BHARAT SCHOOL OF BANKING- VELLORE-1
DATABASE MANAGEMENT SYSTEM

Overview of Database

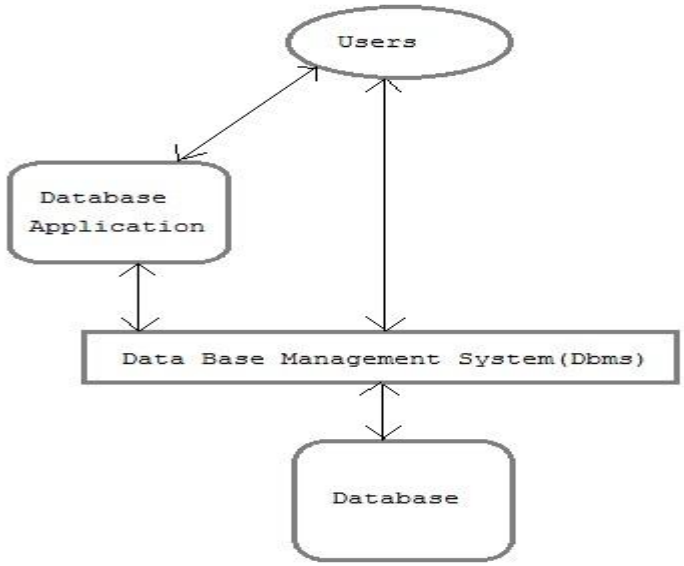
A **Database** is a collection of related data organised in a way that data can be easily accessed, managed and updated. Any piece of information can be a data, for example name of your school. Database is actualy a place where related piece of information is stored and various operations can be performed on it.

DBMS

A **DBMS** is a software that allows creation, definition and manipulation of database. Dbms is actualy a tool used to perform any kind of operation on data in database. Dbms also provides protection and security to database. It maintains data consistency in case of multiple users. Here are some examples of popular dbms, MySql, Oracle, Sybase, Microsoft Access and IBM DB2 etc.

Components of Database System

The database system can be divided into four components.



- **Users :** Users may be of various type such as DB administrator, System developer and End users.

- **Database application :** Database application may be Personal, Departmental, Enterprise and Internal
- **DBMS :** Software that allow users to define, create and manages database access, Ex: MySql, Oracle etc.
- **Database :** Collection of logical data.

Functions of DBMS

- Provides data Independence
- Concurrency Control
- Provides Recovery services
- Provides Utility services
- Provides a clear and logical view of the process that manipulates data.

Advantages of DBMS

- Segregation of applicaion program.
- Minimal data duplicacy.
- Easy retrieval of data.
- Reduced development time and maintainance need.

Disadvantages of DBMS

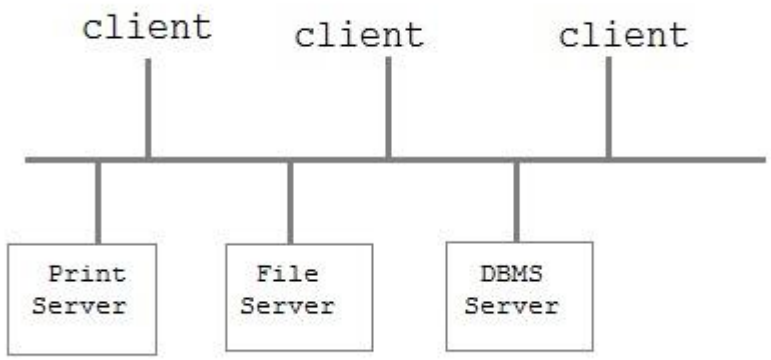
- Complexity
- Costly
- Large in size

Database Architecture

Database architecture is logically divided into two types.

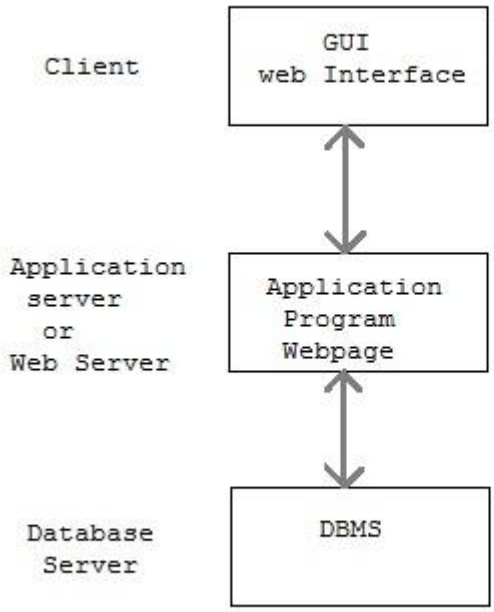
1. Logical two-tier Client / Server architecture
2. Logical three-tier Client / Server architecture

Two-tier Client / Server Architecture



Two-tier Client / Server architecture is used for User Interface program and Application Programs that runs on client side. An interface called ODBC(Open Database Connectivity) provides an API that allow client side program to call the dbms. Most DBMS vendors provide ODBC drivers. A client program may connect to several DBMS's. In this architecture some variation of client is also possible for example in some DBMS's more functionality is transferred to the client including data dictionary, optimization etc. Such clients are called **Data server**.

Three-tier Client / Server Architecture



Three-tier Client / Server database architecture is commonly used architecture for web applications. Intermediate layer called **Application server** or Web Server stores the web connectivty software and the business logic(constraints) part of application used to access the right amount of data from the database server. This layer acts like medium for sending partially processed data between the database server and the client.

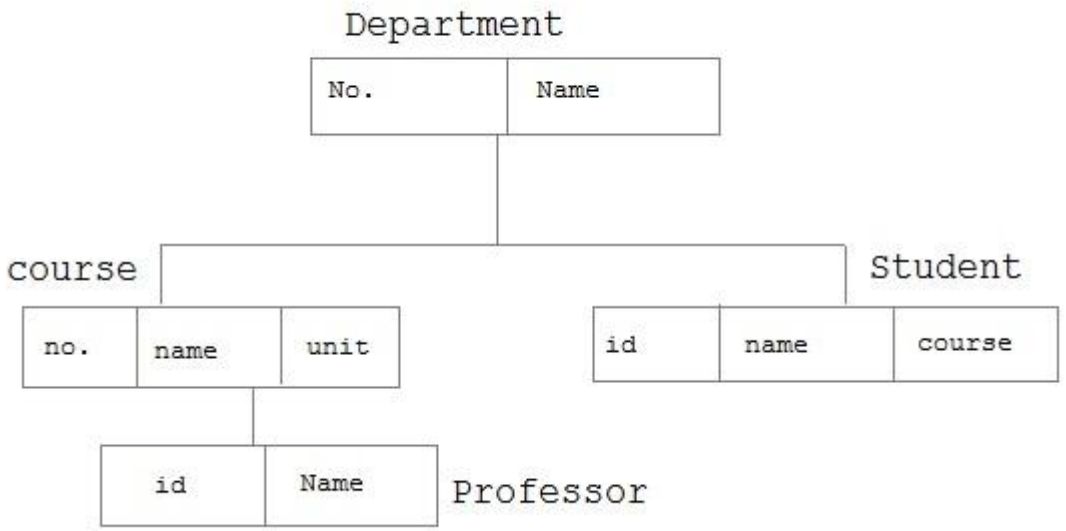
Database Model

A Database model defines the logical design of data. The model describes the relationships between different parts of the data. Historically, in database design, three models are commonly used. They are,

- Hierarchical Model
- Network Model
- Relational Model

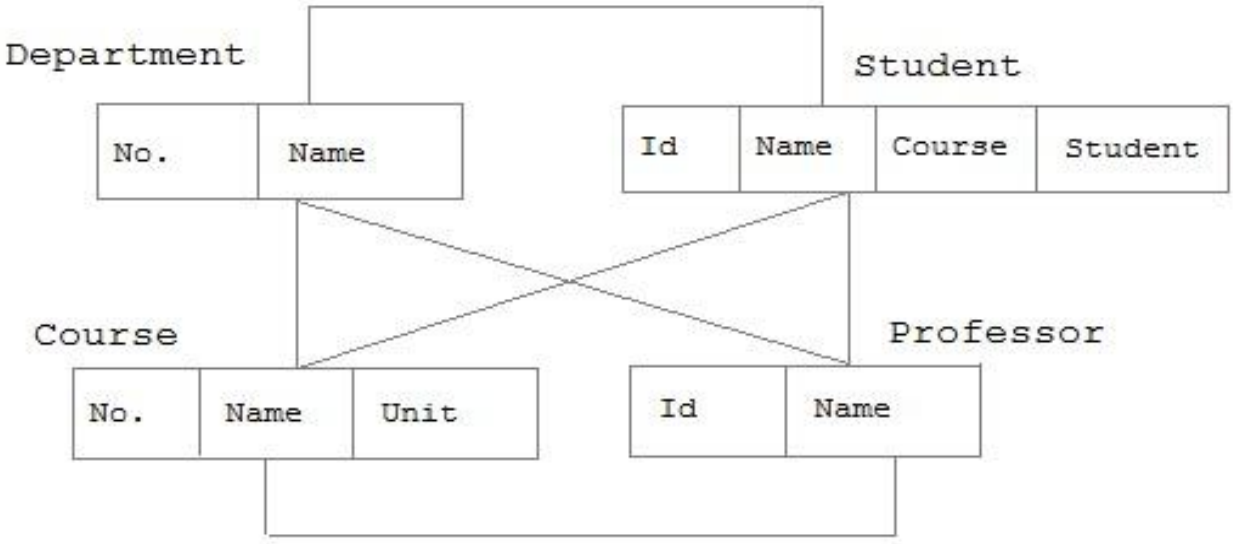
Hierarchical Model

In this model each entity has only one parent but can have several children . At the top of hierarchy there is only one entity which is called **Root**.



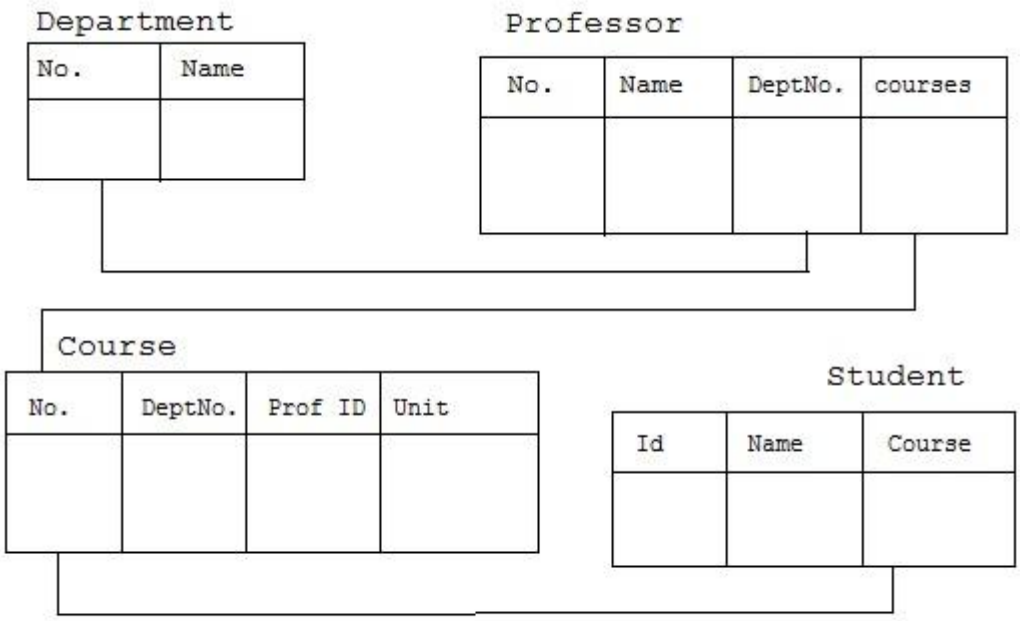
Network Model

In the network model, entities are organised in a graph,in which some entities can be accessed through several path



Relational Model

In this model, data is organised in two-dimesional tables called **relations**. The tables or relation are related to each other.



Codd's Rule

E.F Codd was a Computer Scientist who invented **Relational model** for Database management. Based on relational model, **Relation database** was created. Codd proposed 13 rules popularly known as **Codd's 12 rules** to test DBMS's concept against his relational model. Codd's rule actualy define what quality a DBMS requires in order to become a Relational Database Management System(RDBMS). Till now, there is hardly any commercial product that follows all the 13 Codd's rules. Even **Oracle** follows only eight and half out(8.5) of 13. The Codd's 12 rules are as follows.

Rule zero

This rule states that for a system to qualify as an **RDBMS**, it must be able to manage database entirely through the relational capabilities.

Rule 1 : Information rule

All information(including metadata) is to be represented as stored data in cells of tables. The rows and columns have to be strictly unordered.

Rule 2 : Guaranted Access

Each unique piece of data(atomic value) should be accesible by : **Table Name + primary key(Row) + Attribute(column)**.

NOTE : Ability to directly access via POINTER is a violation of this rule.

Rule 3 : Systemetic treatment of NULL

Null has several meanings, it can mean missing data, not applicable or no value. It should be handled consistently. Primary key must not be null. Expression on **NULL** must give null.

Rule 4 : Active Online Catalog

Database dictionary(catalog) must have description of **Database**. Catalog to be governed by same rule as rest of the database. The same query language to be used on catalog as on application database.

Rule 5 : Powerful language

One well defined language must be there to provide all manners of access to data. Example: **SQL**. If a file supporting table can be accessed by any manner except SQL interface, then its a violation to this rule.

Rule 6 : View Updation rule

All view that are theoretically updatable should be updatable by the system.

Rule 7 : Relational Level Operation

There must be Insert, Delete, Update operations at each level of relations. Set operation like Union, Intersection and minus should also be supported.

Rule 8 : Physical Data Independence

The physical storage of data should not matter to the system. If say, some file supporting table were renamed or moved from one disk to another, it should not effect the application.

Rule 9 : Logical Data Independence

If there is change in the logical structure(table structures) of the database the user view of data should not change. Say, if a table is split into two tables, a new view should give result as the join of the two tables. This rule is most difficult to satisfy.

Rule 10 : Integrity Independence

The database should be able to conforce its own integrity rather than using other programs. Key and Check constraints, trigger etc should be stored in Data Dictionary. This also make **RDBMS** independent of front-end.

Rule 11 : Distribution Independence

A database should work properly regardless of its distribution across a network. This lays foundation of distributed database.

Rule 12 : Non subversion rule

If low level access is allowed to a system it should not be able to subvert or bypass integrity rule to change data. This can be achieved by some sort of looking or encryption.

RDBMS Concepts

A **Relational Database management System**(RDBMS) is a database management system based on relational model introduced by E.F Codd. In relational model, data is represented in terms of tuples(rows).

RDBMS is used to manage Relational database. **Relational database** is a collection of organized set of tables from which data can be accessed easily. Relational Database is most commonly used database. It consists of number of tables and each table has its own primary key.

What is Table ?

In Relational database, a **table** is a collection of data elements organised in terms of rows and columns. A table is also considered as convenient representation of **relations**. But a table can have duplicate tuples while a true **relation** cannot have duplicate tuples. Table is the most simplest form of data storage. Below is an example of Employee table.

ID	Name	Age	Salary
1	Adam	34	13000
2	Alex	28	15000
3	Stuart	20	18000
4	Ross	42	19020

What is a Record ?

A single entry in a table is called a **Record** or **Row**. A **Record** in a table represents set of related data. For example, the above **Employee** table has 4 records. Following is an example of single record.

1	Adam	34	13000

What is Field ?

A table consists of several records(row), each record can be broken into several smaller entities known as **Fields**. The above **Employee** table consist of four fields, **ID**, **Name**, **Age** and **Salary**.

What is a Column ?

In **Relational** table, a column is a set of value of a particular type. The term **Attribute** is also used to represent a column. For example, in Employee table, Name is a column that represent names of employee.

Name
Adam
Alex
Stuart
Ross

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DATABASE MANAGEMENT SYSTEM

Database Keys

Keys are very important part of Relational database. They are used to establish and identify relation between tables. They also ensure that each record within a table can be uniquely identified by combination of one or more fields within a table.

Super Key

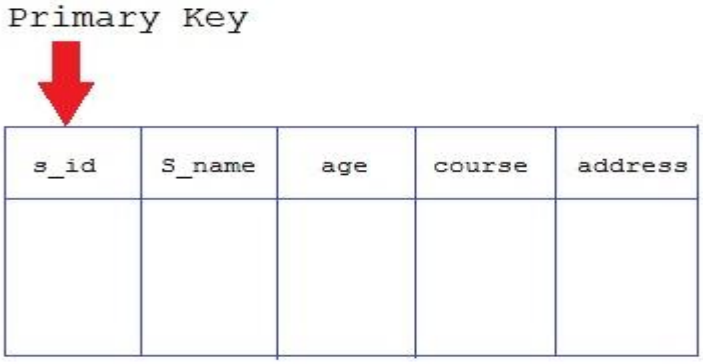
Super Key is defined as a set of attributes within a table that uniquely identifies each record within a table. Super Key is a superset of Candidate key.

Candidate Key

Candidate keys are defined as the set of fields from which primary key can be selected. It is an attribute or set of attribute that can act as a primary key for a table to uniquely identify each record in that table.

Primary Key

Primary key is a candidate key that is most appropriate to become main key of the table. It is a key that uniquely identify each record in a table.



Composite Key

Key that consist of two or more attributes that uniquely identify an entity occurance is called **Composite key**. But any attribute that makes up the **Composite key** is not a simple key in its own.

Secondary or Alternative key

The candidate key which are not selected for primary key are known as secondary keys or alternative keys

Non-key Attribute

Non-key attributes are attributes other than **candidate key** attributes in a table.

Non-prime Attribute

Non-prime Attributes are attributes other than **Primary attribute**.

Normalization of Database

Database Normalisation is a technique of organizing the data in the database. Normalization is a systematic approach of decomposing tables to eliminate data redundancy and undesirable characteristics like Insertion, Update and Deletion Anamolies. It is a multi-step process that puts data into tabular form by removing duplicated data from the relation tables.

Normalization is used for mainly two purpose,

- Eliminating reduntant(useless) data.
- Ensuring data dependencies make sense i.e data is logically stored.

Problem Without Normalization

Without Normalization, it becomes difficult to handle and update the database, without facing data loss. Insertion, Updation and Deletion Anamolies are very frequent if Database is not Normalized. To understand these anomalies let us take an example of **Student** table.

S_id	S_Name	S_Address	Subject_opted
401	Adam	Noida	Bio
402	Alex	Panipat	Maths
403	Stuart	Jammu	Maths
404	Adam	Noida	Physics

- **Updation Anamoly :** To update address of a student who occurs twice or more than twice in a table, we will have to update **S_Address** column in all the rows, else data will become inconsistent.
- **Insertion Anamoly :** Suppose for a new admission, we have a Student id(S_id), name and address of a student but if student has not opted for any subjects yet then we have to insert **NULL** there, leading to Insertion Anamoly.
- **Deletion Anamoly :** If (S_id) 401 has only one subject and temporarily he drops it, when we delete that row, entire student record will be deleted along with it.

Normalization Rule

Normalization rule are divided into following normal form.

1. First Normal Form
2. Second Normal Form
3. Third Normal Form
4. BCNF

First Normal Form (1NF)

As per First Normal Form, no two Rows of data must contain repeating group of information i.e each set of column must have a unique value, such that multiple columns cannot be used to fetch the same row. Each table should be organized into rows, and each row should have a primary key that distinguishes it as unique.

The **Primary key** is usually a single column, but sometimes more than one column can be combined to create a single primary key. For example consider a table which is not in First normal form

Student Table :

Student	Age	Subject
Adam	15	Biology, Maths
Alex	14	Maths
Stuart	17	Maths

In First Normal Form, any row must not have a column in which more than one value is saved, like separated with commas. Rather than that, we must separate such data into multiple rows.

Student Table following 1NF will be :

Student	Age	Subject
Adam	15	Biology
Adam	15	Maths
Alex	14	Maths
Stuart	17	Maths

Using the First Normal Form, data redundancy increases, as there will be many columns with same data in multiple rows but each row as a whole will be unique.

Second Normal Form (2NF)

As per the Second Normal Form there must not be any partial dependency of any column on primary key. It means that for a table that has concatenated primary key, each column in the table that is not part of the primary key must depend upon the entire concatenated key for its existence. If any column depends only on one part of the concatenated key, then the table fails **Second normal form**.

In example of First Normal Form there are two rows for Adam, to include multiple subjects that he has opted for. While this is searchable, and follows First normal form, it is an inefficient use of space. Also in the above Table in First Normal Form, while the candidate key is {**Student**, **Subject**}, **Age** of Student only depends on Student column, which is incorrect as per Second Normal Form. To achieve second normal form, it would be helpful to split out the subjects into an independent table, and match them up using the student names as foreign keys.

New Student Table following 2NF will be :

Student	**Age**
Adam	15
Alex	14
Stuart	17

In Student Table the candidate key will be **Student** column, because all other column i.e **Age** is dependent on it.

New Subject Table introduced for 2NF will be :

Student	**Subject**
Adam	Biology

Adam	Maths
Alex	Maths
Stuart	Maths

In Subject Table the candidate key will be {**Student**, **Subject**} column. Now, both the above tables qualifies for Second Normal Form and will never suffer from Update Anomalies. Although there are a few complex cases in which table in Second Normal Form suffers Update Anomalies, and to handle those scenarios Third Normal Form is there.

Third Normal Form (3NF)

Third Normal form applies that every non-prime attribute of table must be dependent on primary key, or we can say that, there should not be the case that a non-prime attribute is determined by another non-prime attribute. So this *transitive functional dependency* should be removed from the table and also the table must be in **Second Normal form**. For example, consider a table with following fields.

Student_Detail Table :

Student_id	Student_name	DOB	Street	city	State	Zip

In this table Student_id is Primary key, but street, city and state depends upon Zip. The dependency between zip and other fields is called **transitive dependency**. Hence to apply **3NF**, we need to move the street, city and state to new table, with **Zip** as primary key.

New Student_Detail Table :

Student_id	Student_name	DOB	Zip

Address Table :

Zip	Street	city	state

The advantage of removing transtive dependency is,

- Amount of data duplication is reduced.
- Data integrity achieved.

Boyce and Codd Normal Form (BCNF)

Boyce and Codd Normal Form is a higher version of the Third Normal form. This form deals with certain type of anamoly that is not handled by 3NF. A 3NF table which does not have multiple overlapping candidate keys is said to be in BCNF. For a table to be in BCNF, following conditions must be satisfied:

- R must be in 3rd Normal Form
- and, for each functional dependency (X -> Y), X should be a super Key.

Consider the following relationship : **R (A,B,C,D)**

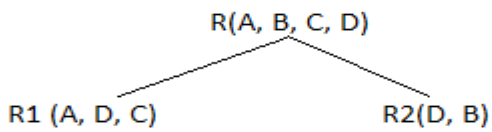
and following dependencies :

A -> BCD
BC -> AD
D -> B

Above relationship is already in 3rd NF. Keys are **A** and **BC**.

Hence, in the functional dependency, **A -> BCD**, A is the super key.
in second relation, **BC -> AD**, BC is also a key.
but in, **D -> B**, D is not a key.

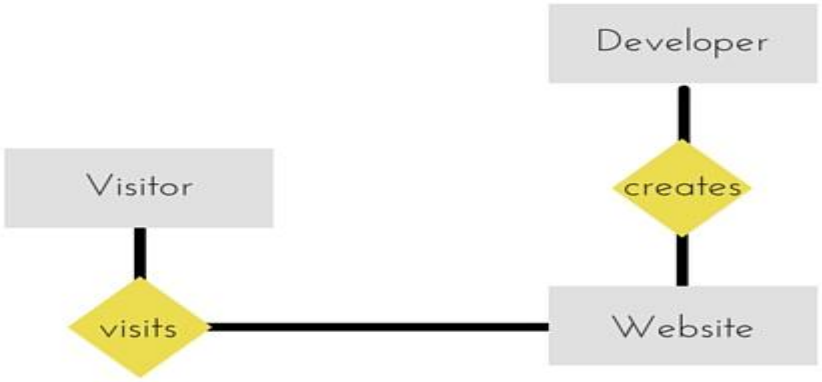
Hence we can break our relationship R into two relationships **R1** and **R2**.



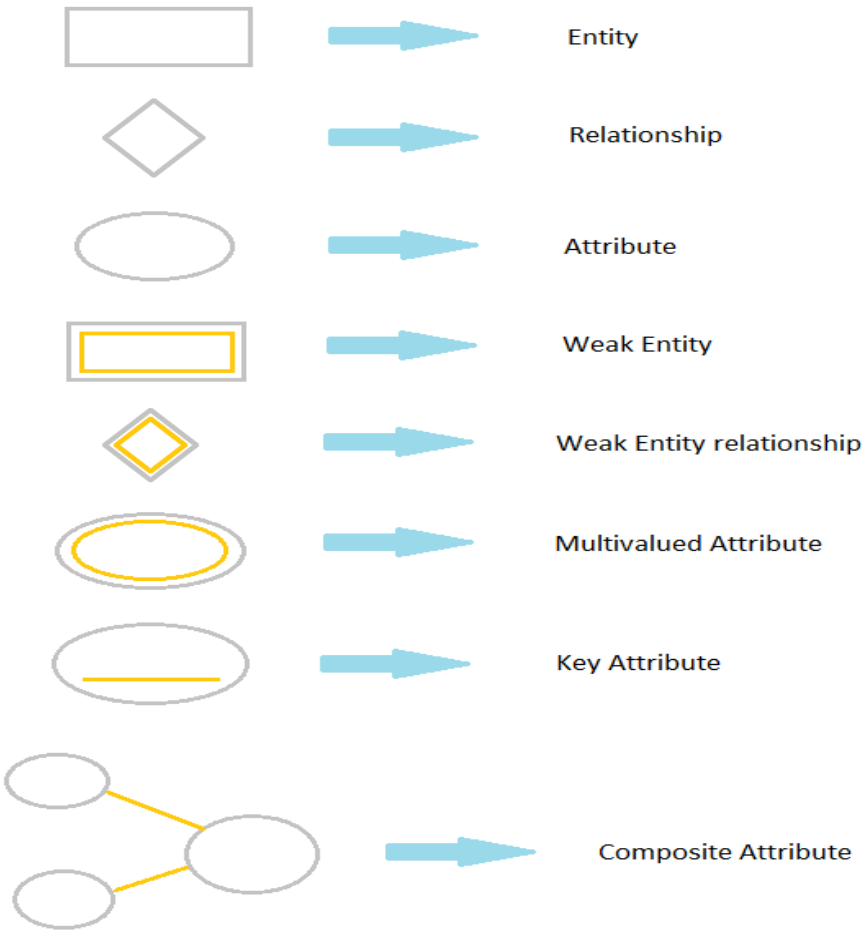
Breaking, table into two tables, one with A, D and C while the other with D and B.

E-R Diagram

ER-Diagram is a visual representation of data that describes how data is related to each other.



Symbols and Notations



Components of E-R Diagram

The E-R diagram has three main components.

1) Entity

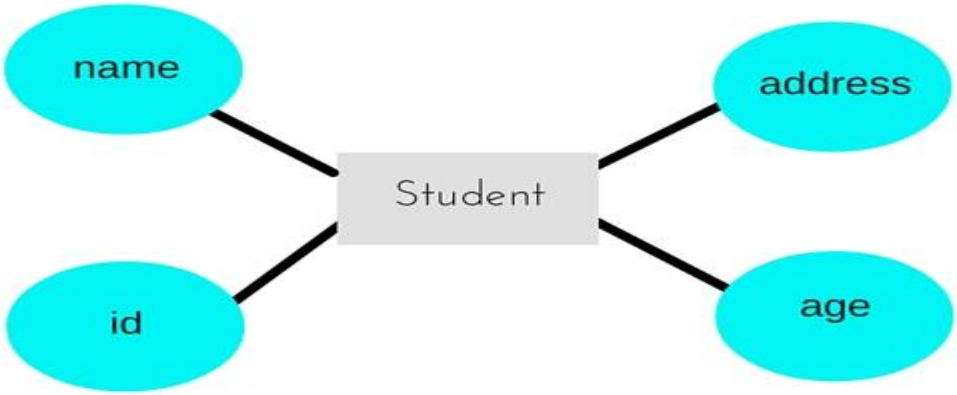
An **Entity** can be any object, place, person or class. In E-R Diagram, an **entity** is represented using rectangles. Consider an example of an Organisation. Employee, Manager, Department, Product and many more can be taken as entities from an Organisation.

Weak Entity

Weak entity is an entity that depends on another entity. Weak entity doen't have key attribute of their own. Double rectangle represents weak entity.

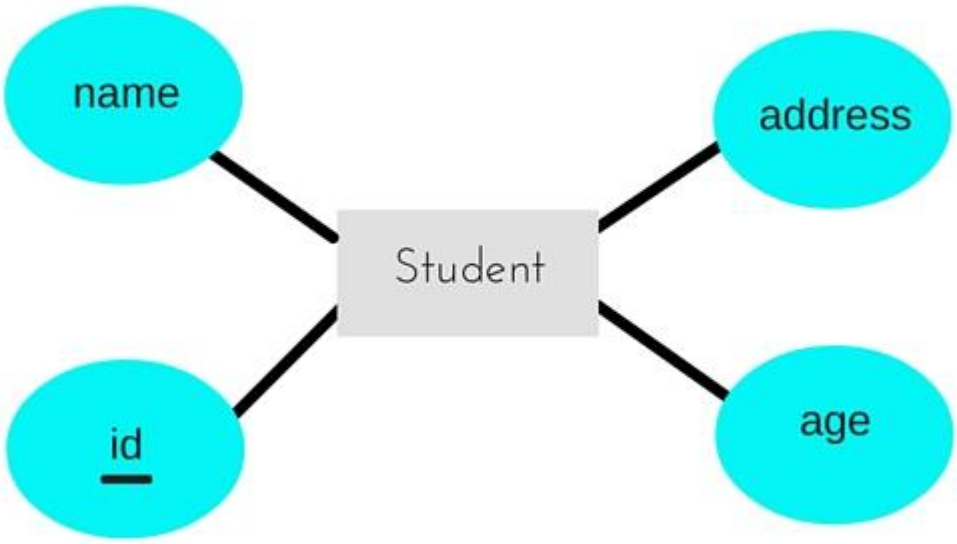
2) Attribute

An **Attribute** describes a property or characterstic of an entity. For example, Name, Age, Address etc can be attributes of a Student. An attribute is represented using eclipse.



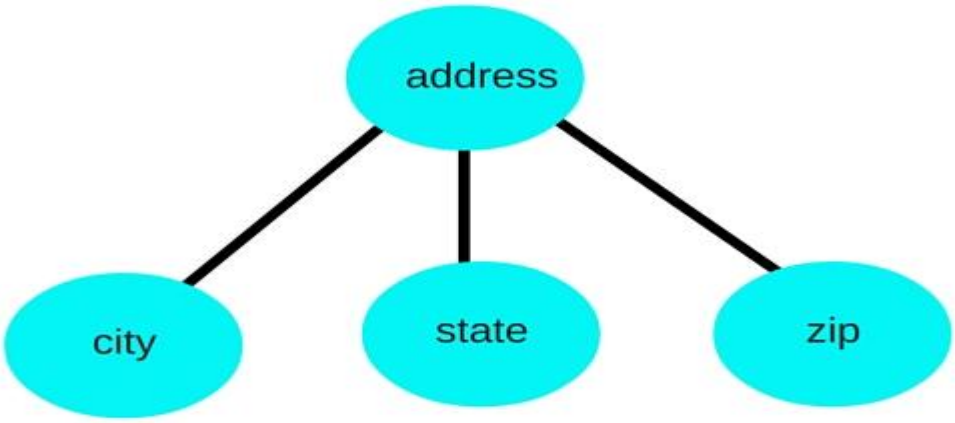
Key Attribute

Key attribute represents the main characterstic of an Entity. It is used to represent Primary key. Ellipse with underlying lines represent Key Attribute.



Composite Attribute

An attribute can also have their own attributes. These attributes are known as **Composite** attribute.



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3) Relationship

A Relationship describes relations between **entities**. Relationship is represented using diamonds.

There are three types of relationship that exist between Entities.

- Binary Relationship
- Recursive Relationship
- Ternary Relationship

Binary Relationship

Binary Relationship means relation between two Entities. This is further divided into three types.

1. **One to One :** This type of relationship is rarely seen in real world.

The above example describes that one student can enroll only for one course and a course will also have only one Student. This is not what you will usually see in relationship.

2. **One to Many :** It reflects business rule that one entity is associated with many number of same entity. The example for this relation might sound a little weird, but this menas that one student can enroll to many courses, but one course will have one Student.

The arrows in the diagram describes that one student can enroll for only one course.

3. **Many to One :** It reflects business rule that many entities can be associated with just one entity. For example, Student enrolls for only one Course but a Course can have many Students.

4. **Many to Many :**

The above diagram represents that many students can enroll for more than one courses.

Recursive Relationship

When an Entity is related with itself it is known as **Recursive** Relationship.

Ternary Relationship

Relationship of degree three is called Ternary relationship.

Generalization

Generalization is a bottom-up approach in which two lower level entities combine to form a higher level entity. In generalization, the higher level entity can also combine with other lower level entity to make further higher level entity.

Introduction to SQL

Structure Query Language(SQL) is a programming language used for storing and managing data in RDBMS. SQL was the first commercial language introduced for E.F Codd's **Relational** model. Today almost all RDBMS(MySql, Oracle, Infomix, Sybase, MS Access) uses **SQL** as the standard database language. SQL is used to perform all type of data operations in RDBMS.

SQL Command

SQL defines following data languages to manipulate data of RDBMS.

DDL : Data Definition Language

All DDL commands are auto-committed. That means it saves all the changes permanently in the database.

Command	Description
create	to create new table or database
alter	for alteration

truncate	delete data from table
drop	to drop a table
rename	to rename a table

DML : Data Manipulation Language

DML commands are not auto-committed. It means changes are not permanent to database, they can be rolled back.

Command	Description
insert	to insert a new row
update	to update existing row
delete	to delete a row
merge	merging two rows or two tables

TCL : Transaction Control Language

These commands are to keep a check on other commands and their affect on the database. These commands can annul changes made by other commands by rolling back to original state. It can also make changes permanent.

Command	Description
commit	to permanently save

rollback	to undo change
savepoint	to save temporarily

DCL : Data Control Language

Data control language provides command to grant and take back authority.

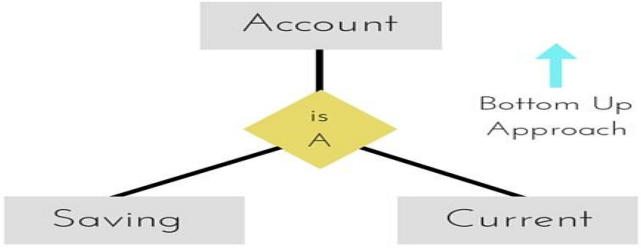
Command	Description
grant	grant permission of right
revoke	take back permission.

DQL : Data Query Language

Command	Description
select	retrieve records from one or more table

Generalization

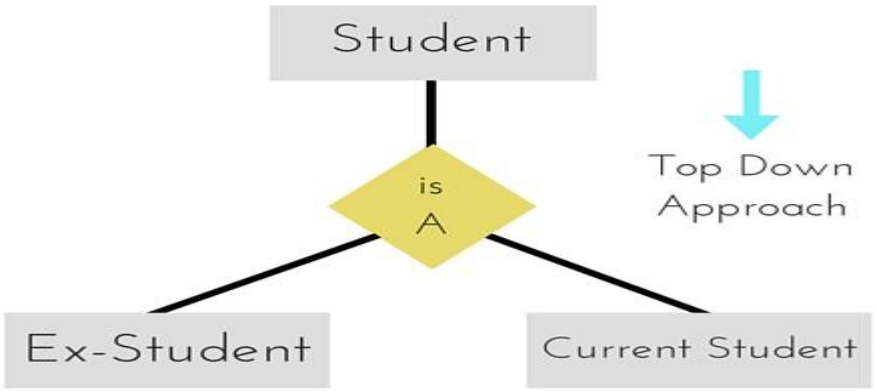
Generalization is a bottom-up approach in which two lower level entities combine to form a higher level entity. In generalization, the higher level entity can also combine with other lower level entit



y to make further higher level entity.

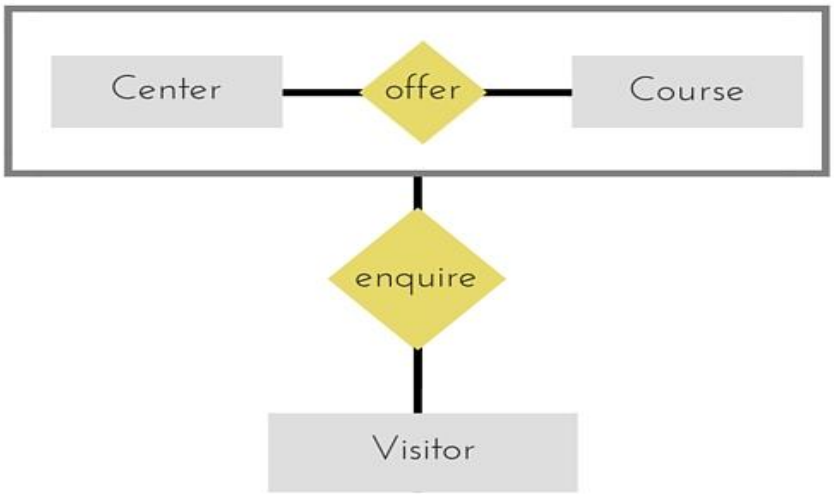
Specialization

Specialization is opposite to Generalization. It is a top-down approach in which one higher level entity can be broken down into two lower level entity. In specialization, some higher level entities may not have lower-level entity sets at all.



Aggregration

Aggregration is a process when relation between two entity is treated as a single entity. Here the relation between Center and Course, is acting as an Entity in relation with Visitor.



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TCL command

Transaction Control Language(TCL) commands are used to manage transactions in database.These are used to manage the changes made by DML statements. It also allows statements to be grouped together into logical transactions.

Commit command

Commit command is used to permanently save any transaaction into database.

Following is Commit command's syntax,

commit;

Rollback command

This command restores the database to last commited state. It is also use with savepoint command to jump to a savepoint in a transaction.

Following is Rollback command's syntax,

rollback to *savepoint-name*;

Savepoint command

savepoint command is used to temporarily save a transaction so that you can rollback to that point whenever necessary.

Following is savepoint command's syntax,

savepoint *savepoint-name*;

Example of Savepoint and Rollback

Following is the **class** table,

ID	NAME
1	abhi
2	adam
4	alex

Lets use some SQL queries on the above table and see the results.

INSERT into class values(5,'Rahul');

commit;

UPDATE class set name='abhijit' where id='5';

savepoint **A**;

INSERT into class values(6,'Chris');

savepoint **B**;

INSERT into class values(7,'Bravo');

savepoint **C**;

SELECT * from class;

The resultant table will look like,

ID	NAME
1	abhi

2	adam
4	alex
5	abhijit
6	chris
7	bravo

Now **rollback** to **savepoint B**

rollback to B;

SELECT * from class;

The resultant table will look like

ID	**NAME**
1	abhi
2	adam
4	alex
5	abhijit
6	chris

Now **rollback** to **savepoint A**

rollback to A;

SELECT * from class;

The result table will look like

ID	NAME
1	abhi
2	adam
4	alex
5	abhijit

Functional Dependency

Functional dependency (FD) is a set of constraints between two attributes in a relation. Functional dependency says that if two tuples have same values for attributes A1, A2,..., An, then those two tuples must have to have same values for attributes B1, B2, ..., Bn.

Functional dependency is represented by an arrow sign (→) that is, X→Y, where X functionally determines Y. The left-hand side attributes determine the values of attributes on the right-hand side.

Armstrong's Axioms

If F is a set of functional dependencies then the closure of F, denoted as F^+, is the set of all functional dependencies logically implied by F. Armstrong's Axioms are a set of rules, that when applied repeatedly, generates a closure of functional dependencies.

- **Reflexive rule** − If alpha is a set of attributes and beta is_subset_of alpha, then alpha holds beta.
- **Augmentation rule** − If a → b holds and y is attribute set, then ay → by also holds. That is adding attributes in dependencies, does not change the basic dependencies.

- **Transitivity rule** − Same as transitive rule in algebra, if a → b holds and b → c holds, then a → c also holds. a → b is called as a functionally that determines b.

Trivial Functional Dependency

- **Trivial** − If a functional dependency (FD) X → Y holds, where Y is a subset of X, then it is called a trivial FD. Trivial FDs always hold.
- **Non-trivial** − If an FD X → Y holds, where Y is not a subset of X, then it is called a non-trivial FD.
- **Completely non-trivial** − If an FD X → Y holds, where x intersect Y = Φ, it is said to be a completely non-trivial FD.

Normalization

If a database design is not perfect, it may contain anomalies, which are like a bad dream for any database administrator. Managing a database with anomalies is next to impossible.

- **Update anomalies** − If data items are scattered and are not linked to each other properly, then it could lead to strange situations. For example, when we try to update one data item having its copies scattered over several places, a few instances get updated properly while a few others are left with old values. Such instances leave the database in an inconsistent state.
- **Deletion anomalies** − We tried to delete a record, but parts of it was left undeleted because of unawareness, the data is also saved somewhere else.
- **Insert anomalies** − We tried to insert data in a record that does not exist at all.

Normalization is a method to remove all these anomalies and bring the database to a consistent state.

First Normal Form

First Normal Form is defined in the definition of relations (tables) itself. This rule defines that all the attributes in a relation must have atomic domains. The values in an atomic domain are indivisible units.

Course	Content
Programming	Java, c++
Web	HTML, PHP, ASP

We re-arrange the relation (table) as below, to convert it to First Normal Form.

Course	Content
Programming	Java
Programming	c++
Web	HTML
Web	PHP
Web	ASP

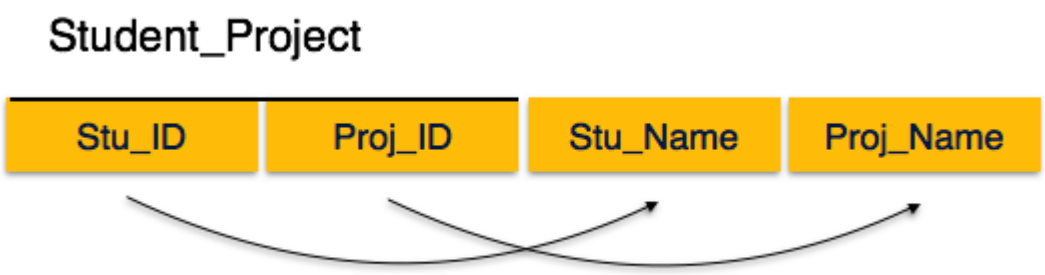
Each attribute must contain only a single value from its pre-defined domain.

Second Normal Form

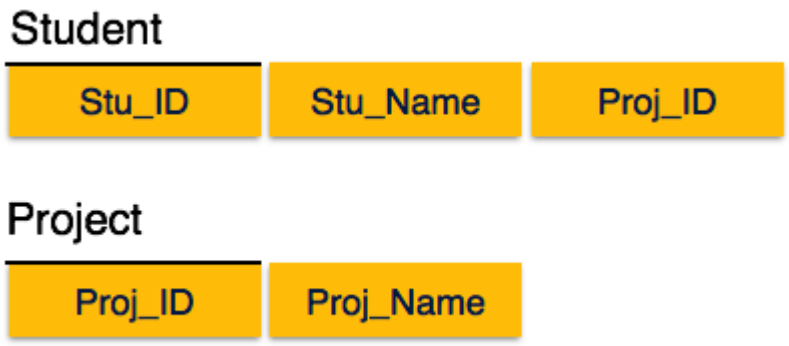
Before we learn about the second normal form, we need to understand the following −

- **Prime attribute** − An attribute, which is a part of the prime-key, is known as a prime attribute.
- **Non-prime attribute** − An attribute, which is not a part of the prime-key, is said to be a non-prime attribute.

If we follow second normal form, then every non-prime attribute should be fully functionally dependent on prime key attribute. That is, if X → A holds, then there should not be any proper subset Y of X, for which Y → A also holds true.



We see here in Student_Project relation that the prime key attributes are Stu_ID and Proj_ID. According to the rule, non-key attributes, i.e. Stu_Name and Proj_Name must be dependent upon both and not on any of the prime key attribute individually. But we find that Stu_Name can be identified by Stu_ID and Proj_Name can be identified by Proj_ID independently. This is called **partial dependency**, which is not allowed in Second Normal Form.



We broke the relation in two as depicted in the above picture. So there exists no partial dependency.

Third Normal Form

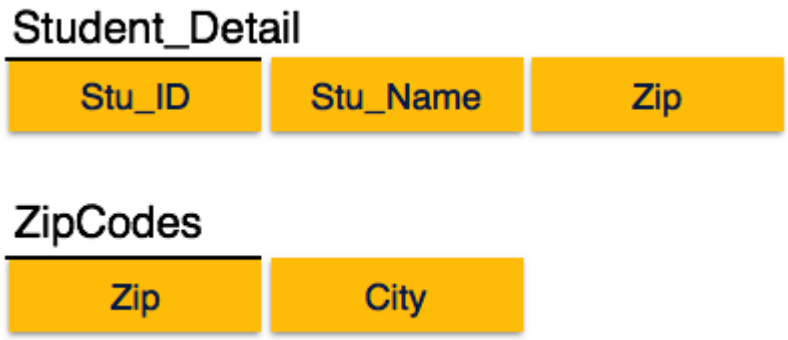
For a relation to be in Third Normal Form, it must be in Second Normal form and the following must satisfy −

- No non-prime attribute is transitively dependent on prime key attribute.
- For any non-trivial functional dependency, X → A, then either −
    - X is a superkey or,
    - A is prime attribute.

We find that in the above Student_detail relation, Stu_ID is the key and only prime key attribute. We find that City can be identified by Stu_ID as well as Zip

itself. Neither Zip is a superkey nor is City a prime attribute. Additionally, Stu_ID → Zip → City, so there exists **transitive dependency**.

To bring this relation into third normal form, we break the relation into two relations as follows −



Boyce-Codd Normal Form

Boyce-Codd Normal Form (BCNF) is an extension of Third Normal Form on strict terms. BCNF states that −

- For any non-trivial functional dependency, X → A, X must be a super-key.

In the above image, Stu_ID is the super-key in the relation Student_Detail and Zip is the super-key in the relation ZipCodes. So,

Stu_ID → Stu_Name, Zip

and

Zip → City

Which confirms that both the relations are in BCNF.

Loss of Volatile Storage

A volatile storage like RAM stores all the active logs, disk buffers, and related data. In addition, it stores all the transactions that are being currently executed. What happens if such a volatile storage crashes abruptly? It would obviously take away all the logs and active copies of the database. It makes recovery almost impossible, as everything that is required to recover the data is lost.

Following techniques may be adopted in case of loss of volatile storage −

- We can have **checkpoints** at multiple stages so as to save the contents of the database periodically.
- A state of active database in the volatile memory can be periodically **dumped** onto a stable storage, which may also contain logs and active transactions and buffer blocks.
- <dump> can be marked on a log file, whenever the database contents are dumped from a non-volatile memory to a stable one.

Recovery

- When the system recovers from a failure, it can restore the latest dump.
- It can maintain a redo-list and an undo-list as checkpoints.
- It can recover the system by consulting undo-redo lists to restore the state of all transactions up to the last checkpoint.

Database Backup & Recovery from Catastrophic Failure

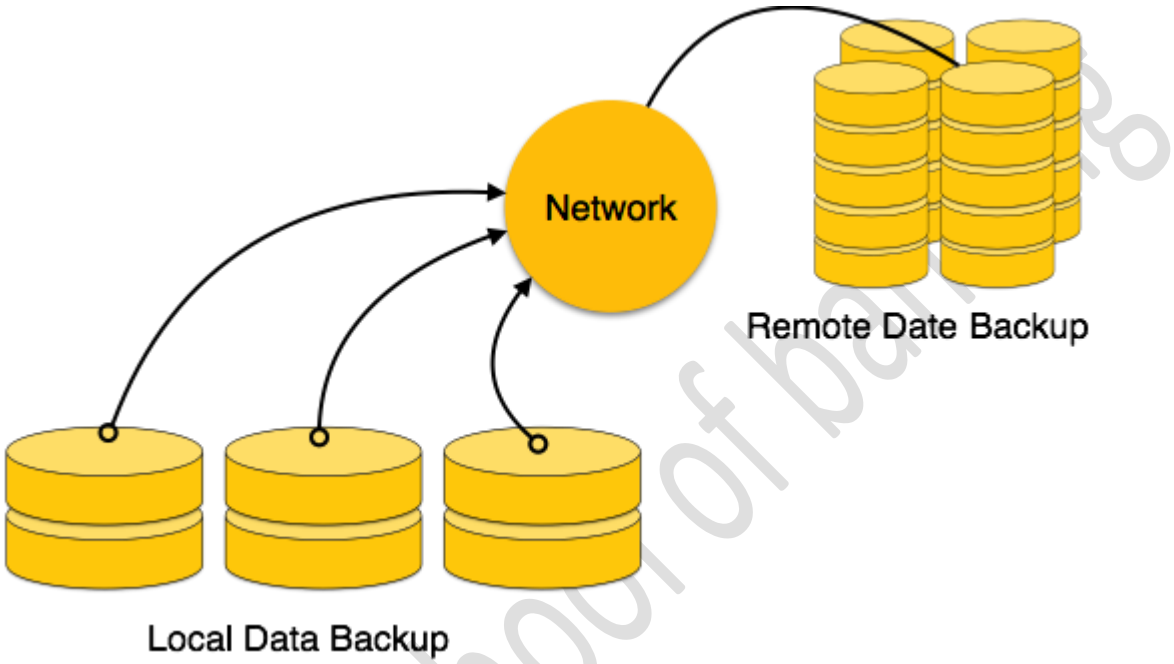
A catastrophic failure is one where a stable, secondary storage device gets corrupt. With the storage device, all the valuable data that is stored inside is lost. We have two different strategies to recover data from such a catastrophic failure −

- Remote backup &minu; Here a backup copy of the database is stored at a remote location from where it can be restored in case of a catastrophe.
- Alternatively, database backups can be taken on magnetic tapes and stored at a safer place. This backup can later be transferred onto a freshly installed database to bring it to the point of backup.

Grown-up databases are too bulky to be frequently backed up. In such cases, we have techniques where we can restore a database just by looking at its logs. So, all that we need to do here is to take a backup of all the logs at frequent intervals of time. The database can be backed up once a week, and the logs being very small can be backed up every day or as frequently as possible.

Remote Backup

Remote backup provides a sense of security in case the primary location where the database is located gets destroyed. Remote backup can be offline or real-time or online. In case it is offline, it is maintained manually.



Online backup systems are more real-time and lifesavers for database administrators and investors. An online backup system is a mechanism where every bit of the real-time data is backed up simultaneously at two distant places. One of them is directly connected to the system and the other one is kept at a remote place as backup.

As soon as the primary database storage fails, the backup system senses the failure and switches the user system to the remote storage. Sometimes this is so instant that the users can't even realize a failure.

o ensure the integrity of data during a transaction (**A transaction is a unit of program that updates various data items, read more about it here**), the database system maintains the following properties. These properties are widely known as ACID properties:

- **Atomicity**: This property ensures that either all the operations of a transaction reflect in database or none. Let's take an example of banking system to understand this: Suppose Account **A** has a balance of 400$

& **B** has 700$. Account **A** is transferring 100$ to Account **B**. This is a transaction that has two operations a) Debiting 100$ from A's balance b) Creating 100$ to B's balance. Let's say first operation passed successfully while second failed, in this case A's balance would be 300$ while B would be having 700$ instead of 800$. This is unacceptable in a banking system. Either the transaction should fail without executing any of the operation or it should process both the operations. The Atomicity property ensures that.

- **Consistency**: To preserve the consistency of database, the execution of transaction should take place in isolation (that means no other transaction should run concurrently when there is a transaction already running). For example account A is having a balance of 400$ and it is transferring 100$ to account B & C both. So we have two transactions here. Let's say these transactions run concurrently and both the transactions read 400$ balance, in that case the final balance of A would be 300$ instead of 200$. This is wrong. If the transaction were to run in isolation then the second transaction would have read the correct balance 300$ (before debiting 100$) once the first transaction went successful.

- **Isolation**: For every pair of transactions, one transaction should start execution only when the other finished execution. I have already discussed the example of Isolation in the Consistency property above.

- **Durability**: Once a transaction completes successfully, the changes it has made into the database should be permanent even if there is a system failure. The recovery-management component of database systems ensures the durability of transaction.