ER - DIAGRAM

COURSE 1: Databases

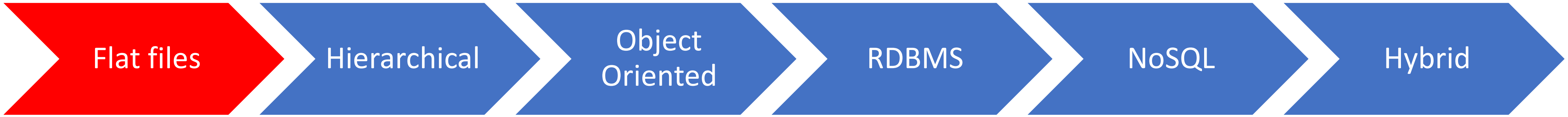
DBMS (Database Management System)

- System designed to define and manipulate data.
    - Storage.
    - Retrieval.
    - Updates.

DBMS (Database Management System)

- Avoid redundancy, inconsistency.
- Concurrent data access.
- Provides security and recovery.
- Declarative language to manipulate, query, define and control data.
- DDL, DML, DCL.
- Data dictionary: database providing info about database structure.

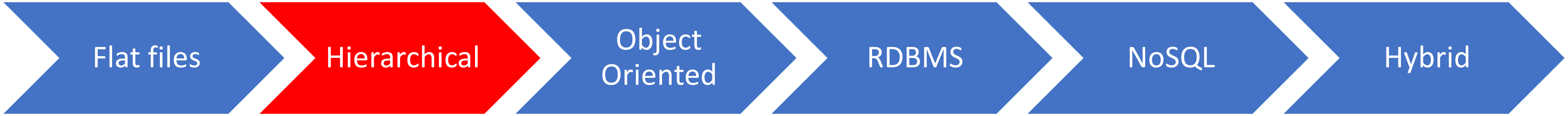
DBMS (Database Management System)



Flat files → Hierarchical → Object Oriented → RDBMS → NoSQL → Hybrid

- Text database, example CSV format.
- Implemented in 1970 (IBM).
- File = table with a single record on each line.
- Read, store and send.
- Simple structure.
- Inefficient: slow, duplicated values, hard to update etc.

DBMS (Database Management System)



Flat files

Hierarchical

Object Oriented

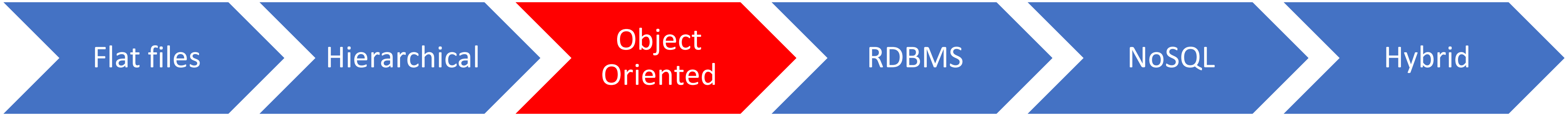
RDBMS

NoSQL

Hybrid

- Tree structure, examples: file system, Windows Registry
- IBM Information Management System (IMS)
- XML, XAML
- Used in mainframe era.
- Rigid structure.
- Only *One-to-many* relationship.
- Traversing very easy, moving a node difficult

DBMS (Database Management System)



Flat files

Hierarchical

Object Oriented

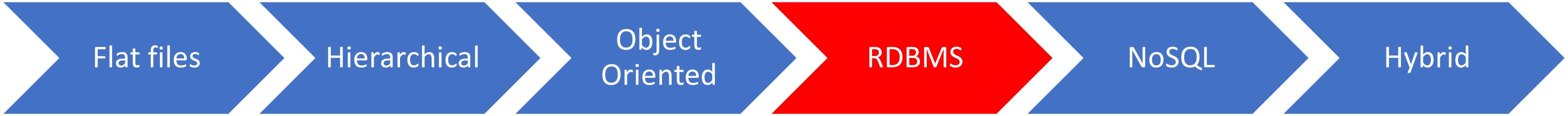
RDBMS

NoSQL

Hybrid

- Hybrid relation + objects =>> tables of objects.
- Realm database for Android/IoS: classes used as schema definition, alternative for SQLite.
- Next: MongoDB Realm.

DBMS (Database Management System)



Flat files

Hierarchical

Object Oriented

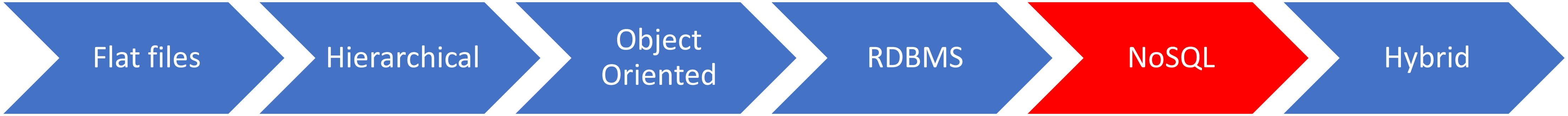
RDBMS

NoSQL

Hybrid

- Transaction oriented systems (financial transactions).
- ACID: Atomicity, consistency, isolation, durability.
- Suitable for structured data.

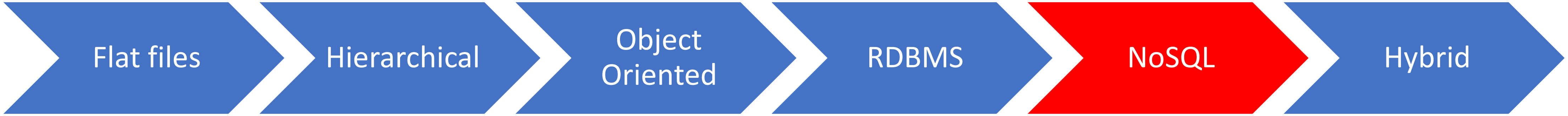
DBMS (Database Management System)



Flat files → Hierarchical → Object Oriented → RDBMS → NoSQL → Hybrid

- RDBMS hard to scale (only scale vertically, not horizontally).
- RDB Restrictive schemas =>> flexible structure.
- The state of the database can change.
- !!! availability, scalability, performance
- Sharding: distribute data on different servers

DBMS (Database Management System)



Flat files → Hierarchical → Object Oriented → RDBMS → NoSQL → Hybrid

- Cloud and bigdata.
- BASE (Basically Available, Soft state, Eventually consistent)
- Types:
  - key-value: Redis
  - Document: Mongo
  - Column: Apache Cassandra
  - Graph: Neo4j

Sql or NoSQL

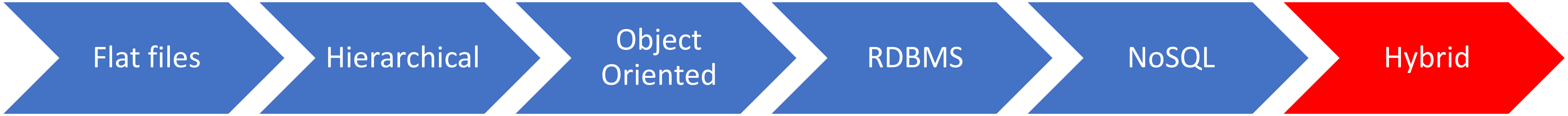
Relational

- Vertical scalability
- ACID
- pre-defined schema
- SQL language
- Normalized data

NoSql

- Horizontal scalabitily
- BASE
- Flexible schema
- No standard
- Collections, redundancy

DBMS (Database Management System)



Flat files

Hierarchical

Object Oriented

RDBMS

NoSQL

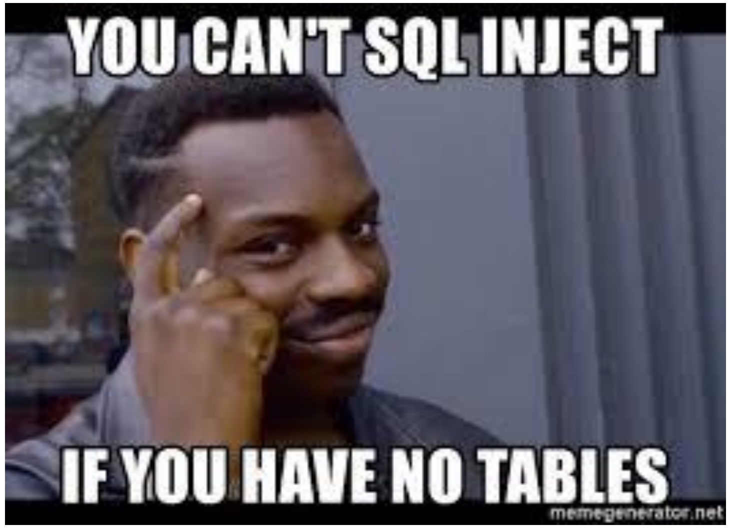
Hybrid

- Integration of Relational and NoSQL databases.
- Integration of in-memory DB and on-disk DB
- Altibase, Orient DB

Course roadmap

- Database design
- SQL
- NoSql
- … & other topics …

Course roadmap



ER diagram

- Visual representation of the ER model.
- Describes the logical structure of the (relational) database.
- Proposed by Chen in 1971.
- Easy to translate into relational tables.
- High-level design.
- Suitable for structured systems.

ER - Diagram

Entity Relationship model

ER - Diagram

- Visual representation of the ER conceptual data model.
- Describes the structure of the (relational) database.
- Not linked to the implementation or hardware.

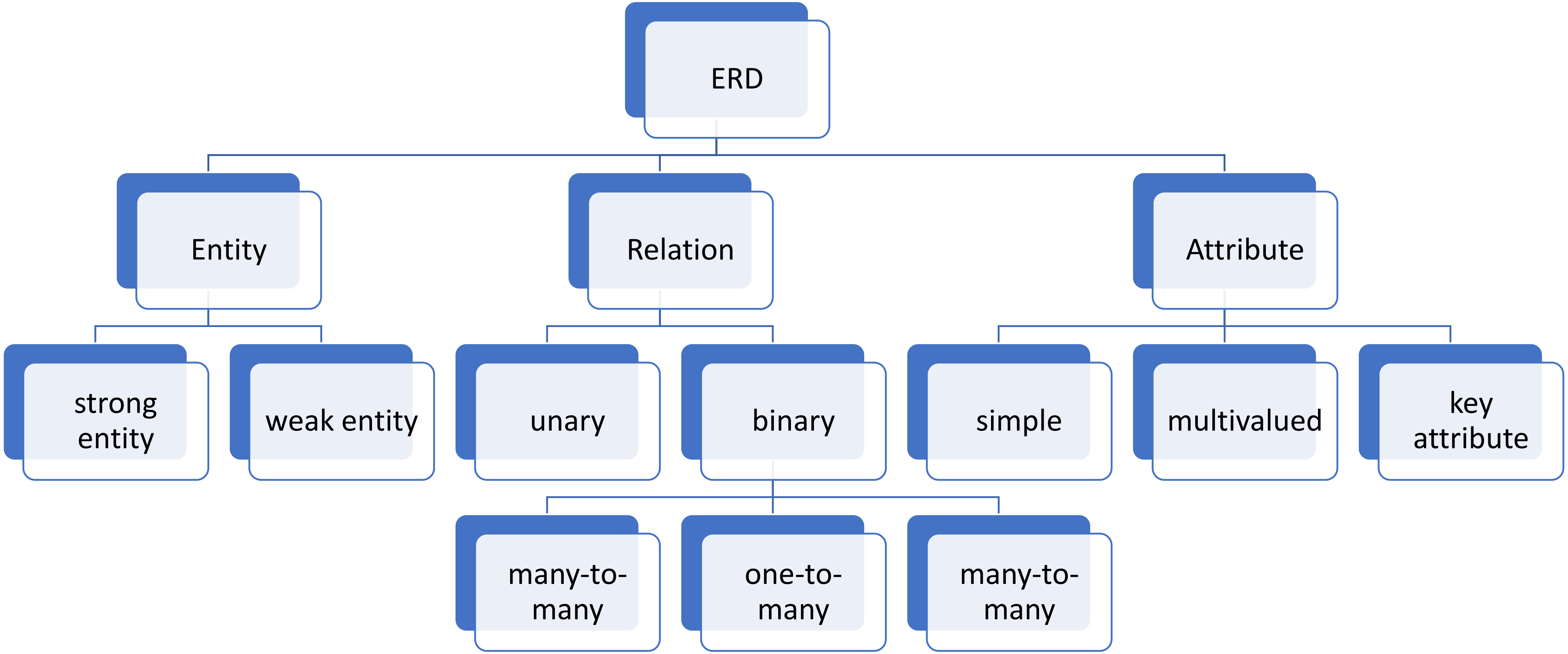
- Peter Chen developed ERDs in 1976.

ER - Diagram

- User story/requirement analysis ➔ **ER** ➔relational database schema.
- Easy to translate into relational tables.

- High-level design.
- Suitable for structured systems.

ERD - components



ER - Diagram

ENTITY

person, place, activity, event, concept, real world object etc.

usually a noun

RELATION

ATTRIBUTE

ER - Diagram

ENTITY

person, place, activity, event, concept, real world object etc.

usually a noun

RELATION

links entities (unary, binary, ternary).

usually a verb

ATTRIBUTE

ER - Diagram

ENTITY

person, place, activity, event, concept, real world object etc.

usually a noun

RELATION

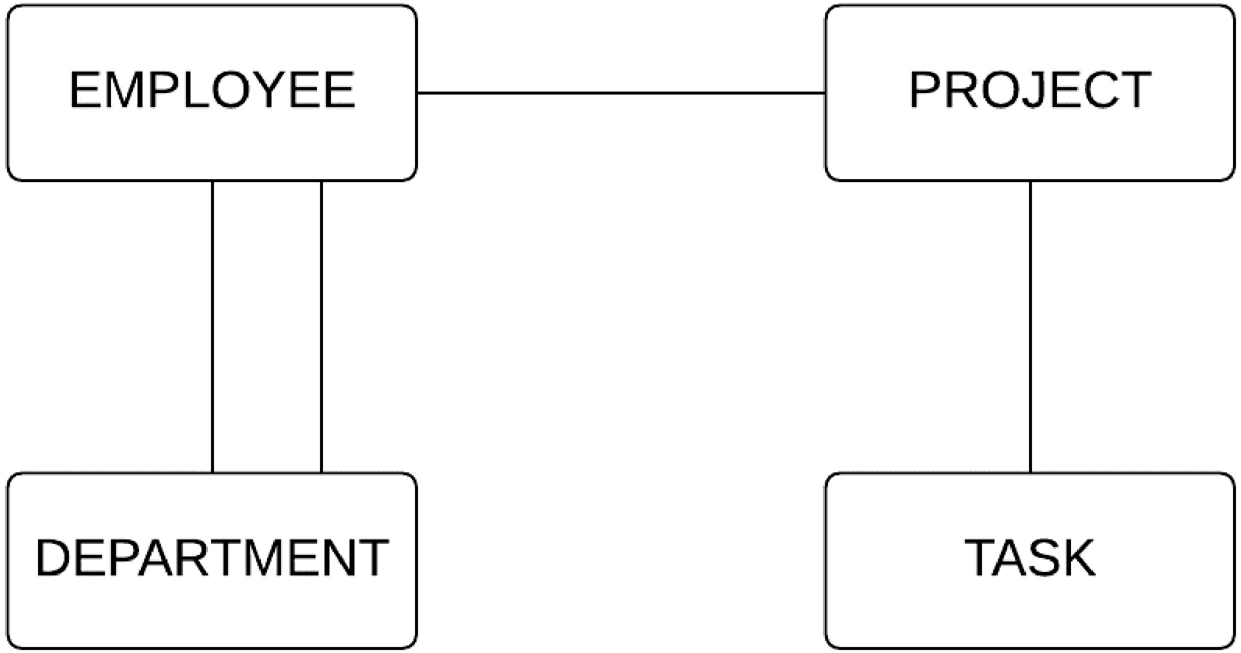
links entities (unary, binary, ternary).

usually a verb

ATTRIBUTE

describe entities or relations

Entities



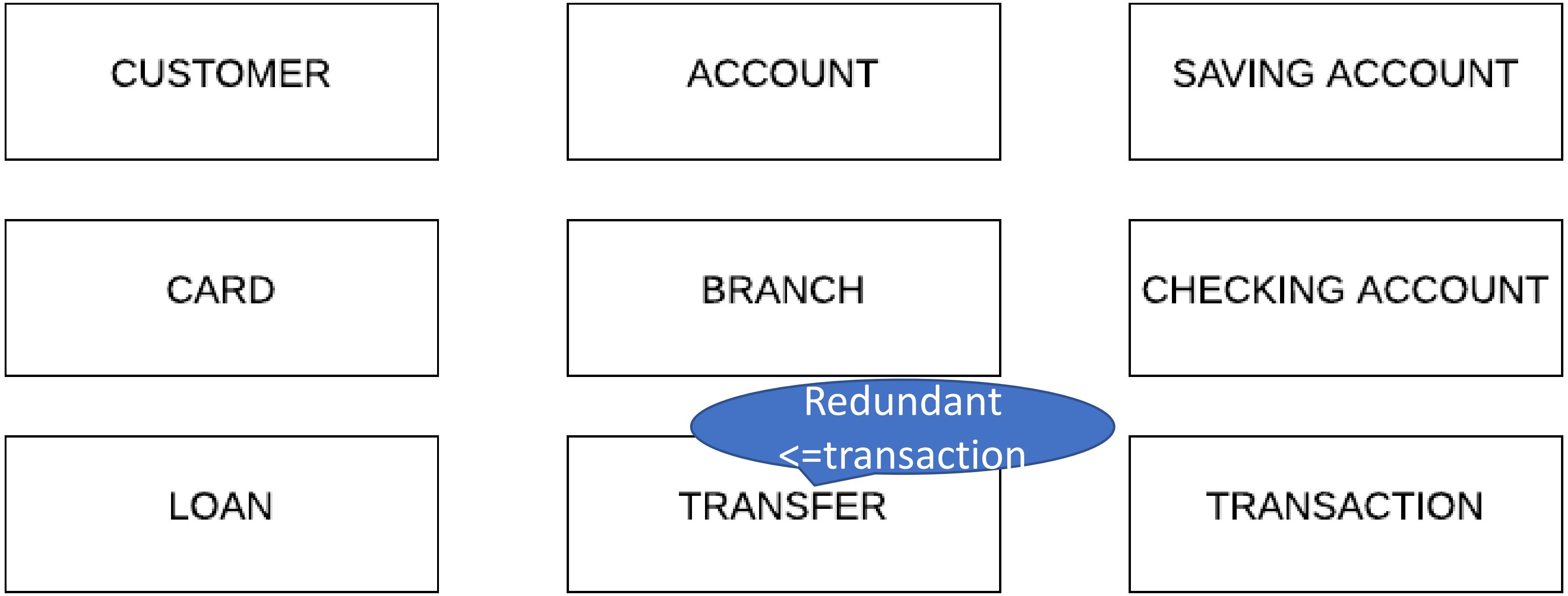
Banking (1)Entities

- A customer opens a saving account or a checking account, at a bank branch. He may also access loans. For each checking account he has a card. Periodically he may withdraw money from his account or partially pay his loans. He may also transfer money from one account to another.

Entities

- Unique names, uppercase characters
- Graphical representation: rectangles

- Relational database: entity ➔ table (line & columns)
- Primary key: attribute or group of attributes that uniquely identifies an entity instance



CUSTOMER

ACCOUNT

SAVING ACCOUNT

CARD

BRANCH

CHECKING ACCOUNT

LOAN

TRANSFER

TRANSACTION

Redundant <=transaction

Primary key

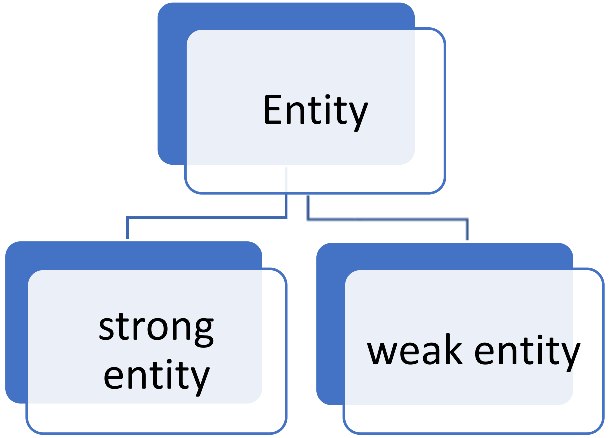
- Unique identifier
- Must be known at any moment
- Simple
- No ambiguities
- Immutable

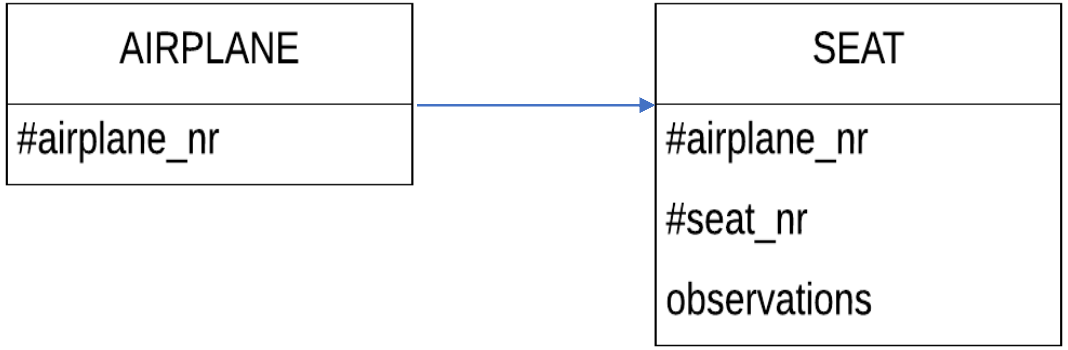
- Composed keys may be replaced with an artificial key.

Airline (1)Entities

- The airline has one or more airplanes. An airplane has a model number, and capacity. Each flight is carried out by airplanes. An airplane is uniquely identified by its Registration_no and a flight is identified by its Flight_no. A passenger can book a ticket for a flight.

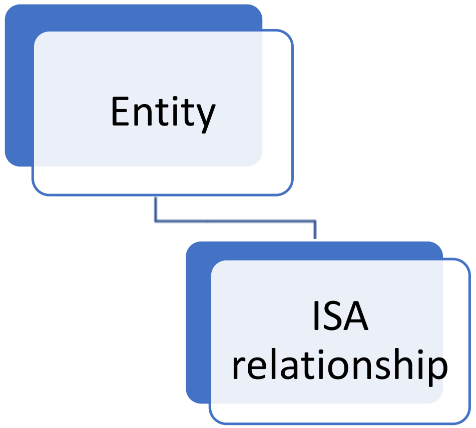
Entities

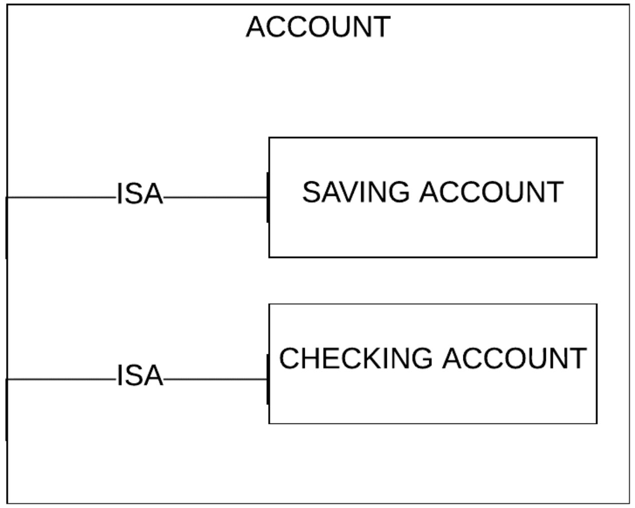




- Weak entity is an entity that depends on another entity.
- The primary key of a weak entity contains the primary key of the strong entity that it depends on + description/partial key.

Entities





- A sub-entity has the same key as the *super*-entity and all its attributes and relationships.

Relationship

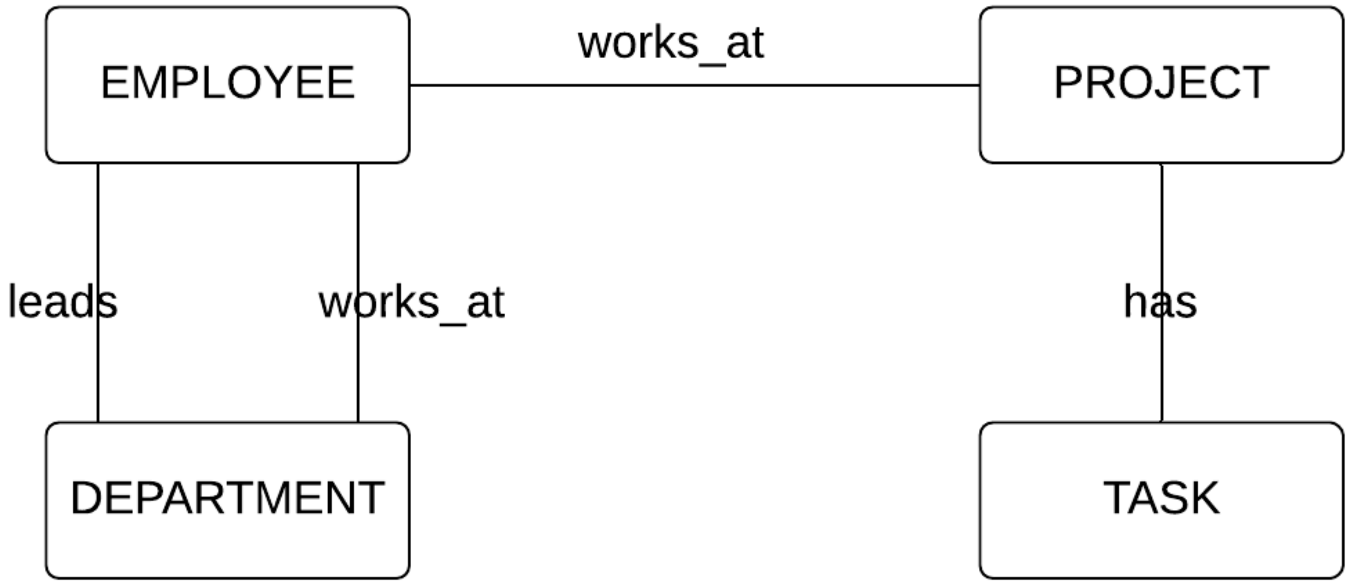
- Association between two or more entities (binary, ternary etc.)
- Relationship → column (foreign key) or table.
- Graphical representation: oriented arc.

- Two relationships with the same name link different entities.

- Cardinality defines the numerical attributes of the relationship between two entities: MANDATORY (min) OPTIONAL (max)

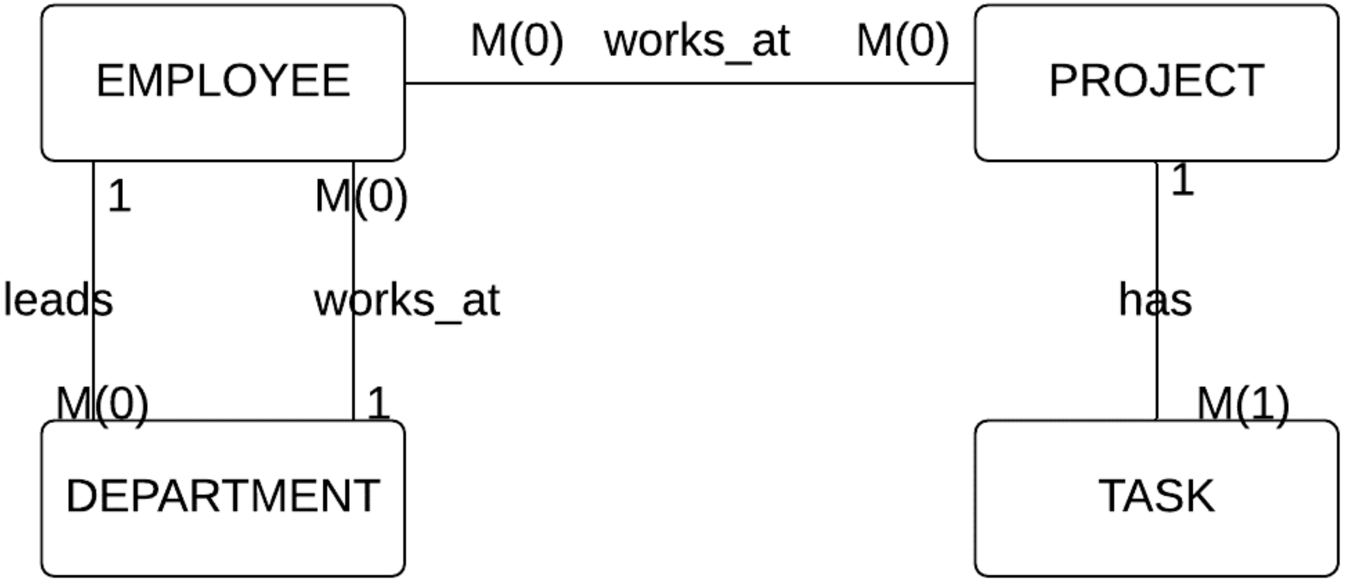
Relationship cardinality

- MANDATORY (must)
- OPTIONAL (may)



Relationship cardinality

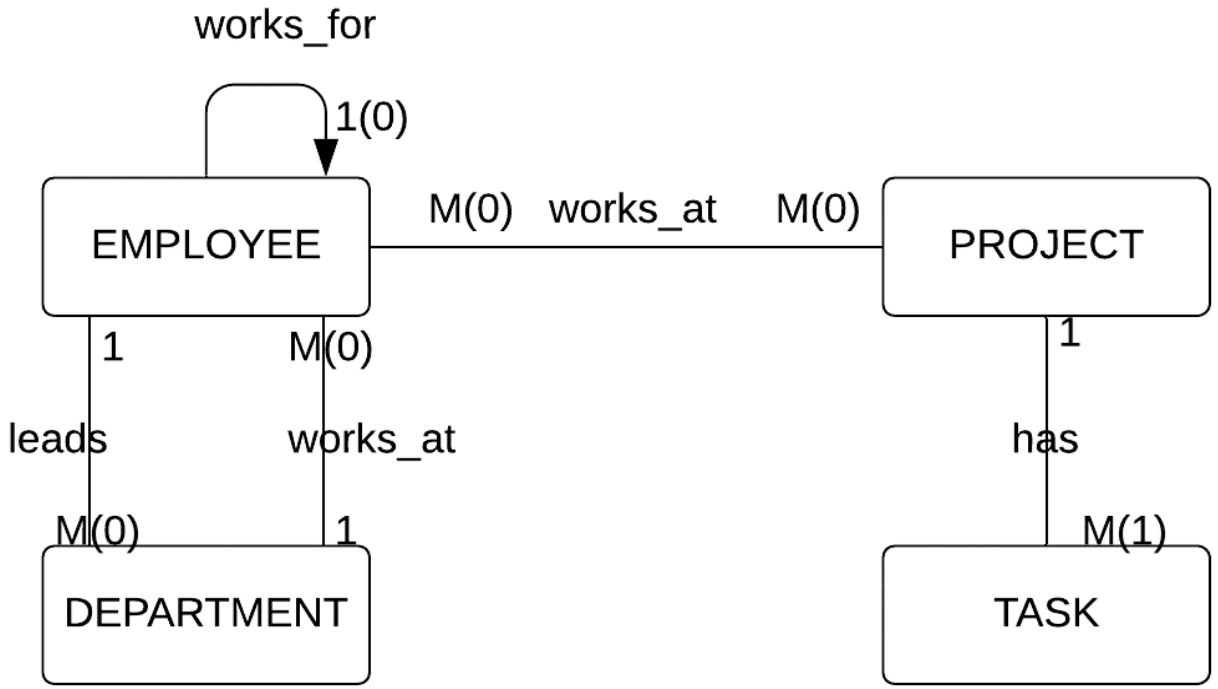
- MANDATORY (must)
- OPTIONAL (may)

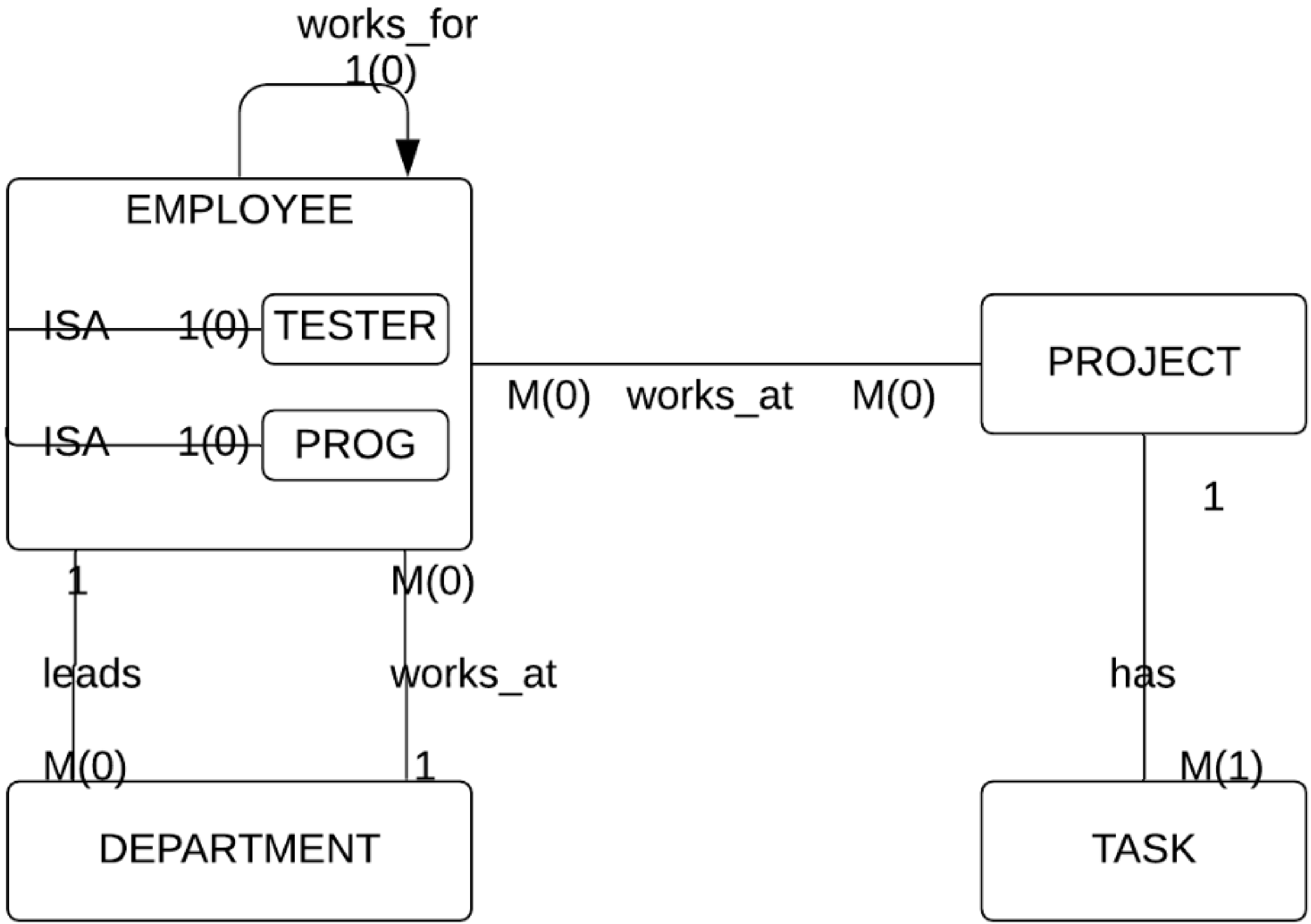


Relationship cardinality

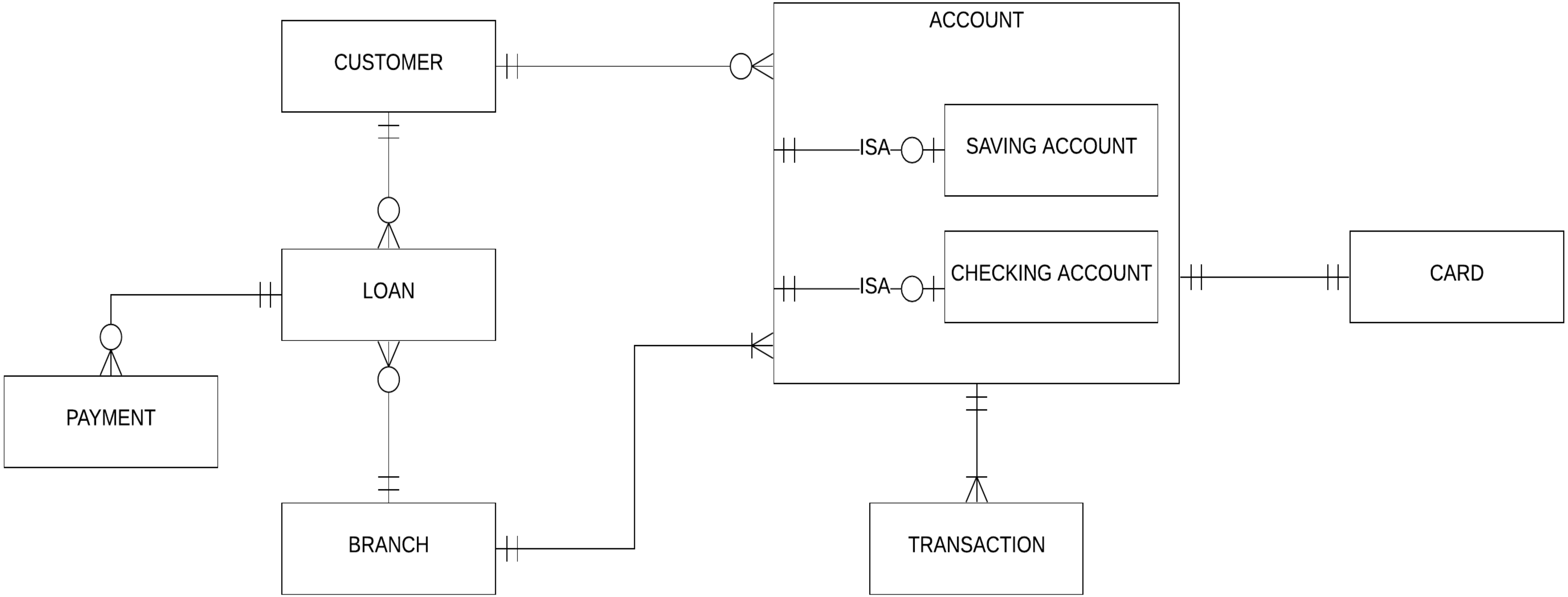
- Reflexive relationship

  unary relationship.




works_for
1(0)
EMPLOYEE
ISA
1(0)
TESTER
ISA
1(0)
PROG
M(0)
works_at
M(0)
PROJECT
1
1
M(0)
leads
works_at
has
M(0)
1
M(1)
DEPARTMENT
TASK

Banking (2)Relationships



Airline (1)Relationships

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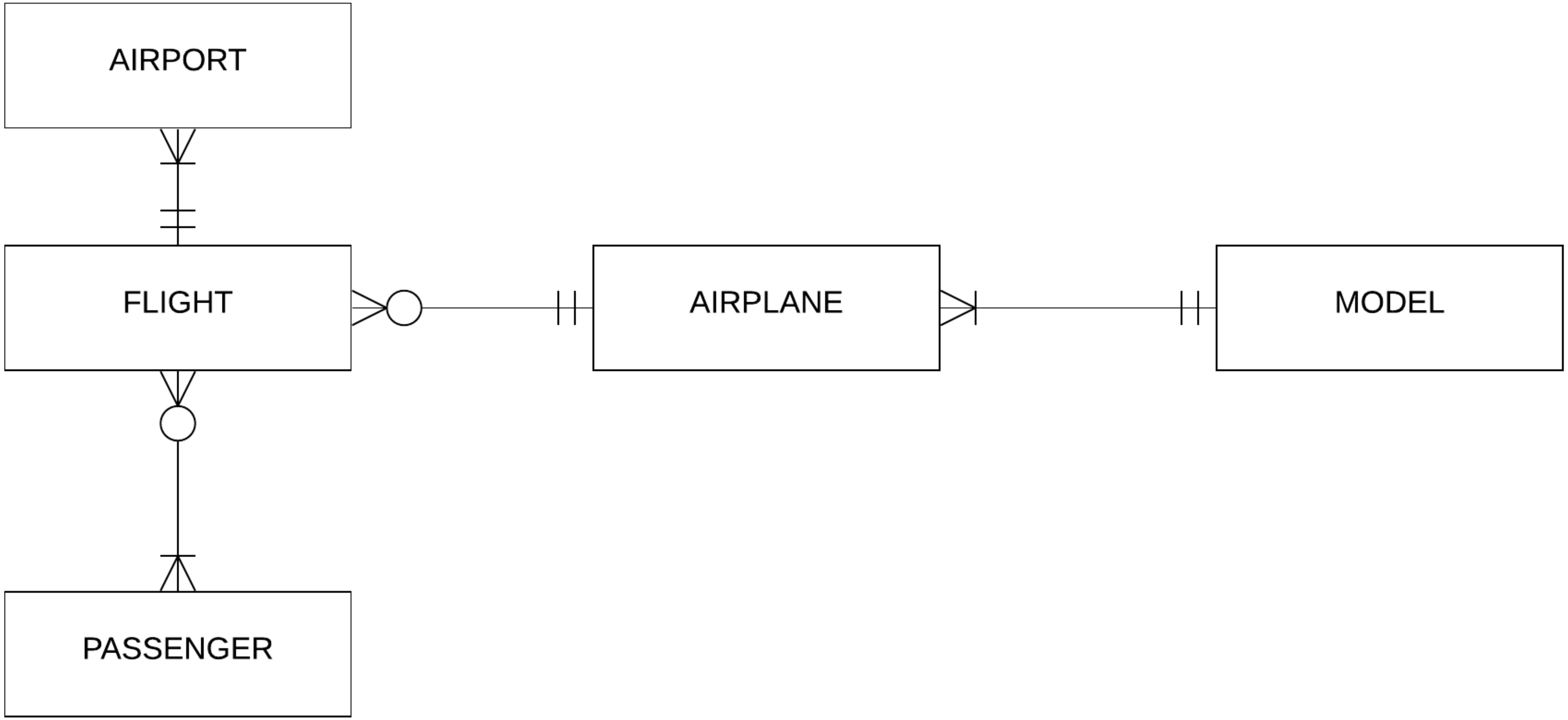
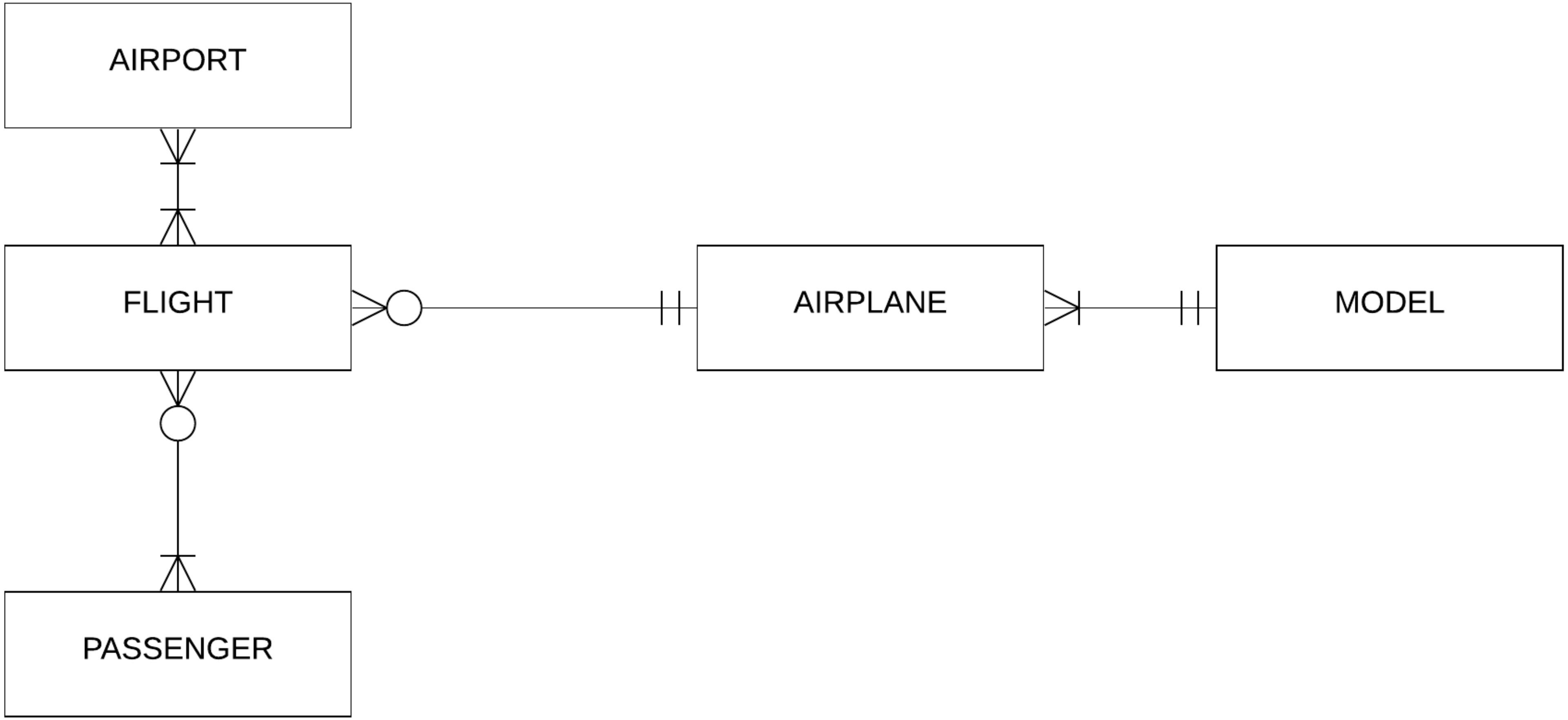

AIRPORT
FLIGHT
AIRPLANE
MODEL
PASSENGER


AIRPORT
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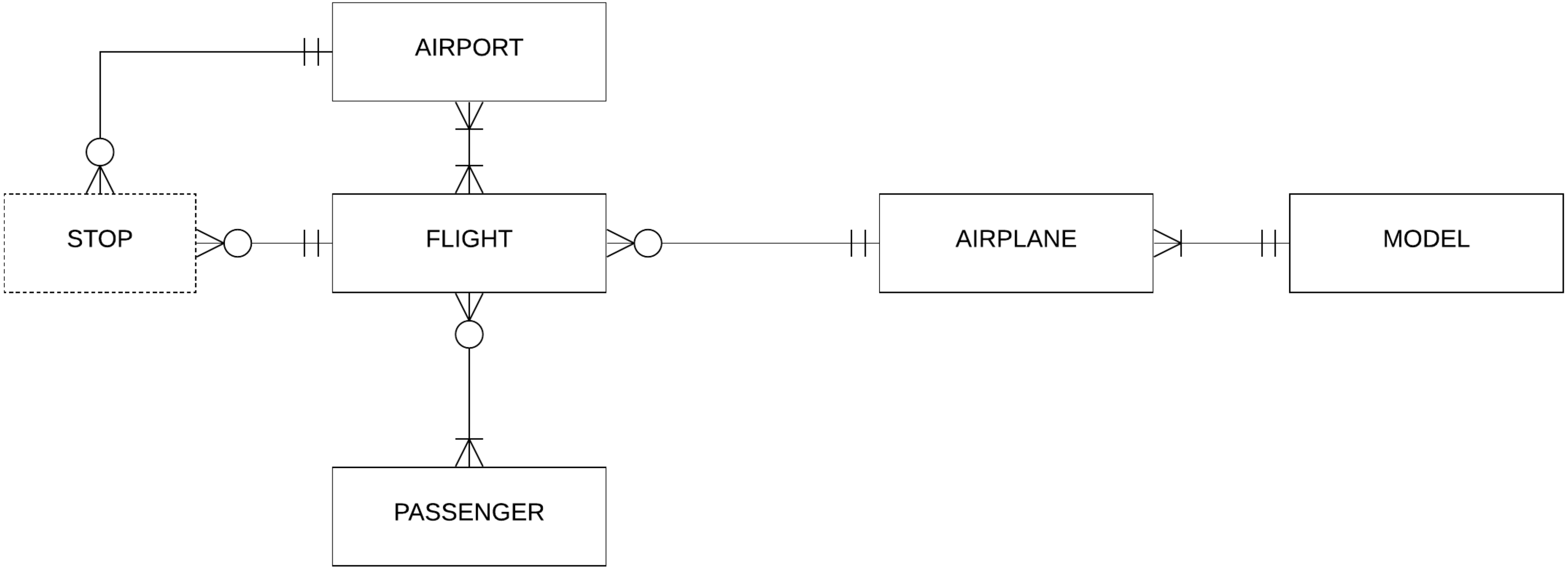
AIRPORT
STOP
FLIGHT
AIRPLANE
MODEL
PASSENGER

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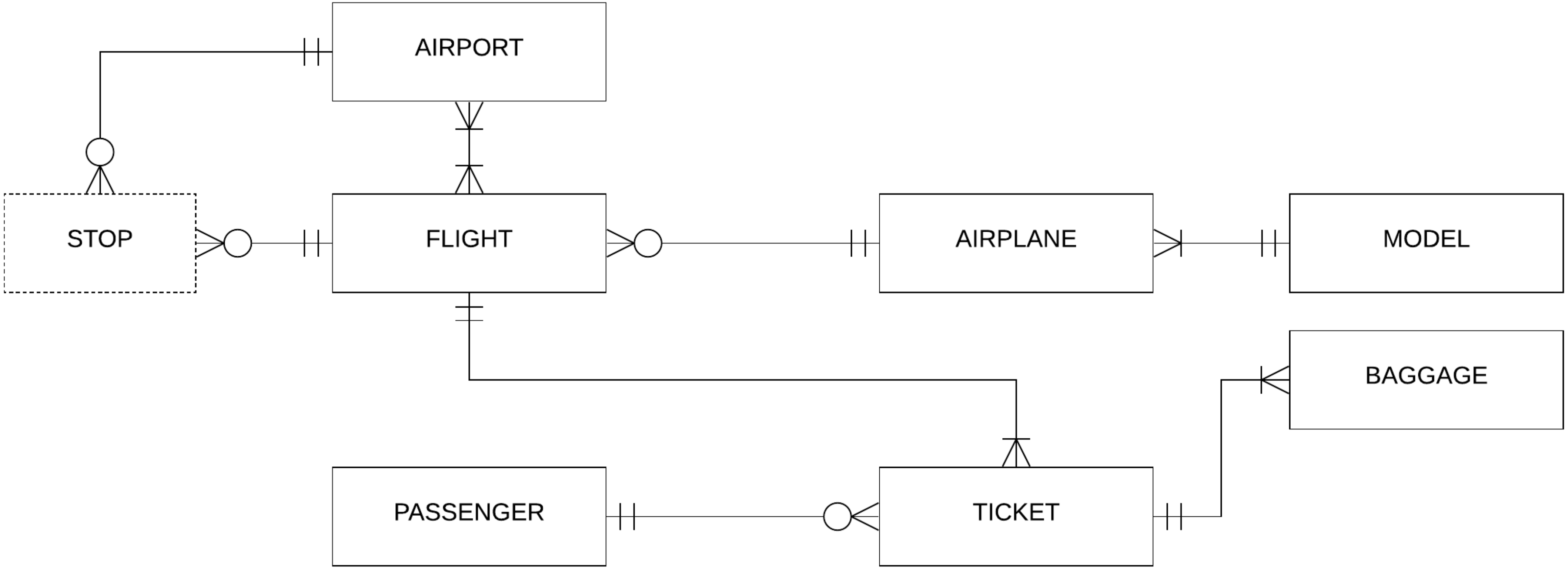
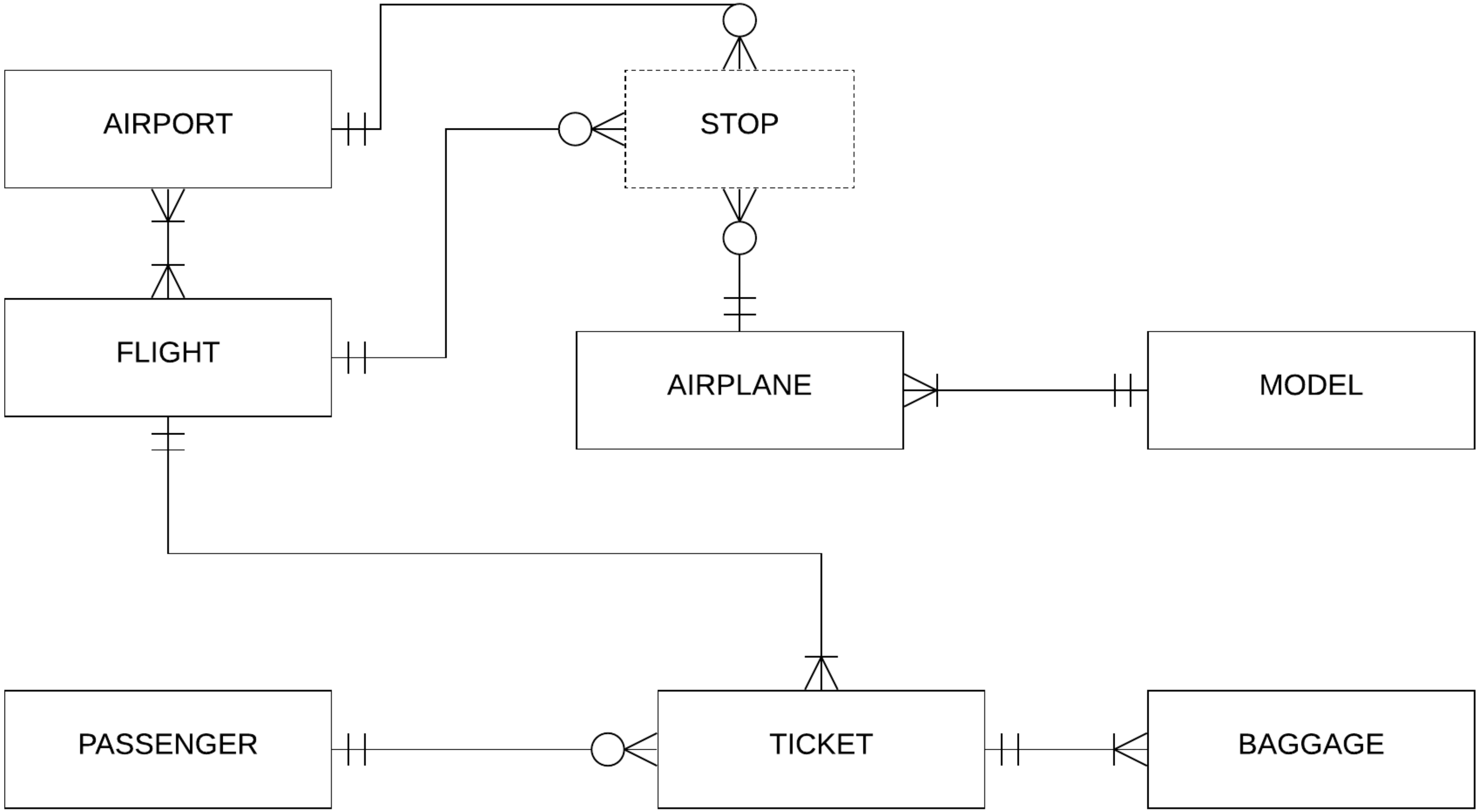
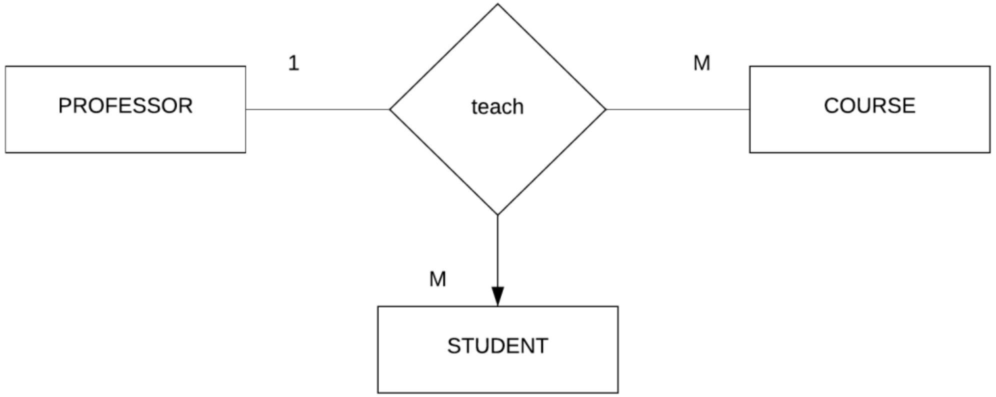

AIRPORT
STOP
FLIGHT
AIRPLANE
MODEL
BAGGAGE
PASSENGER
TICKET


AIRPORT
STOP
FLIGHT
AIRPLANE
MODEL
PASSENGER
TICKET
BAGGAGE

Ternary relationships

- Relationship binding simultaneously 3 entities.



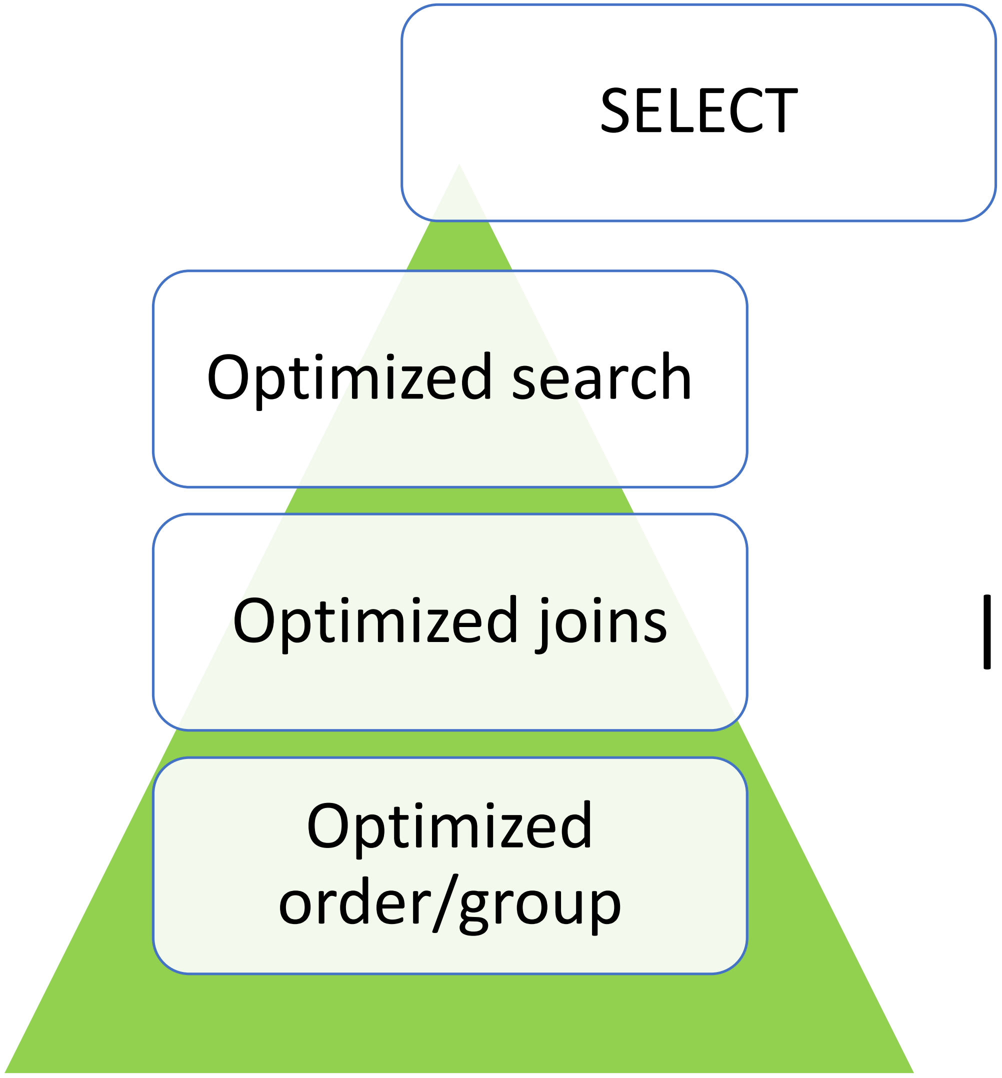
Indexes

Indexes

- Maps search key to data using specific data structures.

- Optimized search.
- Optimized joins (lookup in more than one table)
- Optimized order/group

- slower DML (insert and update operations).
- extra memory



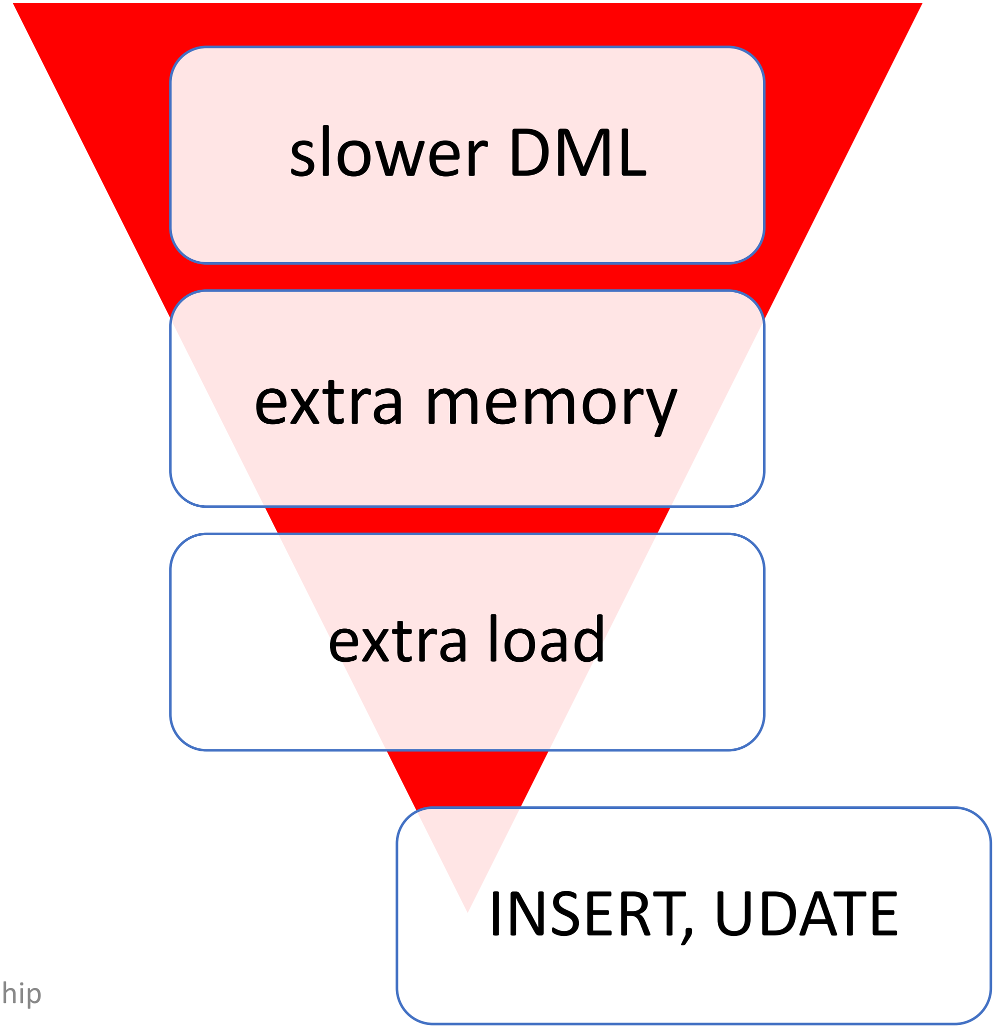
SELECT

Optimized search

Optimized joins

Optimized order/group

Index



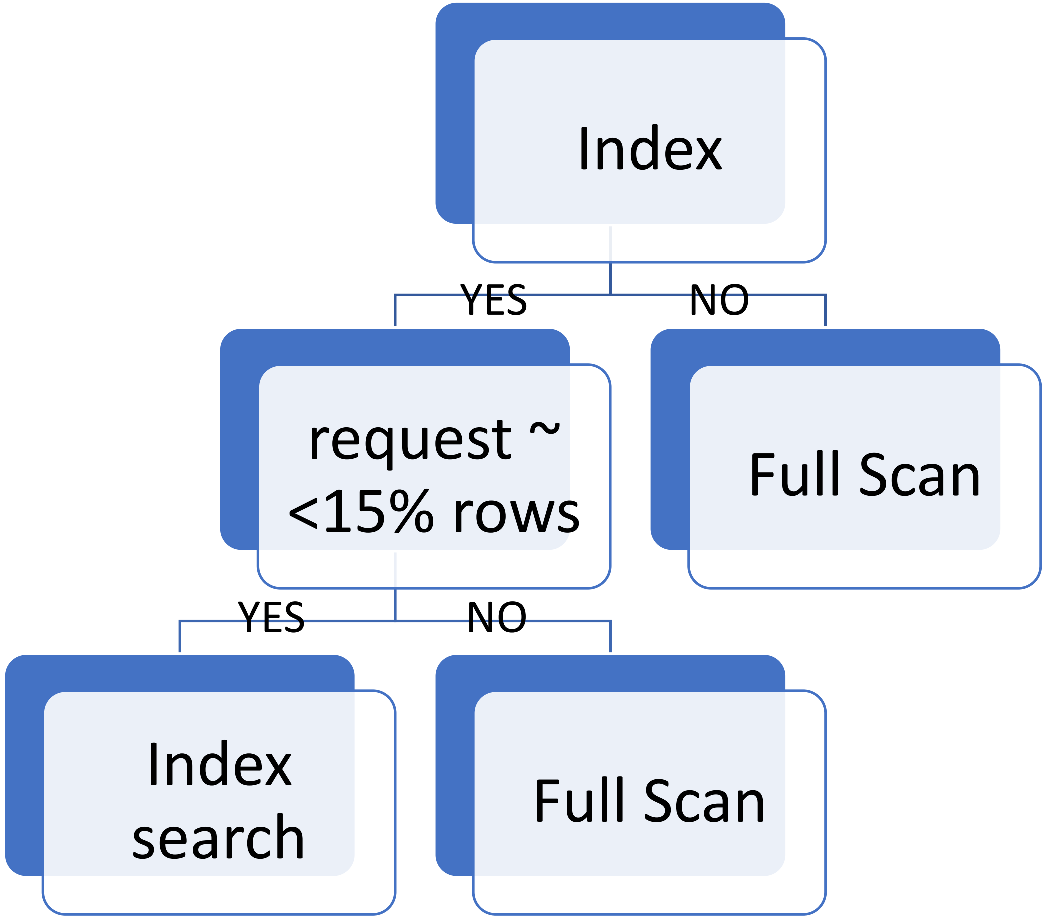
slower DML

extra memory

extra load

INSERT, UDATE

Sql Optimizer



Autogenerated columns

- MySQL auto-generated index (key):
  - DB_ROW_ID increases monotonically as new rows are inserted.
  - DB_ROLL_PTR roll pointer, points to log record.
  - DB_TRX_ID last transaction that updated or inserted the row.

- Oracle rowid:
  - Pseudo column 18 characters = 10 + 4 + 4 (block, row, file).
  - Store and return row address in hexadecimal format (string).
  - Unique identifier for each row.
  - Immutable.

Autogenerated columns

- Oracle rowid:
  - Used in where clause to select/update/delete a row.

- Oracle rownum:
  - Sequential number in which oracle has fetched the row, before ordering the result
  - Temporary generated along with a select statement.

- Mongo
  - ObjectID (timestamp 4Bytes + random 5Bytes + Count 3Bytes.

Index

- Data structure that optimize search.
- Automatically created when a primary key is defined.

MySQL

```
SHOW EXTENDED INDEX FROM index_test;
```

Oracle

```
select * from user_indexes
where table_name = 'INDEX_TEST';
```

Primay key

- Constraint imposed on insert/update behavior.
- NotNull & Unique.

MySQL

```
select * from  information_schema.statistics
where table_name = 'index_test1’
        and index_name = 'primary';
```

Oracle

```
select * from user_constraints
where table_name = 'INDEX_TEST';
```

Index types

Clustered index (SqlServer, MySql)

- Defines the order in which data is physically stored in a table. (index on column semester)
- Only one clustered index on a table (data can be stored in only one order)
- A cluster index is created automatically when a primary key is defined.
- No second data structure for the table

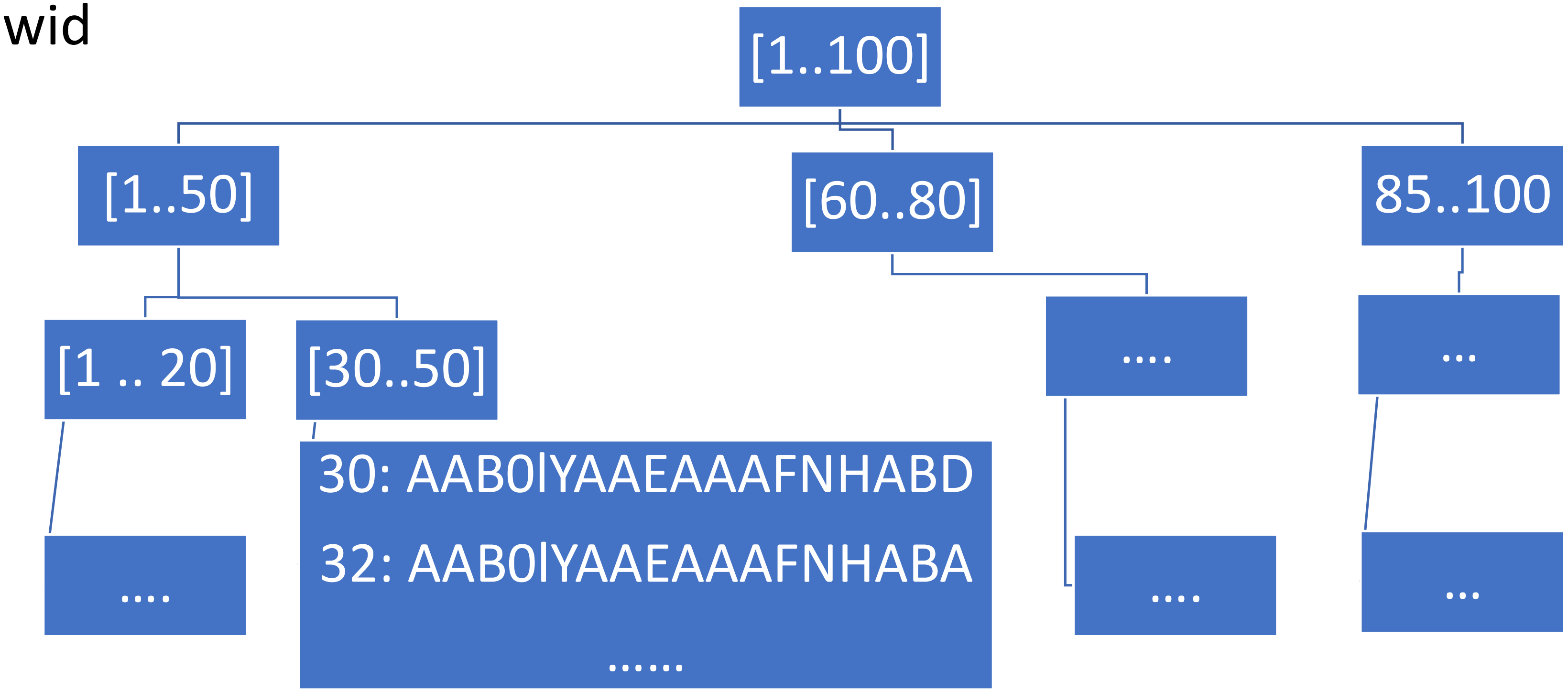
- Oracle: IOT index organized tables. Table is stored in a B-tree structure. (key and non-keys column are stored in leafs)

B – Tree

- B -- Balanced tree.
- Default index type in Oracle.
- Two types of nodes: branch blocks and leaf blocks.
- Branch blocks pointers to lower levels.
- Leaf blocks contain rowids/physical address.
- The number of blocks traversed in order to reach a leaf block is the same for each leaf block.

B – Tree

- create index idx_emp_id on employees(employee_id).
    - Devide employee_id values in sorted ranges.
    - Leafs nodes store rowid



Reverse index

- B – tree where keys are in reverse order. Key 4573 is stored 3754.
- Optimized insert operations.
- Key 4573 will be stored in the same block with key 9573

  while 4574 will be stored in a different block.

Bitmap index

- Used for columns with limited number of distinct values.
- Example: language proficiency levels (en)

emp_id	en	fr
1	A1	B1
2	A2	B2
3	C1	A1
4	A1	B1
5	A1	

row_id	A1	A2	B1	B2	C1	C2
AAB0lYAAEAAAFNHABD	1	0	0	0	0	0
AAB0lYAAEAAAFNHABV	0	1	0	0	0	0
AAB0lYAAEAAAFNHABX	0	0	0	0	1	0
AAB0lYAAEAAAFNHAAv	1	0	0	0	0	0
AAB0lYAAEAAAFNHAAV	1	0	0	0	0	0