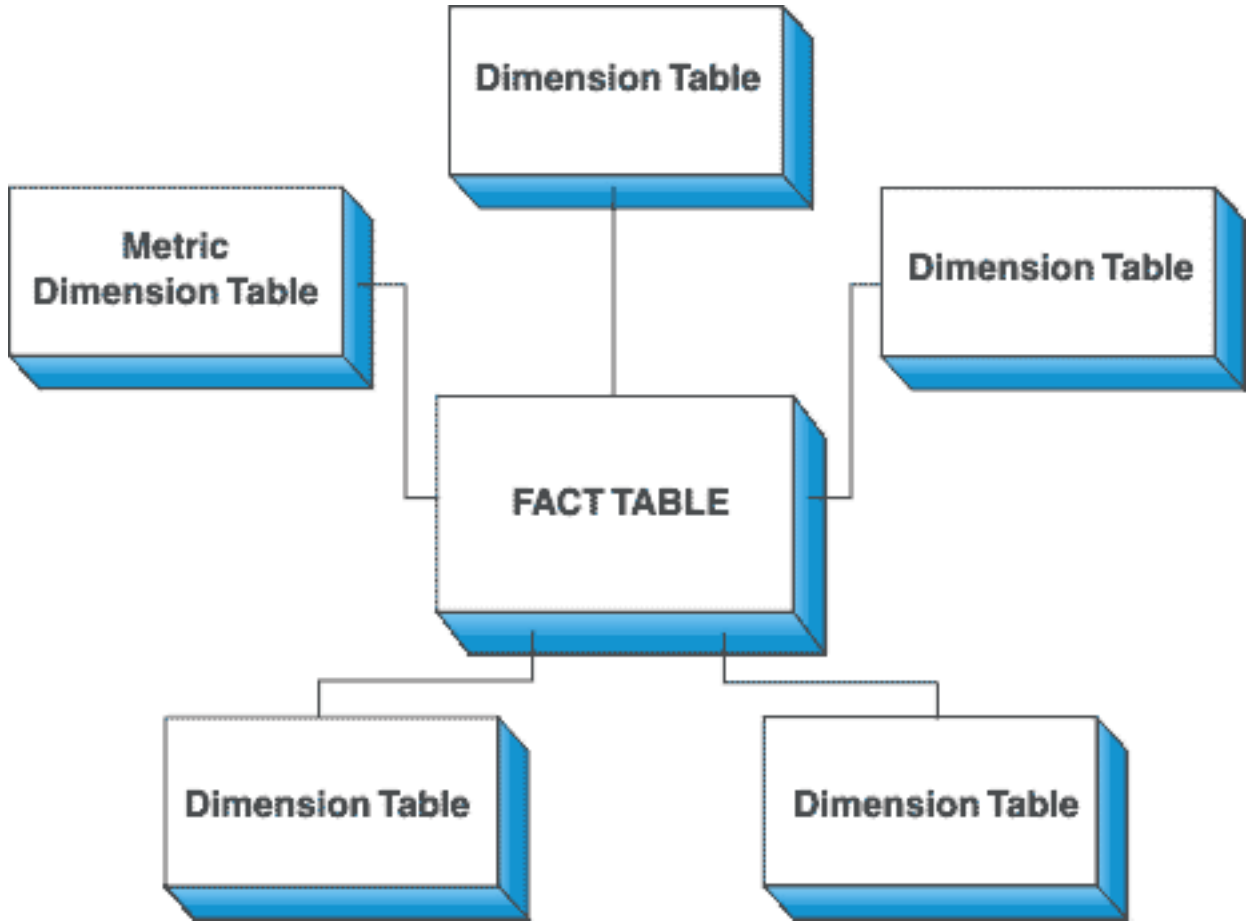
- Constrains the possible values for a given field
- Lookup tables (sometimes called code tables) have a primary key that is used as a foreign key in the transaction table

# OLAP: OnLine Analytical Processing (database optimized for analytical work)

- Longer running tasks
- More complicated queries against larger volumes of data
- Precomputed values can be stored as OLAP cubes (3-dimensions)
  - For dimensions like:
    - Dates (year, quarter, month)
    - Geographic (country, city, region)
    - Product Category
    - Customer
  - Aggregated totals are pre-calculated and stored at the “intersections” of the cube
  - Instead of needing to aggregate two-dimensional (tabular) data as you go, work is done and stored in advance

- OLAP Operations
  - ***Slicing*** (holding the value of one dimension fixed; for example looking at one particular year of sales data)
  - ***Dicing*** (looking at a subset of each dimension; for example looking at sales between 2015 and 2017 for the Nashville and Memphis markets)
  - ***Rollup*** (summarizing/aggregating the data along a dimension; for example calculating the total sales for 2016)
- Data sometimes stored as columnar data stores

**star schema model** (AKA dimensional database)




A database model optimized for queries and data warehouse tools.

Goal: query performance and schema simplicity

Design: “fact table” surrounded by some number of “dimension tables”

# Star Schema

**Facts:**

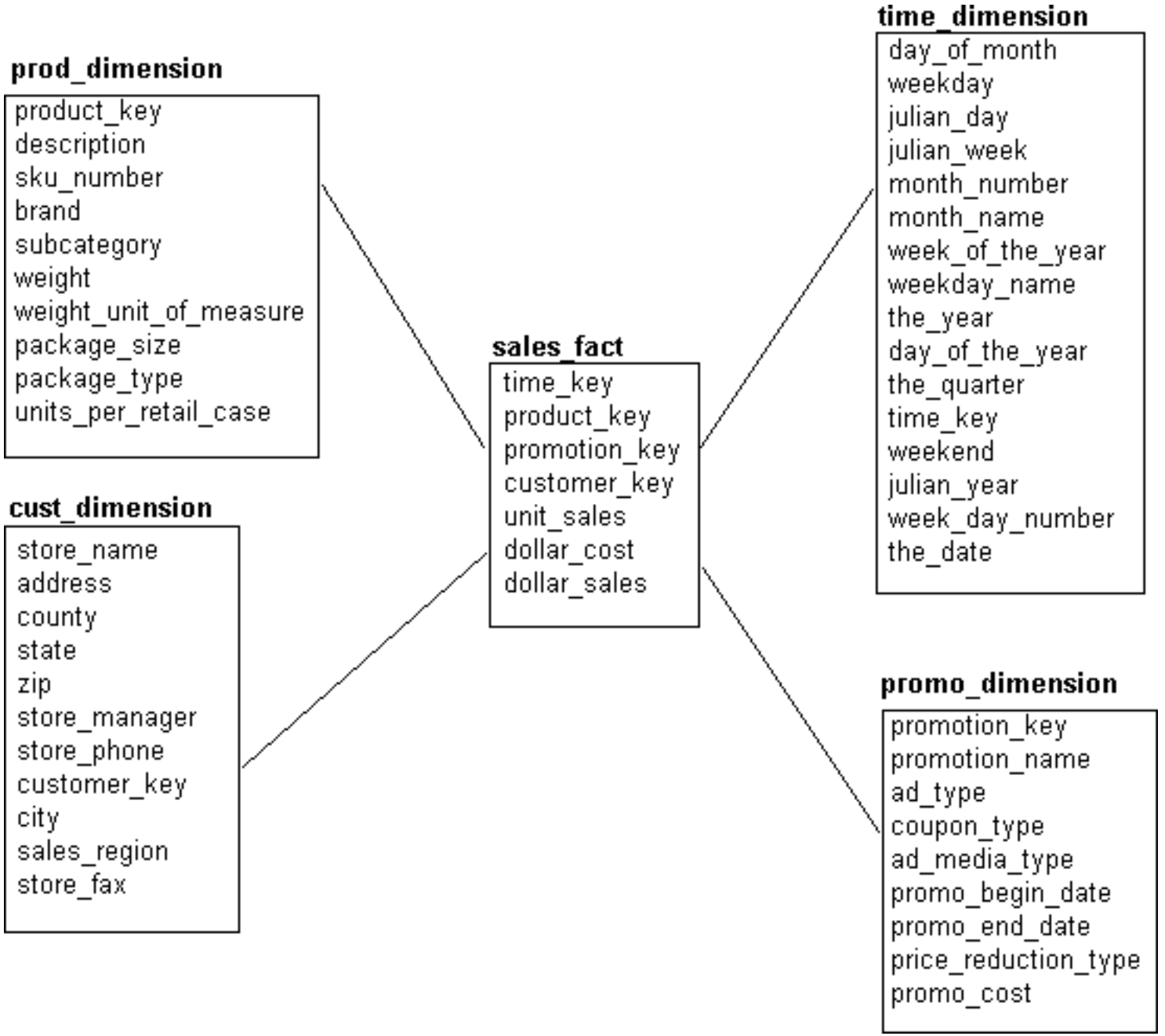
- Usually numeric measurements of a business
- Examples: Sales dollars, sales units, costs
- Often one fact per business transaction
- Change regularly

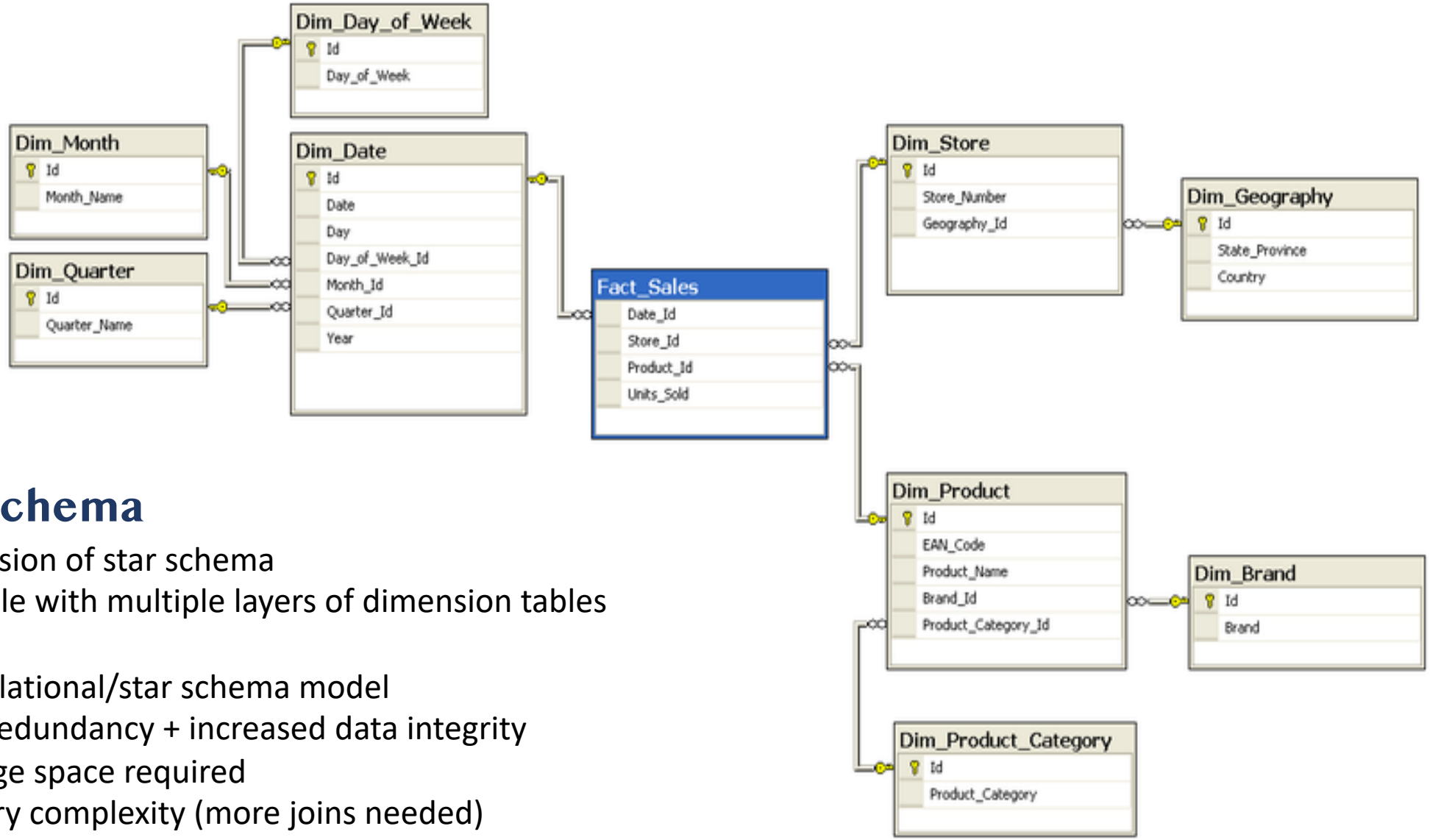
**Dimensions:**

- Descriptive data providing context for facts
- Examples: Product description, customer contact information, time dimensions
- Rarely if ever change

# Star Schema

- Fact table is connected to dimensional tables through keys
- The primary key of each dimension table is linked to a foreign key of fact table
- Allows fast queries





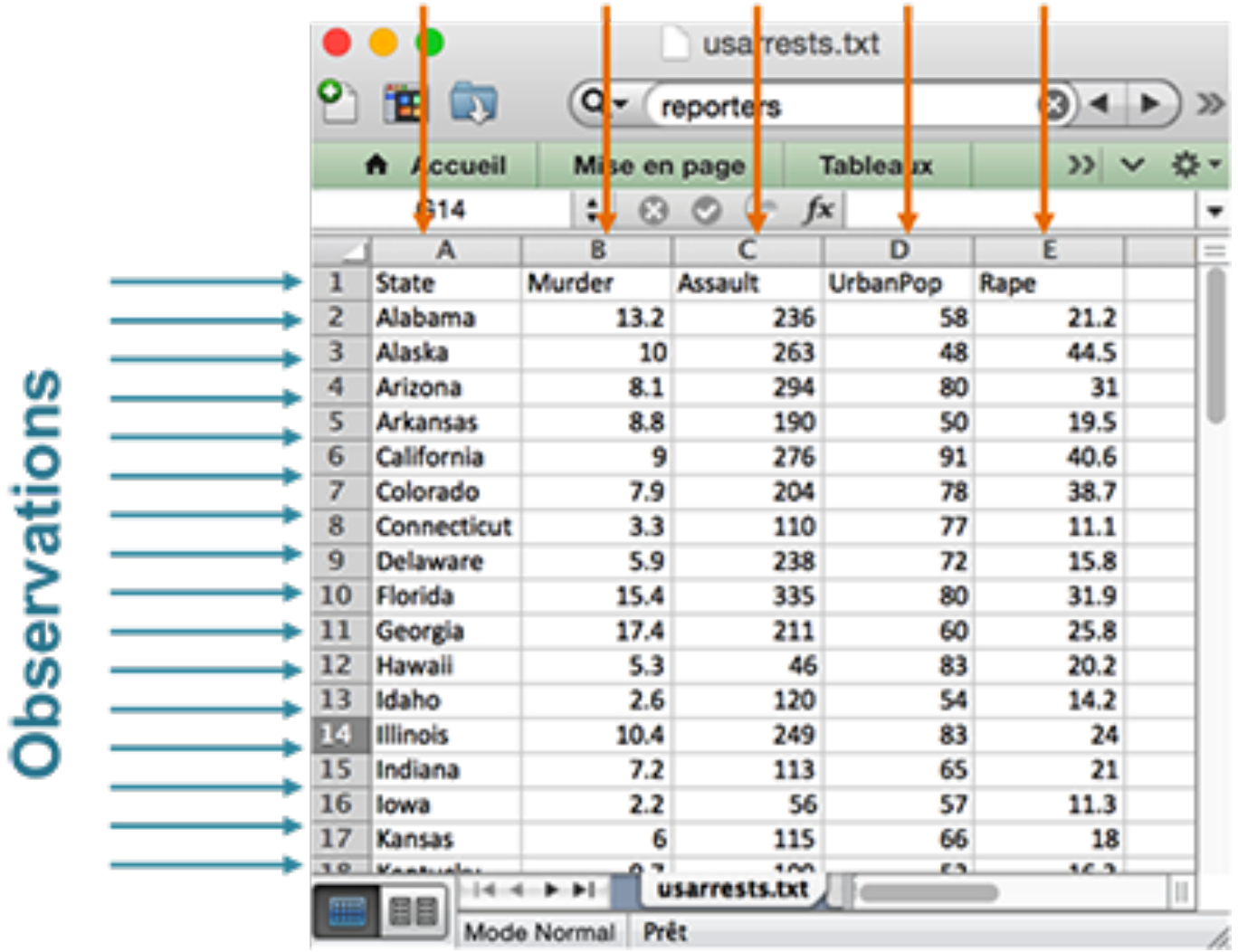

# Snowflake Schema

- Normalized version of star schema
- Central fact table with multiple layers of dimension tables

- Like a hybrid relational/star schema model
  - Reduced redundancy + increased data integrity
  - Less storage space required
  - More query complexity (more joins needed)

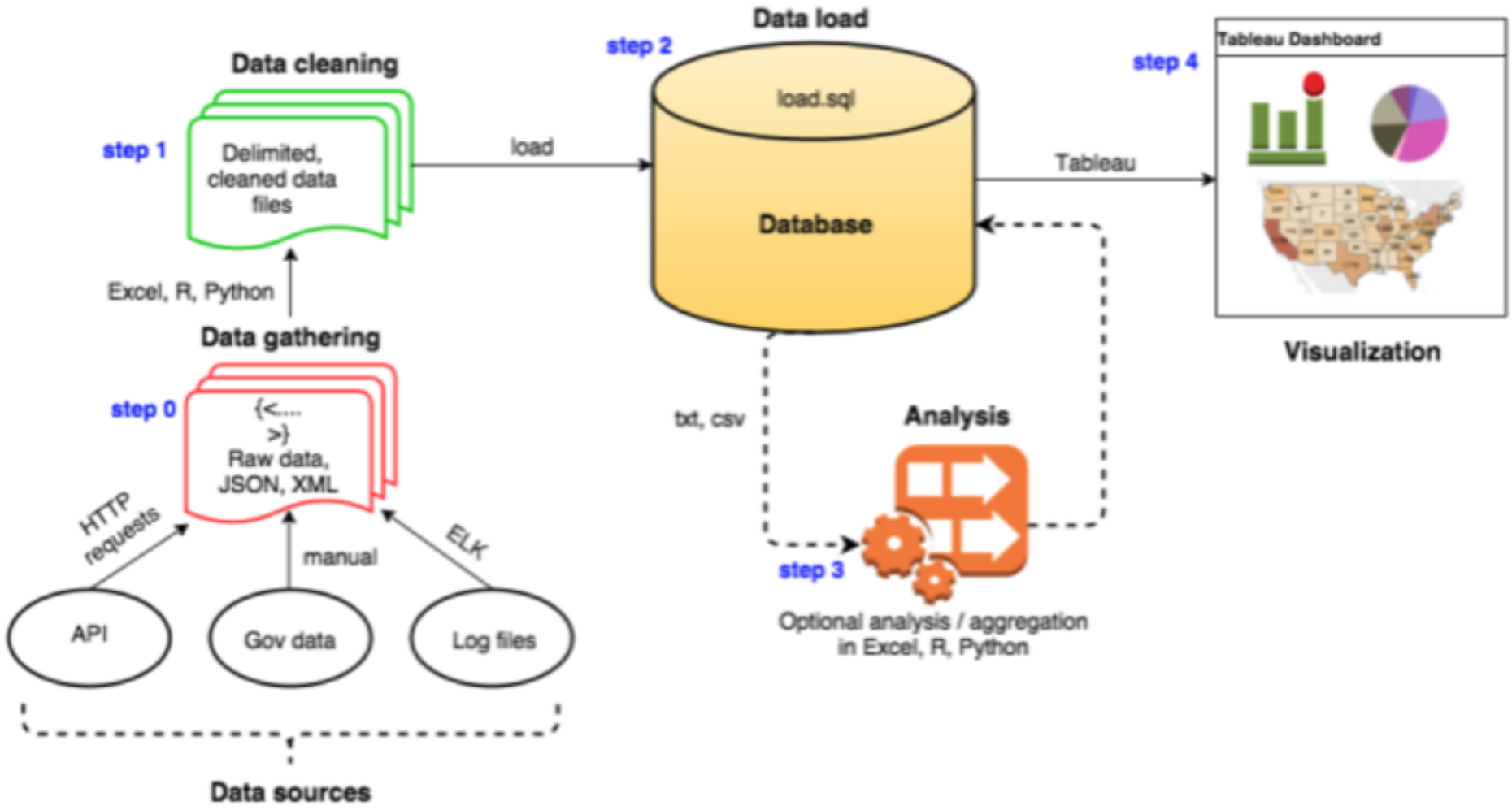
# Tidy data

**tidy data** – *optimized for ad hoc analyses*
( data merged and flattened)




| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | State | Murder | Assault | UrbanPop | Rape |
| 2 | Alabama | 13.2 | 236 | 58 | 21.2 |
| 3 | Alaska | 10 | 263 | 48 | 44.5 |
| 4 | Arizona | 8.1 | 294 | 80 | 31 |
| 5 | Arkansas | 8.8 | 190 | 50 | 19.5 |
| 6 | California | 9 | 276 | 91 | 40.6 |
| 7 | Colorado | 7.9 | 204 | 78 | 38.7 |
| 8 | Connecticut | 3.3 | 110 | 77 | 11.1 |
| 9 | Delaware | 5.9 | 238 | 72 | 15.8 |
| 10 | Florida | 15.4 | 335 | 80 | 31.9 |
| 11 | Georgia | 17.4 | 211 | 60 | 25.8 |
| 12 | Hawaii | 5.3 | 46 | 83 | 20.2 |
| 13 | Idaho | 2.6 | 120 | 54 | 14.2 |
| 14 | Illinois | 10.4 | 249 | 83 | 24 |
| 15 | Indiana | 7.2 | 113 | 65 | 21 |
| 16 | Iowa | 2.2 | 56 | 57 | 11.3 |
| 17 | Kansas | 6 | 115 | 66 | 18 |

***Analytics Workflow*** *- Ketaki Kekatpure*



# What is ETL?
# A data integration process.

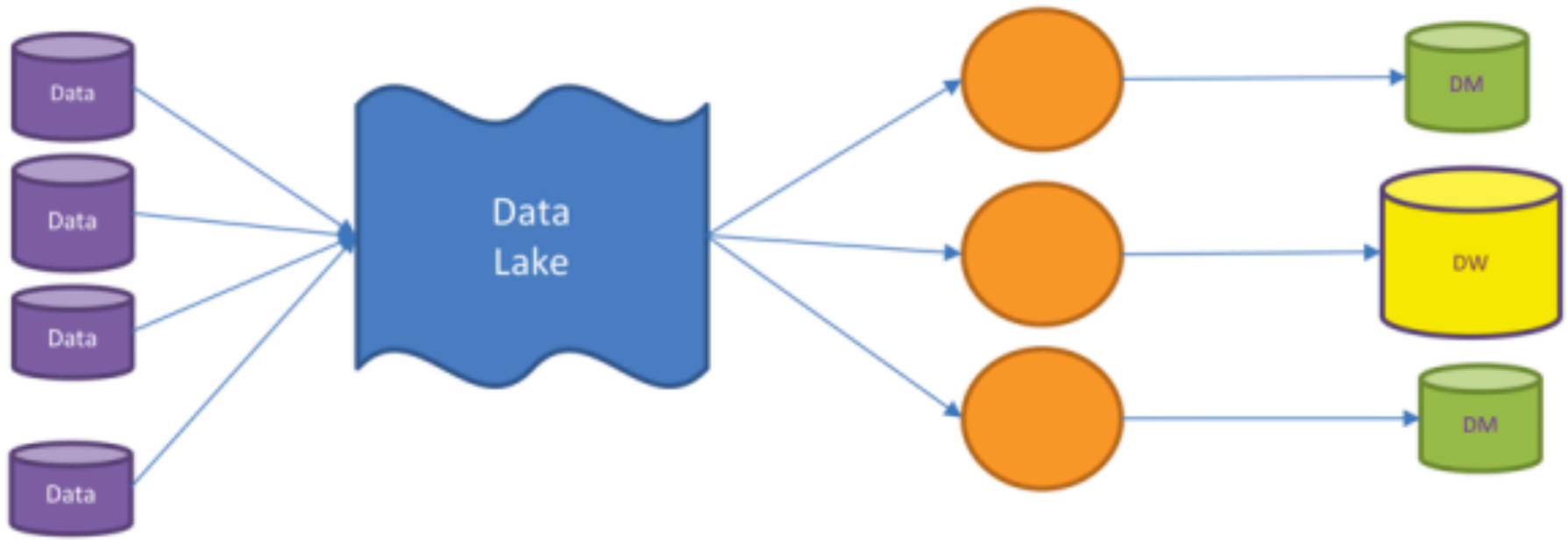
**Extract** – **Transform** – **Load**
Data is **extracted** from a source (an API, a CSV, scraped from the web, etc.)
Data is **transformed** to a useable format and state (cleaning, melting, splitting)
Data is **loaded** to a new location (typically a database, but could also be a new *clean* csv)

There are special tools for doing ETL in different environments, but ETL is a general process. You have already done ETL!

- Excel PowerPivot
- Tableau
- PowerBI

And you'll do even more in Python.

# The Data Lake Pattern




Data Sources

Data in raw format

Data transforms

Data ready for each need