Fundamentals of Data Engineering

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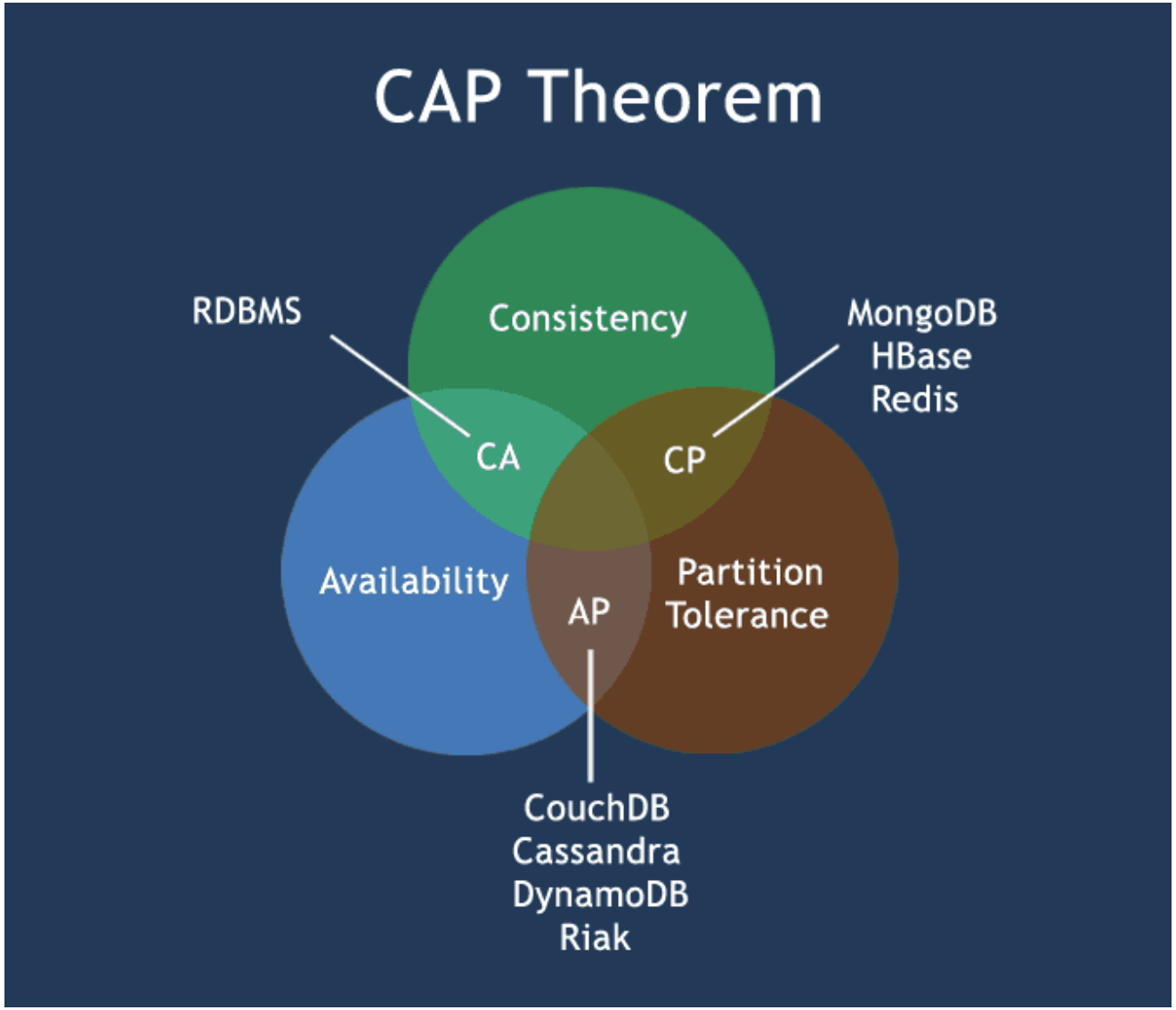
CAP Theorem

- **Consistency - Data is consistent after operation. After an update operation, all clients see the same data.**
- **Availability - System is always on (i.e. service guarantee), no downtime.**
- **Partition Tolerance - System continues to function even the communication among the servers is unreliable.**



NoSQL Databases

- **Key-value databases - e.g. redis, dynamodb, riak**
  - **Based on Amazon's Dynamo database.**
  - **Keys are unique and values can be of any type i.e. JSON, BLOB, etc.**
  - **Implemented as big distributed hash-table for fast searching.**

key - value

Product ID	Type	Schema is defined per item		
1	Book ID	Odyssey	Homer	1871
2	Album ID	6 Partitas	Bach	
2	Album ID: Track ID	Partita No. 1		
3	Movie ID	The Kid	Drama, Comedy	Chaplin

- **Wide Column databases - e.g. hbase, cassandra, bigtable, …**
  - **Values of columns are stored contiguously.**
  - **Better performance while accessing few columns & aggregations.** count, sum, min, max, avg
  - **Good for data-warehousing, business intelligence, CRM, ...**

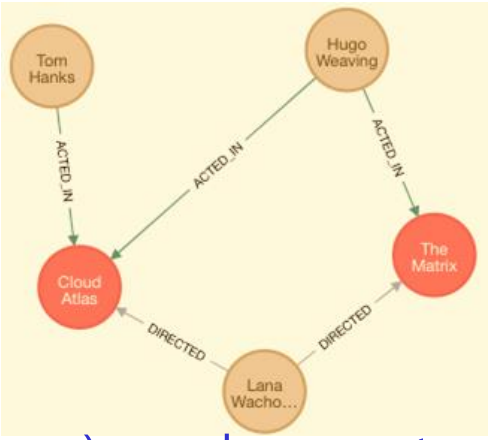
50000 X 30 =RDBMS

1000 2000

Row Key	Customer		Sales	
Customer Id	Name	City	Product	Amount
101	John White	Los Angeles, CA	Chairs	$400.00
102	Jane Brown	Atlanta, GA	Lamps	$200.00
103	Bill Green	Pittsburgh, PA	Desk	$500.00
104	Jack Black	St. Louis, MO	Bed	$1600.00

NoSQL Databases

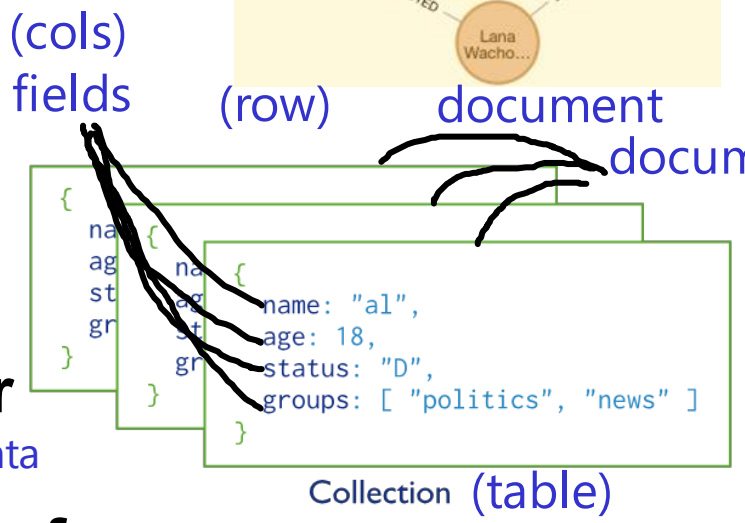
- **Graph databases - e.g. Neo4J, Titan, …**
  - **Graph is collection of vertices and edges.**
  - **Excellent performance, while dealing with all relations of an entity**
    (irrespective of size of data).



- **Document oriented databases - e.g. MongoDb, CouchDb, …**
  - **Document contains data as key-value pair as JSON or XML.**
  - **Document schema is flexible & are added in collection for processing.**

JavaScript Object Notation

semi- struct data



Document – flexible schema

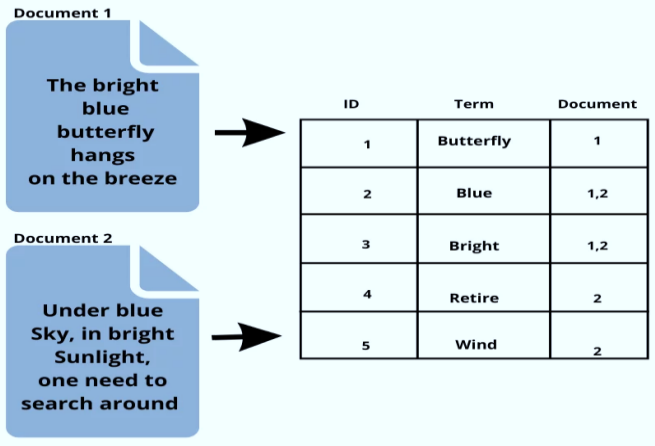
```
mobile m1
{
        cpu:___,
        Ram:_____,
        kaypad:__,
        display:_____
}
```

```
mobile m2
{
        cpu:___,
        Ram:_____,
        display:_____,
        bth:___'
        GPS:_____,
        OS:_____,
        Camera,____
}
```

RDBMS	DoC -NoSQL
Table	Collection
Rows	Documents
column s	fields

NoSQL Databases

- **Search databases – e.g. Elasticsearch, Solr, Lucene, …**
  - **For faster search – Text search, Log analysis.**
  - **Indexed, Exact/Fuzzy matches, Anomaly detection, Analytics.**

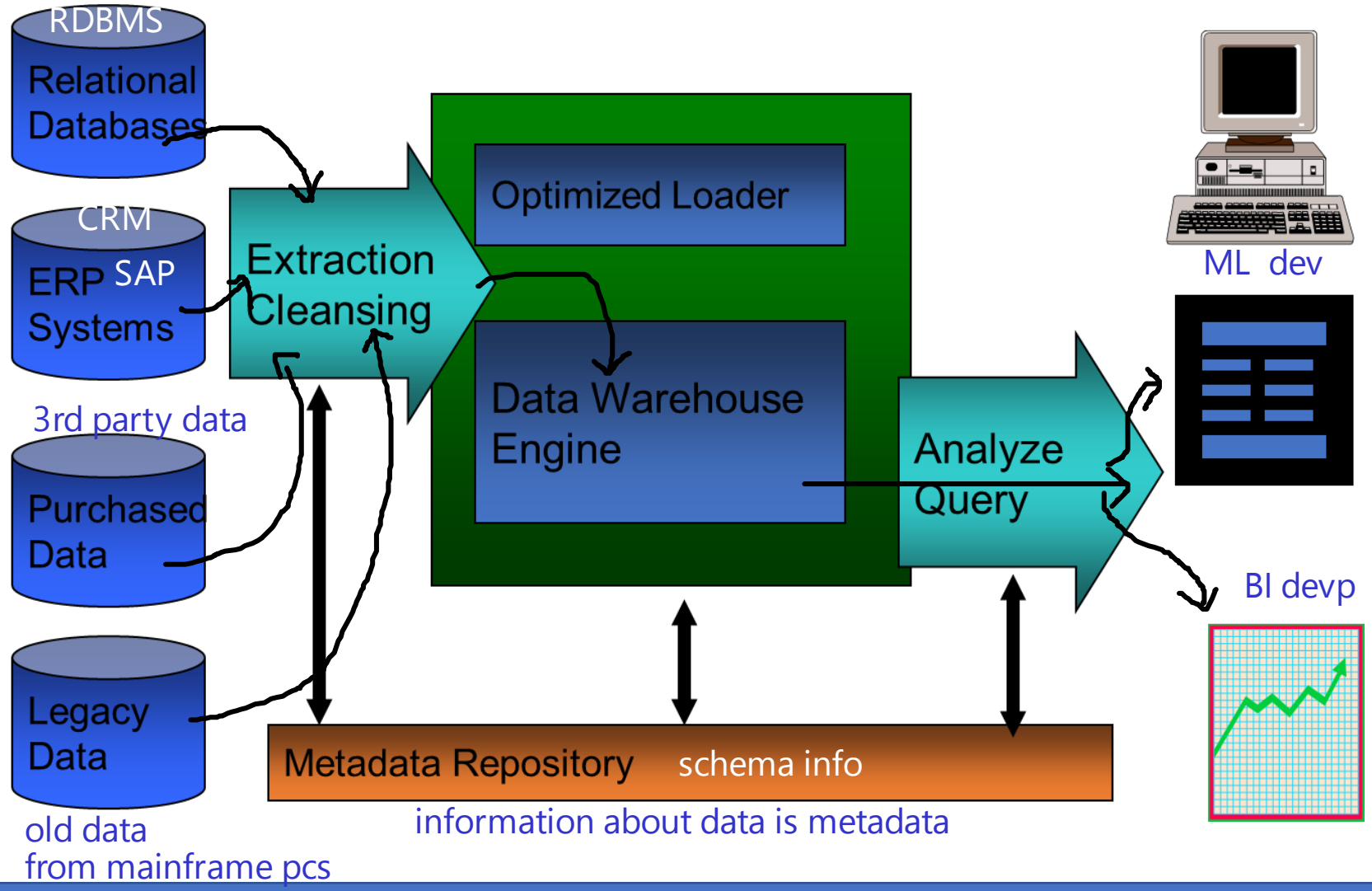


- **Time series databases – e.g. Influx, Druid, …**
  - **Values organized by time like stock market, weather, …**
  - **Optimized for retrieval, statistical processing, …**
  - **Used for measurement data (weather, …) and event-based data (accidents, …)**

Date	Ozone ($\mu g/m^3$)	Temperature (°C)	Relative humidity (%)	*n* deaths
1 Jan 2002	4.59	−0.2	75.7	199
2 Jan 2002	4.88	0.1	77.5	231
3 Jan 2002	4.71	0.9	81.3	210
4 Jan 2002	4.14	0.5	85.4	203
5 Jan 2002	2.01	4.3	93.5	224
6 Jan 2002	2.4	7.1	96.4	198

Data warehousing

- **Data warehouse is a single, complete and consistent store of data obtained from a variety of different sources made available to end users in a what they can understand and use in a business context.**
- **Data warehousing is a process of transforming data into information and making it available to users in a timely enough manner to make a difference.**



Extract – Transform – Load

temp area

- Extracting: Extract data from sources into staging area
- Conditioning: Data types conversion to fit warehouse.
- House holding: Grouping similar data 1000/4=250
- Enrichment: Add relevant data from external sources
- Scoring: Computation of probability of an event
- Scrubbing: Data cleaning: find duplicate, missing data
- Merging: Merging data from various sources.
- De-normalize: Duplicate data to reduce joins.
- Loading: Load data in warehouse models like Star, Snowflake, Galaxy.
- Delta Updating: Incremental data uploading
- Partitioning: Dividing the data in logical parts to improve performance.

De-normalize :- Duplicate data to reduce joins.

join

batch table (7 cols)

id	name
1	OM50
2	PH24
3	PH25
4	PH26
5	CH06
6	py
7	java

students table (10 cols)

ro	name	batchID
1	a	1
2	b	2
3	c	1
4	d	3
5	e	1
6	f	1
7	g	5
8	h	1
9	i	1
10	j	3
11	k	4

Normalized data

not reduntdent

10+7=17

data is reduntdent

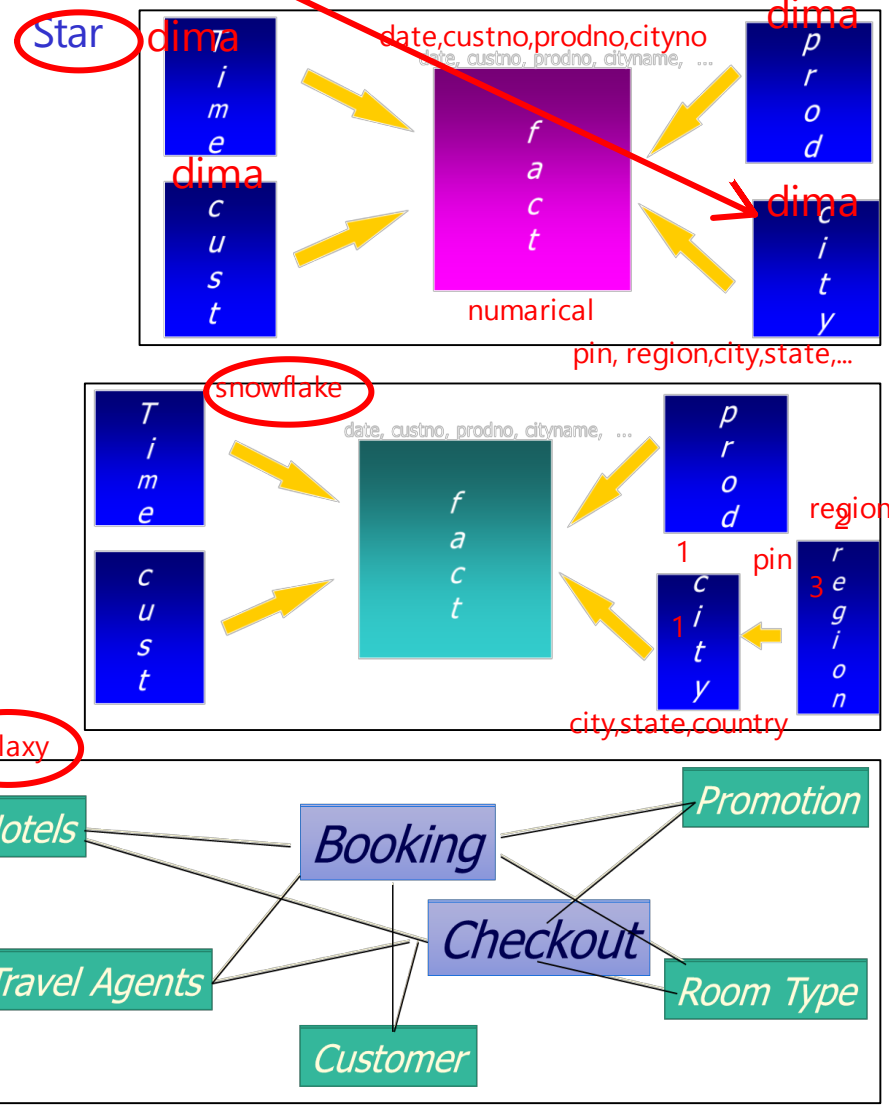
Ro	name	batch name
1	a	OM50
2	b	PH24
3	c	OM50
4	d	PH25
5	e	OM50
6	f	OM50
7	g	CH06
8	h	OM50
9	i	OM50
10	j	PH25
11	k	PH26

De-Normalized

DWH Schemas

hinjewadi	pune	mh	IND
market yard	pune	mh	ind
katraj	pune	mh	ind

- **DWH schema is how data is stored in tables in warehouse for the efficient processing of the data.**
- **A fact table stores metrics, measurements, or facts about business processes.** number
- **Dimension tables are tables used to store data attributes or dimensions.** string+number
- **Star schema: Single facts table and a few dimension tables (de-normalized) – Simple design.**
- **Snowflake schema: Single facts table and connected dimension/sub-dimension tables (normalized).**
- **Galaxy or Fact-Constellation schema: Multiple facts tables mapped to multiple dimension/sub-dimension tables.**

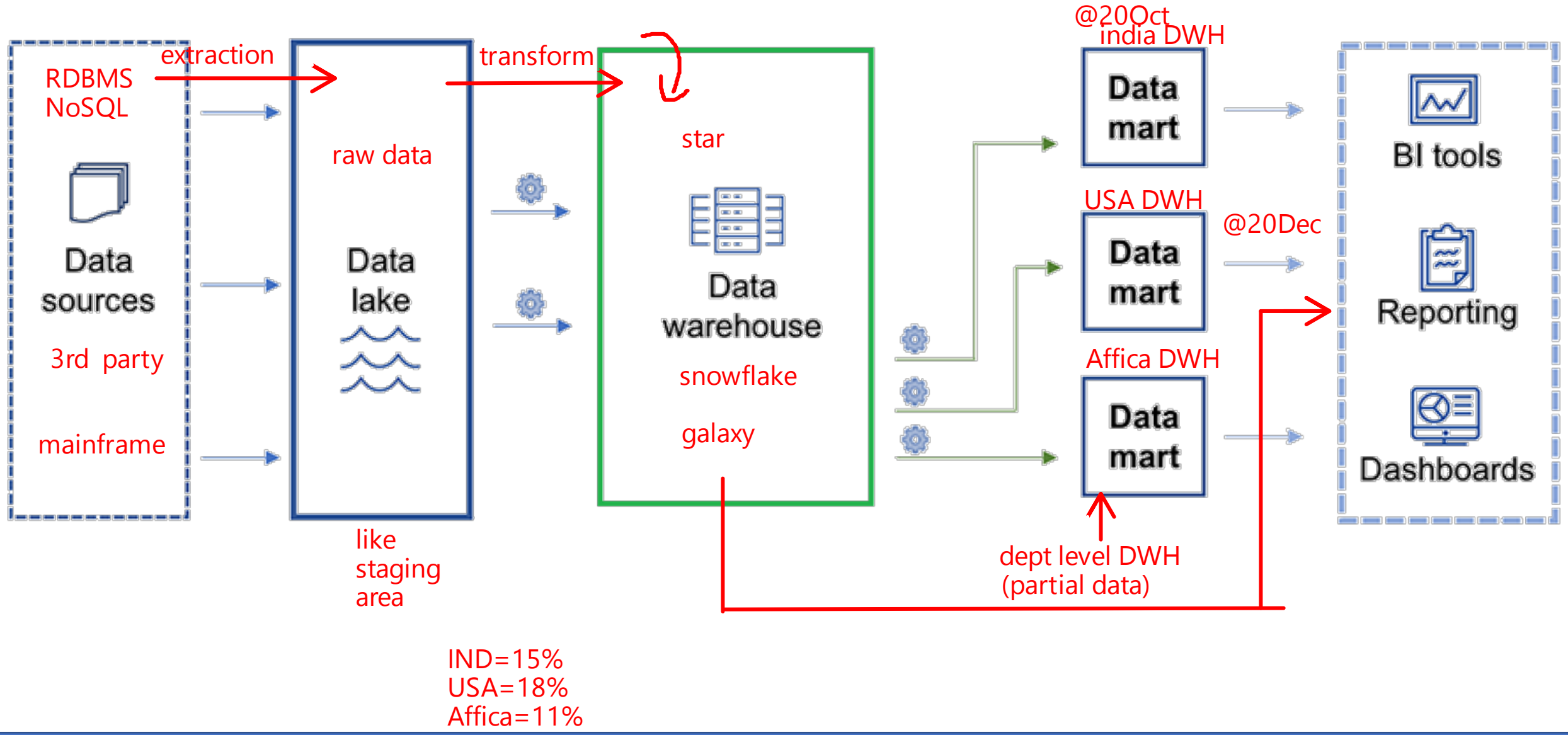


OLTP (Database) vs OLAP (Data warehouse)

- Online Transaction Processing
- Modeled to run the business
- Detailed/Transactional normalized real-time data
- Transaction performance DML
- Read/Write operations
- Isolated data (Application specific) – Limited data (100 MB to 100 GB)

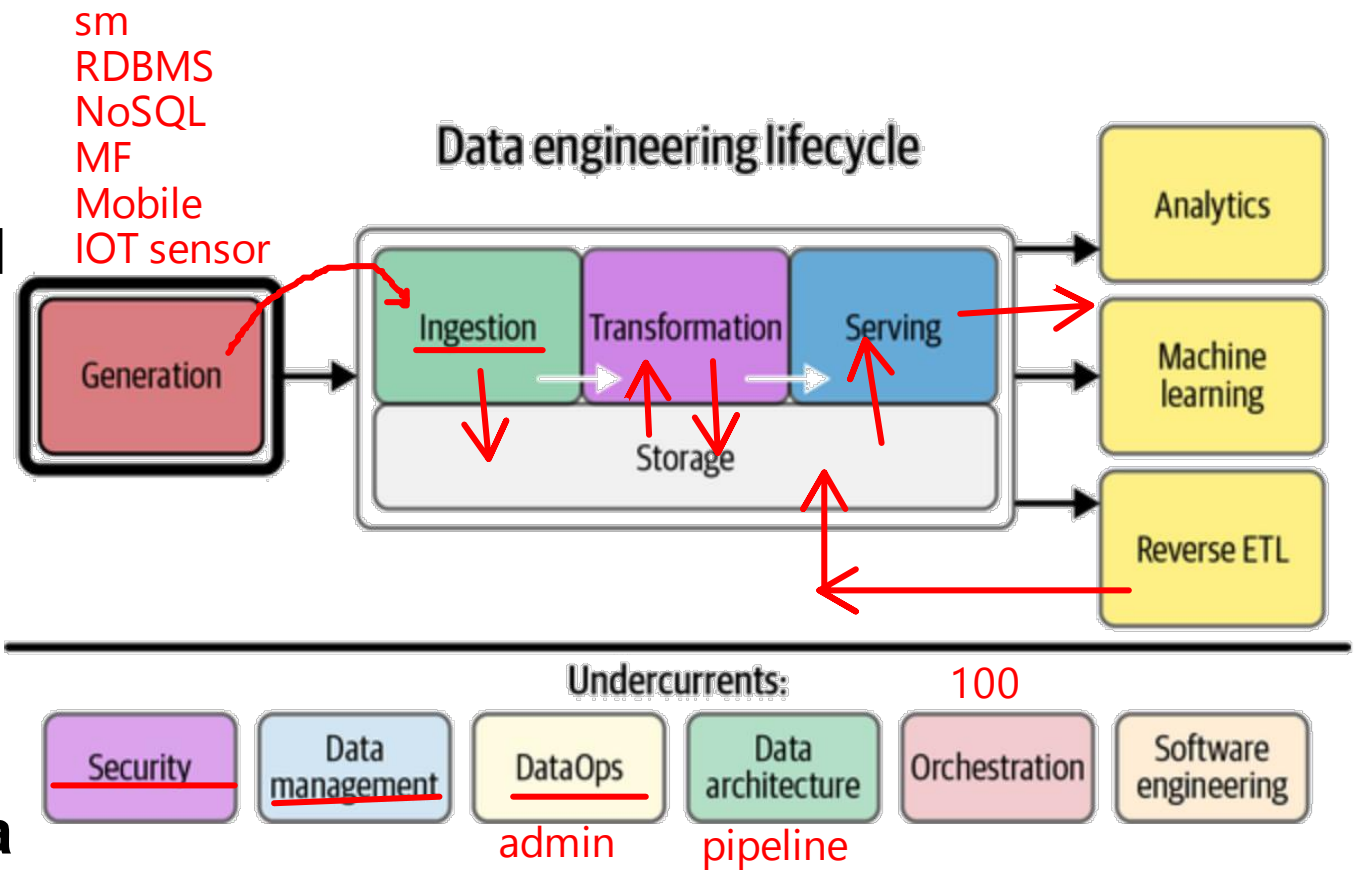
- Online Analytical Processing
- Modeled to analyze/optimize business
- Summarized/refined redundant snapshot data
  Historical data
- Analytical query performance DQL join Aggr
- Mostly Read operations sum ,count,avg
- Integrated data (from all sources) – Huge data (100 GB to Few TB)

Data lake vs Data warehouse vs Data mart



Data engineering

- **Data engineering is the development, implementation, and maintenance of systems and processes that take in raw data and produce high-quality, consistent information that supports downstream use cases, such as analysis and machine learning.**
- **Data engineer manages data engineering lifecycle, beginning with getting data from source systems & ending with serving data for use cases, such as analysis or machine learning.**



Traditional ETL vs Hadoop ELT

- ETL stands for Extract, Transform and Load.
- The ETL process typically extracts data from the source/transactional systems, transforms it to fit the model of data-warehouse and finally loads it to the data warehouse.
- The transformation process involves cleansing, enriching and applying transformations to create desired output.
- Data is usually dumped to a staging area after extraction.

- ELT stands for Extract, Load and Transform. bigdata
- As opposed to loading just the transformed data in the target systems, the ELT process loads the entire data into the data lake. This results in faster load times.
- The load process can also perform some basic validations and data cleansing rules.
- The data is then transformed for analytical reporting as per demand.

Data storage

- Data storage is related to multiple stages in data engineering life cycle i.e. ingestion, transformation and serving.
- Storage needs to be selected based on read/write requirement, speed, durability, consistency, availability, scalability, fault tolerance, … factors.
- Storage tradeoffs
  - Local storage vs Distributed storage
  - Strong consistency vs Eventual consistency
- Storage options are: File storage, Local disk storage, Network attached storage (NAS), Cloud file systems (S3/Blob), Block storage, RAID, Storage area network (SAN), Object storage, HDFS, Streaming storage.

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B: Doument

C: Text

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B: Ingesting

C: Serving

D: Analysing

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Thank you!

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