



Group Project

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Part A-Relational Database

1 Chapter 1 - Requirement Analysis

1.1 Functional requirements

Functional requirements refer to the set of actions and capabilities that a database system must possess to meet the project's objectives. These requirements dictate the system's ability to perform specific tasks and establish performance benchmarks for all functional aspects. The key functional requirements for the database system are as follows:

1. **Data Retrieval:** The database system must enable efficient and accurate retrieval of data based on user queries and specified criteria.
2. **Data Modification:** It should provide the capability to modify the content of the database, allowing authorized users to update, insert, or delete records as necessary.
3. **Data Gap Handling:** The system should have the ability to identify and fill in missing data or gaps in the database, ensuring data completeness and accuracy.
4. **Data Modification History:** The system must allow users to track and audit changes made to previously entered data in the database, maintaining a history of revisions.
5. **Commenting Feature:** Users should be able to add comments to data entries, especially when data is missing or questionable. This commenting feature helps in annotating and documenting data quality concerns.
6. **Performance Enhancement:** The database system should be capable of optimizing data access and retrieval processes to ensure improved overall performance.

According to the given mini project topic “Navy”, five entities were selected. They were weapon, ship, service_history, certificate, sailor, rank, department, and base. These eight entities of the Navy database are connected by different relationships. The data spread between those areas can be retrieved by using the database. Also, the above functional requirements are satisfied by this created schema.

1.2 Data requirements

The data requirements of this database can be categorized under 8 Sectors. They are weapon, ship, service_history, certificate, sailor, rank, department and base.

Entity: WEAPON : Attributes

- Weapon_ID
- Ship_ID
- Weapon_Name
- Weight
- Range

Entity: SHIP : Attributes

- Ship_ID
- Ship_Name
- Ship_Type
- Ship_Owner

Entity: CERTIFICATE : Attributes

- Weapon_ID
- Certificate_Name
- Certificate_Type
- Certificate_Date
- Expiration_Date

Entity: DEPARTMENT : Attributes

- Department_ID
- Department_Name
- Department_Email
- Country
- State

Entity: BASE : Attributes

- Base_ID
- Base_Name
- Base_Department
- Country
- State

Entity: SAILER : Attributes

- Sailor_ID
- First_Name
- Last_Name
- Sailor_Department
- Sailor_Ship
- Sailor_Rank
- Sailor_Mentor

Entity: RANK : Attributes

- Rank_ID
- Rank_Name

Entity: SERVICE_HISTORY : Attributes

- Sailor_ID
- Service_Type
- Registration_Date
- Registered_date
- Years_of_Service

Entity: SAILER_CONTACT: Attributes

- Sailor_ID
- Contact_Number

Entity: BASE_CONTACT: Attributes

- Base_ID
- Contact_Number

2 Chapter 2 - Conceptual Design

The Entity – Relationship (ER) diagram of the Navy(Military) schema is drawn using Visual Paradigm tool according to the given instructions.

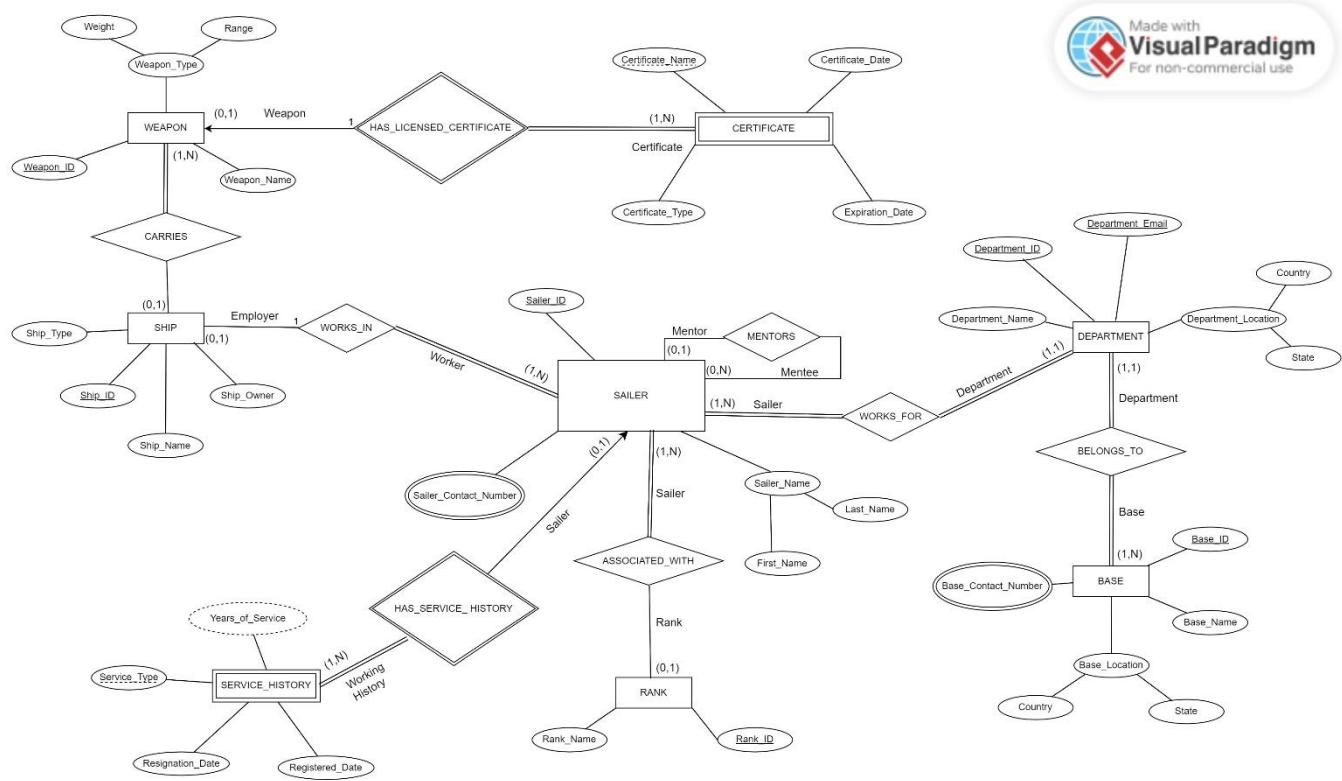


Figure 1 - Entity Relationship Diagram

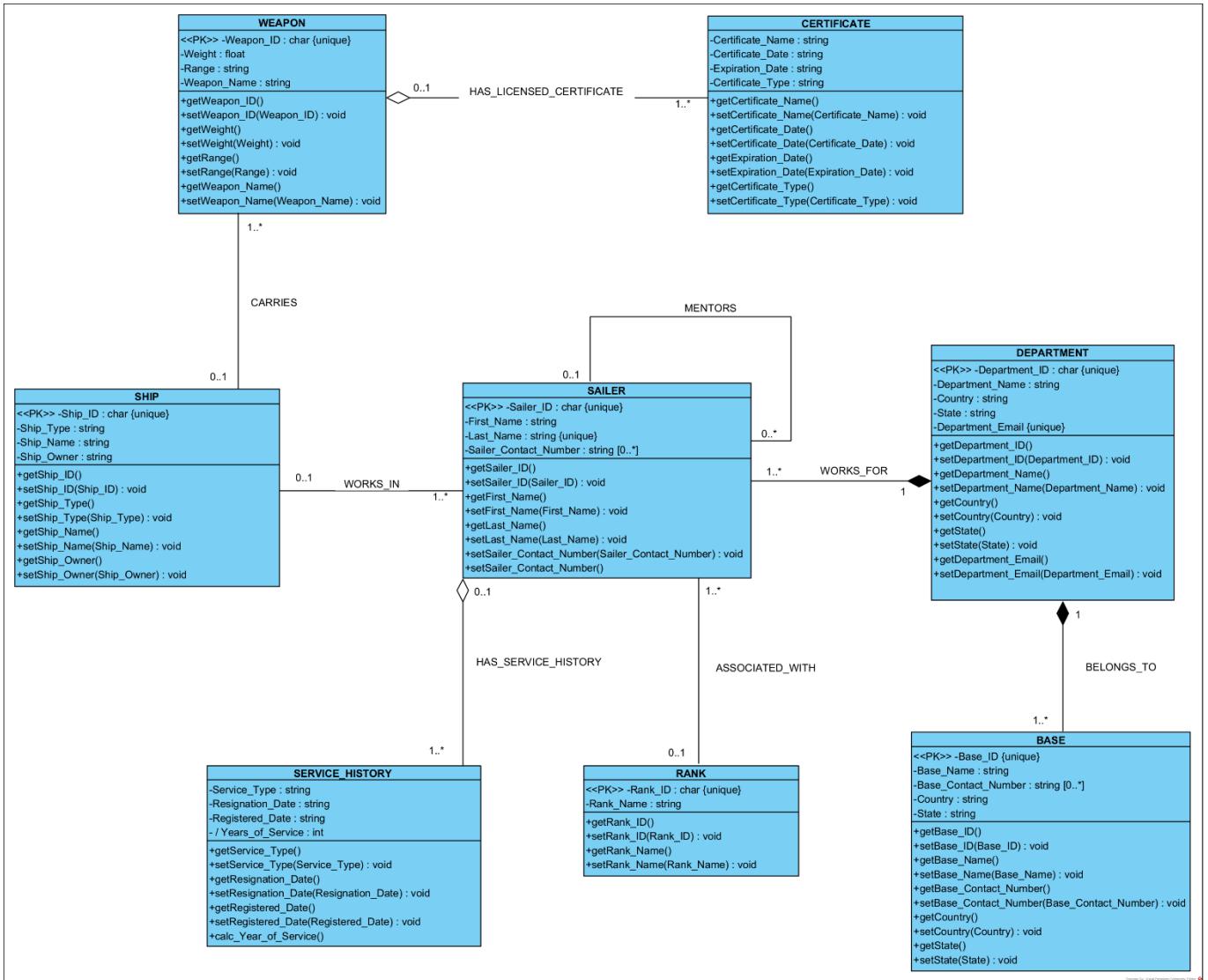


Figure 2 - UML Diagram

3 Chapter 3 - Implementation

Creating a 2NF (Second Normal Form) relational database schema in MySQL Command Line Client involves defining tables, inserting data, and performing various operations to maintain data integrity.

3.1 Schema creation with table creation and creating foreign key constraints

- Create Database and Use database

```
Enter password: ****
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 39
Server version: 8.0.33 MySQL Community Server - GPL

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Oracle is a registered trademark of Oracle Corporation and/or its
affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> CREATE DATABASE NAVY;
Query OK, 1 row affected (0.01 sec)

mysql> USE NAVY;
Database changed
```

- Create SHIP table

```
mysql> CREATE TABLE SHIP(
    -> Ship_ID varchar(5) NOT NULL,
    -> Ship_Type varchar(15),
    -> Ship_Name varchar(15),
    -> Ship_Owner varchar(20),
    -> primary key(Ship_ID)
    -> );
Query OK, 0 rows affected (0.03 sec)
```

- Create SAILER table

```
mysql>
mysql> CREATE TABLE SAILER(
-> Sailor_ID varchar(5) NOT NULL,
-> First_Name varchar(15),
-> Last_Name varchar(15),
-> Sailor_Department varchar(5),
-> Sailor_Ship varchar(5),
-> Sailor_Rank varchar(15),
-> Sailor_Mentor varchar(5),
-> primary key(Sailor_ID),
-> constraint FK_Mentor Foreign key(Sailor_Mentor) references SAILER(Sailor_ID) on update cascade on delete set null,
-> constraint FK_Ship foreign key(Sailor_Ship) references SHIP(Ship_ID) on update cascade on delete set null,
-> constraint FK_Rank foreign key(Sailor_Rank) references _RANK_(Rank_ID) on update cascade on delete set null,
-> constraint FK_Department foreign key(Sailor_Department) references Department(Department_ID) on update cascade on delete cascade
-> );
Query OK, 0 rows affected (0.06 sec)
```

- Create Rank table

```
mysql> CREATE TABLE _RANK_(
-> Rank_ID varchar(5) NOT NULL,
-> Rank_Name varchar(15),
-> primary key(Rank_ID)
-> );
Query OK, 0 rows affected (0.03 sec)
```

- Create DEPARTMENT table

```
mysql> CREATE TABLE DEPARTMENT(
-> Department_ID varchar(5) NOT NULL,
-> Department_Name varchar(30),
-> Country varchar(15),
-> State varchar(15),
-> Department_Email varchar(50),
-> primary key(Department_ID)
-> );
Query OK, 0 rows affected (0.03 sec)
```

- Create BASE table

```
mysql> CREATE TABLE BASE(
-> Base_ID varchar(5) NOT NULL,
-> Base_Department varchar(5),
-> Base_Name varchar(15),
-> Country varchar(15),
-> State varchar(15),
-> primary key(Base_ID),
-> constraint FK_BaseDepartment foreign key(Base_Department) references DEPARTMENT(Department_ID) on update cascade on delete cascade
-> );
Query OK, 0 rows affected (0.02 sec)
```

- Create Base_Contact table

```
mysql> CREATE TABLE Base_Contact(
    -> Base_ID varchar(5) NOT NULL,
    -> Contact_Number varchar(12),
    -> primary key(Base_ID,Contact_Number),
    -> constraint FK_BaseContact foreign key(Base_ID) references BASE(Base_ID) on update cascade on delete cascade
    -> );
Query OK, 0 rows affected (0.03 sec)
```

- Create SAILER_CONTACT table

```
mysql> CREATE TABLE SAILER_CONTACT(
    -> Sailor_ID varchar(5) NOT NULL,
    -> Contact_Number varchar(12),
    -> primary key(Sailor_ID,Contact_Number),
    -> constraint FK_Contact foreign key(Sailor_ID) references SAILER(Sailor_ID) on update cascade on delete cascade
    -> );
Query OK, 0 rows affected (0.03 sec)
```

- Create SERVICE_HISTORY table

```
mysql> CREATE TABLE SERVICE_HISTORY (
    -> Sailor_ID varchar(5) NOT NULL,
    -> Service_Type varchar(15) NOT NULL,
    -> Resignation_Date date,
    -> Registered_Date date,
    -> Years_of_Service INT GENERATED ALWAYS AS (YEAR(Resignation_Date) - YEAR(Registered_Date)),
    -> primary key(Sailor_ID,Service_Type),
    -> constraint FK_Service foreign key(Sailor_ID) references SAILER(Sailor_ID) on delete cascade on update cascade
    -> );
Query OK, 0 rows affected (0.04 sec)
```

- Create WEAPON table

```
mysql> CREATE TABLE WEAPON (
    -> Weapon_ID varchar(5) NOT NULL,
    -> Ship_ID varchar(5),
    -> Weapon_Name varchar(20),
    -> Weight float(15),
    -> Range_ varchar(15),
    -> primary key(Weapon_ID),
    -> constraint FK_CarrierShip foreign key(Ship_ID) references SHIP(Ship_ID) on delete set null on update cascade
    -> );
Query OK, 0 rows affected (0.04 sec)
```

- Create CEARTIFICATE table

```
mysql> CREATE TABLE CERTIFICATE(
->     Weapon_ID varchar(5) NOT NULL,
->     Certificate_Name varchar(35) NOT NULL,
->     Expiration_Date date,
->     Certificate_Type varchar(15),
->     primary key(Weapon_ID,Certificate_Name),
->     constraint FK_SailerCertificate foreign key(Weapon_ID) references WEAPON(Weapon_ID) on update cascade on delete cascade
-> );
Query OK, 0 rows affected (0.03 sec)
```

3.2 Insert, Update, Delete Operations for all tables

- Insert,update delete operations to SHIP table

```
mysql> /* Insert,update delete operations to SHIP table */
mysql> INSERT INTO SHIP VALUES ('H101C', 'Heavy Carrier', 'PHOENIX-77', 'A. Johnson');
Query OK, 1 row affected (0.02 sec)

mysql> INSERT INTO SHIP VALUES ('P306S', 'Passenger', 'OCEANIA-12', 'CruiseCo Ltd.');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SHIP VALUES ('M402C', 'Mini Carrier', 'SEAGULL-9', 'B. Jagath');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SHIP VALUES ('P518S', 'Passenger', 'CITY CRUISER', 'SL Routers');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SHIP VALUES ('B609S', 'Battleship', 'WARHAWK-55', 'Naval Command');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SHIP VALUES ('M724C', 'Mini Carrier', 'TINY WINGS', 'X. Enterprises');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE SHIP set Ship_Name ='SL WINGS' where Ship_ID='M724C';
Query OK, 1 row affected (0.02 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE SHIP set Ship_Owner ='Lexer Ltd.' where Ship_ID='P306S';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM SHIP where Ship_ID='M724C';
Query OK, 1 row affected (0.01 sec)
```

- Insert,update delete operations to DEPARTMENT table

```
mysql>
mysql> /* Insert,update delete operations to DEPARTMENT table */
mysql> INSERT INTO DEPARTMENT VALUES ('SD101', 'Supply Department', 'USA', 'California', 'Supply101@gmail.com');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO DEPARTMENT VALUES ('CD202', 'Communications Department', 'Sri Lanka', 'Hambanthota', 'CommDept202@gmail.com');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO DEPARTMENT VALUES ('OD303', 'Operations Department', 'Australia', 'New South Wales', 'OpsDept303@gmail.com');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO DEPARTMENT VALUES ('DD404', 'Deck Department', 'UK', 'England', 'Deck404@gmail.com');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO DEPARTMENT VALUES ('TD505', 'Training Department', 'Sri Lanka', 'Trincomalee', 'Training505@gmail.com');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE DEPARTMENT set Department_Email='TrainDP123@gmail.com' where Department_ID='TD505';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE DEPARTMENT set Department_Email='TrainDP123@gmail.com' where Department_ID='SD101';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM DEPARTMENT where Department_ID='SD101';
Query OK, 1 row affected (0.01 sec)
```

- Insert,update delete operations to _RANK_ table

```

mysql>
mysql> /* Insert,update delete operations to _RANK_ table */
mysql> INSERT INTO _RANK_ VALUES ('RA-02', 'Rear Admiral');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO _RANK_ VALUES ('LT-01', 'Lieutenant');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO _RANK_ VALUES ('SM-01', 'Seaman');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO _RANK_ VALUES ('TF-01', 'The Fleet');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO _RANK_ VALUES ('CA-03', 'Captain ');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO _RANK_ VALUES ('VA-02', 'Vice Admiral');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE _RANK_ set Rank_ID ='RA-52' where Rank_ID='RA-02';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE _RANK_ set Rank_Name ='New Seaman' where Rank_ID='SM-01';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM _RANK_ where Rank_ID='SM-01';
Query OK, 1 row affected (0.01 sec)

```

- Insert,update delete operations to SAILER_CONTACT table

```

mysql> /* Insert,update delete operations to SAILER_CONTACT table */
mysql> INSERT INTO SAILER_CONTACT values ('NV198','+94773752627');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV198','+94776654471');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV777','+34743772227');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV777','+34775574431');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV987','+14708752345');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV084','+88798752256');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SAILER_CONTACT values ('NV987','+14708722123');
Query OK, 1 row affected (0.00 sec)

mysql>
mysql> UPDATE SAILER_CONTACT set Contact_Number='+1412345678' where Sailer_ID='NV987' and Contact_Number='+14708752345';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE SAILER_CONTACT set Contact_Number='+3400000020' where Sailer_ID='NV777' and Contact_Number='+34775574431';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM SAILER_CONTACT where Sailer_ID='NV987' and Contact_Number='+1412345678';
Query OK, 1 row affected (0.01 sec)

```

- Insert,update delete operations to SERVICE_HISTORY table

```

mysql> /* Insert,update delete operations to SERVICE_HISTORY table */
mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV234','As Lieutenant','2010-05-04','2007-08-11');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV234','As Vice Admiral','2019-09-25','2007-08-11');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV124','As Vice Admiral','2022-08-10','2018-05-13');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV987','As Captain','2009-04-10','2003-08-21');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV198','As Seaman','2019-07-15','2012-10-11');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV198','As Lieutenant','2022-01-03','2019-07-15');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV084','As Lieutenant','2015-11-03','2000-07-15');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV084','As Captain','2000-01-01','1998-02-25');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SERVICE_HISTORY(Sailer_ID, Service_Type, Resignation_Date, Registered_Date) values ('NV987','As Lieutenant','2012-11-01','2005-12-25');
Query OK, 1 row affected (0.00 sec)

mysql>
mysql> UPDATE SERVICE_HISTORY set Registered_Date='2017-11-12' where Sailer_ID='NV198' and Registered_Date='2019-07-15';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> UPDATE SERVICE_HISTORY set Resignation_Date='2017-11-12' where Sailer_ID='NV084' and Registered_Date='2000-07-15';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> DELETE FROM SERVICE_HISTORY where Sailer_ID ='NV198' and Service_Type='As Seaman';
Query OK, 1 row affected (0.01 sec)

```

- Insert,update delete operations to CERTIFICATE table

```

mysql>
mysql> /* Insert,update delete operations to CERTIFICATE table */
mysql> INSERT INTO CERTIFICATE values ('MG_26','CCP','2025-09-07','Local');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO CERTIFICATE values ('MG_26','Security Guard License','2030-12-07','Local');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO CERTIFICATE values ('FA_77','Specialized Licenses','2030-09-12','Local');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO CERTIFICATE values ('MG_68','Security Guard License','2025-09-07','International');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO CERTIFICATE values ('MG_68','Enforcement Licenses','2035-10-07','International');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO CERTIFICATE values ('AT_90','Enforcement Licenses','2050-10-07','International');
Query OK, 1 row affected (0.05 sec)

mysql> INSERT INTO CERTIFICATE values ('AT_90','Military Licenses','2061-09-22','International');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE CERTIFICATE set Certificate_Type='Local' where Weapon_ID='AT_90' and Certificate_Name='Military Licenses' ;
Query OK, 1 row affected (0.00 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> UPDATE CERTIFICATE set Expiration_Date='2035-01-01' where Weapon_ID='AT_90' and Certificate_Name='Military Licenses' ;
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> DELETE FROM CERTIFICATE where Weapon_ID='AT_90' and Certificate_Name='Enforcement Licenses';
Query OK, 1 row affected (0.00 sec)

```

- Insert,update delete operations to WEAPON table

```
mysql> /* Insert,update delete operations to WEAPON table */
mysql> INSERT INTO WEAPON values ('FA_66','H101C','Pistol','1.36','Short');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO WEAPON values ('FA_77','P306S','Shotgun','2.29','Short');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO WEAPON values ('MG_68','H101C','LMG','6.88','Medium');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO WEAPON values ('MG_26','M402C','MMG','9.78','Medium');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO WEAPON values ('AT_90','B609S','Anti-Tank Missile','45.91','Long');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO WEAPON values ('AT_00','B609S','Mortars','135.7','Long');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE WEAPON set Weight='3.6' where Weapon_ID='FA_77';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE WEAPON set Weapon_Name='LongMAG' where Weapon_ID='MG_68';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM WEAPON where Weapon_ID='FA_66';
Query OK, 1 row affected (0.01 sec)
```

- Insert,update delete operations to SAILER table

```

mysql> /* Insert,update delete operations to BASE table */
mysql> INSERT INTO BASE values ('SD_11','DD404','NorthBase', 'USA', 'Florida');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO BASE values ('CD_01','CD244','WestPoint', 'Sri Lanka', 'Hambanthota');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO BASE values ('OD_87','OD303','SouthBase', 'UK', 'England');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO BASE values ('DD_44','DD404','NorthWest', 'Australia', 'South Wales');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO BASE values ('TD_11','TD505','NorthSouth', 'Sri Lanka', 'Trincomalee');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO BASE values ('SD_56','CD244','SouthCoast', 'USA', 'California');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE BASE SET Base_Name='WestPointCoast' where Base_ID='CD_01';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE BASE SET State='North Wales' where Base_ID='DD_44';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM BASE where Base_ID='SD_56';
Query OK, 1 row affected (0.01 sec)

```

- Insert,update delete operations to BASE table

```

mysql> /* Insert,update delete operations to SAILER table */
mysql> INSERT INTO SAILER VALUES ('NV234', 'Sunil', 'Perera', 'CD244', 'H101C','TF-01',null);
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER VALUES ('NV654', 'Andrew', 'James', 'CD244', 'P306S','RA-52','NV234');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER VALUES ('NV987', 'John', 'James', 'OD303', 'M402C','VA-02','NV654');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO SAILER VALUES ('NV198', 'Jagath', 'Ahangama', 'DD404', 'P518S','LT-01','NV987');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER VALUES ('NV084', 'Poorna', 'Iduwara', 'TD505', 'B609S','CA-03','NV198');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER VALUES ('NV777', 'Zeek', 'Johanas', 'DD404', 'B609S','CA-03','NV084');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO SAILER VALUES ('NV124', 'Pramod', 'Madusha', 'TD505', 'B609S','CA-03','NV084');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE SAILER set First_Name= 'Indunil' where Sailer_ID='NV084';
Query OK, 1 row affected (0.00 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> UPDATE SAILER set Sailer_Rank= 'VA-02' where Sailer_ID='NV084';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1  Changed: 1  Warnings: 0

mysql> DELETE FROM SAILER where Sailer_ID='NV654';
Query OK, 1 row affected (0.01 sec)

```

- Insert, update delete operations to Base_Contact table

```
mysql> /* Insert, update delete operations to Base_Contact table */
mysql> INSERT INTO Base_Contact values ('SD_11', '+34876683211');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO Base_Contact values ('CD_01', '+94117653982');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Base_Contact values ('OD_87', '+54009887923');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO Base_Contact values ('CD_01', '+94898880554');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO Base_Contact values ('TD_11', '+48876633354');
Query OK, 1 row affected (0.01 sec)

mysql> INSERT INTO Base_Contact values ('TD_11', '+48787556794');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> UPDATE Base_Contact set Contact_Number='+94000000123' where Base_ID='CD_01' and Contact_Number='+94117653982';
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> UPDATE Base_Contact set Contact_Number='+48123456123' where Base_ID='OD_87' ;
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> DELETE FROM Base_Contact where Base_ID='TD_11' and Contact_Number='+48787556794';
Query OK, 1 row affected (0.01 sec)
```

3.3 Show all tables

- SHIP table

```
mysql>
mysql> select *from ship;
+-----+-----+-----+-----+
| Ship_ID | Ship_Type      | Ship_Name     | Ship_Owner   |
+-----+-----+-----+-----+
| B609S  | Battleship    | WARHAWK-55   | Naval Command|
| H101C  | Heavy Carrier | PHOENIX-77   | A. Johnson   |
| M402C  | Mini Carrier  | SEAGULL-9    | B. Jagath   |
| P306S  | Passenger     | OCEANIA-12   | Lexer Ltd.   |
| P518S  | Passenger     | CITY CRUISER | SL Routers  |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)
```

- RANK table

```
mysql> select * from _rank_;
+-----+-----+
| Rank_ID | Rank_Name |
+-----+-----+
| CA-03   | Captain    |
| LT-01   | Lieutenant |
| RA-52   | Rear Admiral|
| TF-01   | The Fleet  |
| VA-02   | Vice Admiral|
+-----+-----+
5 rows in set (0.00 sec)
```

- DEPARTMENT table

```
mysql>
mysql> select * from Department;
+-----+-----+-----+-----+-----+
| Department_ID | Department_Name      | Country | State       | Department_Email |
+-----+-----+-----+-----+-----+
| CD244        | Communications Department | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| DD404        | Deck Department          | UK        | England     | Deck404@gmail.com   |
| OD303        | Operations Department    | Australia | New South Wales | OpsDept303@gmail.com |
| TD505        | Training Department      | Sri Lanka | Trincomalee | TrainDP123@gmail.com |
+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)
```

- SAILER table

```
mysql> select * from sailer;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+-----+
| NV084     | Indunil    | Iduwara   | TD505            | B609S      | VA-02       | NV198      |
| NV124     | Pramod     | Madusha   | TD505            | B609S      | CA-03       | NV084      |
| NV198     | Jagath     | Ahangama  | DD404            | P518S      | LT-01       | NV987      |
| NV234     | Sunil      | Perera    | CD244            | H101C      | TF-01       | NULL       |
| NV777     | Zeek       | Johanas   | DD404            | B609S      | CA-03       | NV084      |
| NV987     | John       | James     | OD303            | M402C      | VA-02       | NULL       |
+-----+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)
```

- SAILER_CONTACT table

```
mysql> select * from sailor_contact;
+-----+-----+
| Sailor_ID | Contact_Number |
+-----+-----+
| NV084     | +88798752256   |
| NV198     | +94773752627   |
| NV198     | +94776654471   |
| NV777     | +34000000020   |
| NV777     | +34743772227   |
| NV987     | +14708722123   |
+-----+-----+
6 rows in set (0.00 sec)
```

- SERVICE_HISTORY table

```
mysql> select * from service_history;
+-----+-----+-----+-----+-----+
| Sailor_ID | Service_Type | Resignation_Date | Registered_Date | Years_of_Service |
+-----+-----+-----+-----+-----+
| NV084     | As Captain    | 2000-01-01      | 1998-02-25      | 2           |
| NV084     | As Lieutenant  | 2017-11-12      | 2000-07-15      | 17          |
| NV124     | As Vice Admiral| 2022-08-10      | 2018-05-13      | 4           |
| NV198     | As Lieutenant  | 2022-01-03      | 2017-11-12      | 5           |
| NV234     | As Lieutenant  | 2010-05-04      | 2007-08-11      | 3           |
| NV234     | As Vice Admiral| 2019-09-25      | 2007-08-11      | 12          |
| NV987     | As Captain    | 2009-04-10      | 2003-08-21      | 6           |
| NV987     | As Lieutenant  | 2012-11-01      | 2005-12-25      | 7           |
+-----+-----+-----+-----+-----+
8 rows in set (0.00 sec)
```

- BASE table

```
mysql>
mysql> select * from base;
+-----+-----+-----+-----+-----+
| Base_ID | Base_Department | Base_Name       | Country  | State   |
+-----+-----+-----+-----+-----+
| CD_01   | CD244          | WestPointCoast | Sri Lanka | Hambanthota |
| DD_44   | DD404          | NorthWest       | Australia | North Wales |
| OD_87   | OD303          | SouthBase       | UK        | England  |
| SD_11   | DD404          | NorthBase       | USA       | Florida  |
| TD_11   | TD505          | NorthSouth      | Sri Lanka | Trincomalee |
+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)
```

- BASE_CONTACT table

```
mysql> select * from base_contact;
+-----+-----+
| Base_ID | Contact_Number |
+-----+-----+
| CD_01   | +94000000123  |
| CD_01   | +94898880554  |
| OD_87   | +48123456123  |
| SD_11   | +34876683211  |
| TD_11   | +48876633354  |
+-----+-----+
5 rows in set (0.00 sec)
```

- WEAPON table

```
mysql> select * from weapon;
+-----+-----+-----+-----+-----+
| Weapon_ID | Ship_ID | Weapon_Name      | Weight | _Range_ |
+-----+-----+-----+-----+-----+
| AT_00     | B609S   | Mortars          | 135.7  | Long    |
| AT_90     | B609S   | Anti-Tank Missile | 45.91  | Long    |
| FA_77     | P306S   | Shotgun           | 3.6    | Short   |
| MG_26     | M402C   | MMG               | 9.78   | Medium  |
| MG_68     | H101C   | LongMAG          | 6.88   | Medium  |
+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)
```

- CERTIFICATE table

```
mysql> select * from certificate;
+-----+-----+-----+-----+
| Weapon_ID | Certificate_Name      | Expiration_Date | Certificate_Type |
+-----+-----+-----+-----+
| AT_90     | Military Licenses     | 2035-01-01      | Local            |
| FA_77     | Specialized Licenses  | 2030-09-12      | Local            |
| MG_26     | CCP                   | 2025-09-07      | Local            |
| MG_26     | Security Guard License | 2030-12-07      | Local            |
| MG_68     | Enforcement Licenses  | 2035-10-07      | International    |
| MG_68     | Security Guard License | 2025-09-07      | International    |
+-----+-----+-----+-----+
6 rows in set (0.00 sec)
```

4 Chapter 4 – Transactions

4.1 Simple queries

- Select operation

```
mysql>
mysql> /*Select Operation*/
mysql> Select * from Department where Country ='Sri Lanka';
+-----+-----+-----+-----+
| Department_ID | Department_Name | Country | State   | Department_Email |
+-----+-----+-----+-----+
| CD244       | Communications Department | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| TD505       | Training Department    | Sri Lanka | Trincomalee | TrainDP123@gmail.com |
+-----+-----+-----+-----+
2 rows in set (0.04 sec)

mysql>
```



- Project operation

```
mysql>
mysql> /*Project Operation*/
mysql> Select Sailer_ID,First_Name,Sailer_Department,Sailer_Rank,Sailer_Mentor from SAILER where Sailer_Mentor='NV084';
+-----+-----+-----+-----+
| Sailer_ID | First_Name | Sailer_Department | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+
| NV124     | Pranod     | TD505           | CA-03     | NV084      |
| NV777     | Zeek        | DD404           | CA-03     | NV084      |
+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```



- Cartesian product operation

```
mysql> /*the cartesian product operation*/
mysql> Select BASE.Base_ID,BASE.Country,BASE.State,_RANK_.Rank_Name from Base cross join _Rank_;
+-----+-----+-----+-----+
| Base_ID | Country | State | Rank_Name |
+-----+-----+-----+-----+
| TD_11 | Sri Lanka | Trincomalee | Captain |
| SD_11 | USA | Florida | Captain |
| OD_87 | UK | England | Captain |
| DD_44 | Australia | North Wales | Captain |
| CD_01 | Sri Lanka | Hambantotha | Captain |
| TD_11 | Sri Lanka | Trincomalee | Lieutenant |
| SD_11 | USA | Florida | Lieutenant |
| OD_87 | UK | England | Lieutenant |
| DD_44 | Australia | North Wales | Lieutenant |
| CD_01 | Sri Lanka | Hambantotha | Lieutenant |
| TD_11 | Sri Lanka | Trincomalee | Rear Admiral |
| SD_11 | USA | Florida | Rear Admiral |
| OD_87 | UK | England | Rear Admiral |
| DD_44 | Australia | North Wales | Rear Admiral |
| CD_01 | Sri Lanka | Hambantotha | Rear Admiral |
| TD_11 | Sri Lanka | Trincomalee | The Fleet |
| SD_11 | USA | Florida | The Fleet |
| OD_87 | UK | England | The Fleet |
| DD_44 | Australia | North Wales | The Fleet |
| CD_01 | Sri Lanka | Hambantotha | The Fleet |
| TD_11 | Sri Lanka | Trincomalee | Vice Admiral |
| SD_11 | USA | Florida | Vice Admiral |
| OD_87 | UK | England | Vice Admiral |
| DD_44 | Australia | North Wales | Vice Admiral |
| CD_01 | Sri Lanka | Hambantotha | Vice Admiral |
+-----+-----+-----+-----+
25 rows in set (0.01 sec)
```



- Creating user view

```
mysql>
mysql> /* Create a user view*/
mysql> create view UV1 as Select W.Weapon_ID,S.Ship_ID,S.Ship_Name as Carrier_Ship,S.Ship_Type, Weapon_Name,W.Weight from SHIP as S natural join WEAPON as W;
Query OK, 0 rows affected (0.03 sec)

mysql> select * from UV1; /*Drop view UV1*/
+-----+-----+-----+-----+-----+
| Weapon_ID | Ship_ID | Carrier_Ship | Ship_Type | Weapon_Name | Weight |
+-----+-----+-----+-----+-----+
| AT_00 | B609S | WARHAWK-55 | Battleship | Mortars | 135.7 |
| AT_90 | B609S | WARHAWK-55 | Battleship | Anti-Tank Missile | 45.91 |
| FA_77 | P306S | OCEANIA-12 | Passenger | Shotgun | 3.6 |
| MG_26 | M402C | SEAGULL-9 | Mini Carrier | MMG | 9.78 |
| MG_68 | H101C | PHOENIX-77 | Heavy Carrier | LongMAG | 6.88 |
+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql>
```



- Rename operation

```
mysql> /*Renaming Operation*/
mysql> Alter table WEAPON RENAME COLUMN Weight TO Average_Weight;
Query OK, 0 rows affected (0.02 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> /*Alter table WEAPON RENAME COLUMN Average_Weight TO Weight;*/
mysql>
```



- Demonstrating the use of an aggregation function

```
mysql> /*Demonstration of an aggregation function*/
mysql> Select Service_Type, Avg(Years_of_Service),Count(Sailor_ID) from SERVICE_HISTORY group by Service_Type;
+-----+-----+-----+
| Service_Type | Avg(Years_of_Service) | Count(Sailor_ID) |
+-----+-----+-----+
| As Captain   |        4.0000 |         2 |
| As Lieutenant |       8.0000 |         4 |
| As Vice Admiral |      8.0000 |         2 |
+-----+-----+-----+
3 rows in set (0.00 sec)

mysql>
```



- Demonstrating the use of LIKE keyword

```
mysql> /*Demonstration of the use of LIKE keyword*/
mysql> Select Sailor_ID,Service_Type,Registered_Date,Resignation_Date from SERVICE_HISTORY where Resignation_Date like '201_-%-%';
+-----+-----+-----+-----+
| Sailor_ID | Service_Type | Registered_Date | Resignation_Date |
+-----+-----+-----+-----+
| NV234    | As Lieutenant | 2007-08-11    | 2010-05-04 |
| NV234    | As Vice Admiral | 2007-08-11    | 2019-09-25 |
+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```



4.2 Complex queries

Demonstrations of basic set operations (union, intersection, set difference, division) without user views are shown below with aliasing.

- Union operation

```
mysql> Select * from Sailer_Contact ;
+-----+-----+
| Sailer_ID | Contact_Number |
+-----+-----+
| NV084    | +88798752256   |
| NV198    | +94773752627   |
| NV198    | +94776654471   |
| NV777    | +34000000020   |
| NV777    | +34743772227   |
| NV987    | +14708722123   |
+-----+
6 rows in set (0.00 sec)

mysql> Select * from Base_Contact where Contact_Number like '+94%';
+-----+-----+
| Base_ID | Contact_Number |
+-----+-----+
| CD_01   | +94000000123   |
| CD_01   | +94898880554   |
+-----+
2 rows in set (0.00 sec)

mysql> Select Sailer_ID as Base_or_Sailer_ID,Contact_Number from Sailer_Contact
      -> union
      -> select Base_ID,Contact_Number from Base_Contact as B where B.Contact_Number like '+94%';
+-----+-----+
| Base_or_Sailer_ID | Contact_Number |
+-----+-----+
| NV084            | +88798752256   |
| NV198            | +94773752627   |
| NV198            | +94776654471   |
| NV777            | +34000000020   |
| NV777            | +34743772227   |
| NV987            | +14708722123   |
| CD_01            | +94000000123   |
| CD_01            | +94898880554   |
+-----+
8 rows in set (0.00 sec)
```

- Intersection operation

```
mysql> Select * from Sailer;
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+
| NV084    | Indunil   | Iduwara  | TD505          | B609S     | VA-02      | NV198       |
| NV124    | Pramod    | Madusha   | TD505          | B609S     | CA-03      | NV084       |
| NV198    | Jagath    | Ahangama  | DD404          | P518S     | LT-01      | NV987       |
| NV234    | Sunil     | Perera   | CD244          | H101C     | TF-01      | NULL        |
| NV777    | Zeek      | Johanas  | DD404          | B609S     | CA-03      | NV084       |
| NV987    | John      | James    | OD303          | M402C     | VA-02      | NULL        |
+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> Select * from service_history where Years_of_Service > 5;
+-----+-----+-----+-----+-----+
| Sailer_ID | Service_Type | Resignation_Date | Registered_Date | Years_of_Service |
+-----+-----+-----+-----+-----+
| NV084    | As Lieutenant | 2017-11-12      | 2000-07-15      | 17           |
| NV234    | As Vice Admiral | 2019-09-25      | 2007-08-11      | 12           |
| NV987    | As Captain    | 2009-04-10      | 2003-08-21      | 6            |
| NV987    | As Lieutenant | 2012-11-01      | 2005-12-25      | 7            |
+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department,H.Service_Type,H.Registered_Date,H.Resignation_Date from Sailer as S
      -> inner join service_history as H on S.Sailer_ID=H.Sailer_ID where Years_of_Service > 5;
+-----+-----+-----+-----+-----+-----+
| Sailer_ID | Sailer_Rank | Sailer_Department | Service_Type | Registered_Date | Resignation_Date |
+-----+-----+-----+-----+-----+-----+
| NV084    | VA-02      | TD505          | As Lieutenant | 2000-07-15      | 2017-11-12      |
| NV234    | TF-01      | CD244          | As Vice Admiral | 2007-08-11      | 2019-09-25      |
| NV987    | VA-02      | OD303          | As Captain    | 2003-08-21      | 2009-04-10      |
| NV987    | VA-02      | OD303          | As Lieutenant | 2005-12-25      | 2012-11-01      |
+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql>
```

- Set difference operation

```
mysql> Select * from sailer;
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+
| NV084 | Indunil | Iduwara | TD505 | B609S | VA-02 | NV198 |
| NV124 | Pramod | Madusha | TD505 | B609S | CA-03 | NV084 |
| NV198 | Jagath | Ahangama | DD404 | P518S | LT-01 | NV987 |
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL |
| NV777 | Zeek | Johanas | DD404 | B609S | CA-03 | NV084 |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL |
+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> Select * from service_history;
+-----+-----+-----+-----+-----+
| Sailer_ID | Service_Type | Resignation_Date | Registered_Date | Years_of_Service |
+-----+-----+-----+-----+-----+
| NV084 | As Captain | 2000-01-01 | 1998-02-25 | 2 |
| NV084 | As Lieutenant | 2017-11-12 | 2000-07-15 | 17 |
| NV124 | As Vice Admiral | 2022-08-10 | 2018-05-13 | 4 |
| NV198 | As Lieutenant | 2022-01-03 | 2017-11-12 | 5 |
| NV234 | As Lieutenant | 2010-05-04 | 2007-08-11 | 3 |
| NV234 | As Vice Admiral | 2019-09-25 | 2007-08-11 | 12 |
| NV987 | As Captain | 2009-04-10 | 2003-08-21 | 6 |
| NV987 | As Lieutenant | 2012-11-01 | 2005-12-25 | 7 |
+-----+-----+-----+-----+-----+
```

```
mysql> Select * from service_history where Resignation_Date='2000-01-01' or Resignation_Date='2017-11-12';
+-----+-----+-----+-----+-----+
| Sailer_ID | Service_Type | Resignation_Date | Registered_Date | Years_of_Service |
+-----+-----+-----+-----+-----+
| NV084 | As Captain | 2000-01-01 | 1998-02-25 | 2 |
| NV084 | As Lieutenant | 2017-11-12 | 2000-07-15 | 17 |
+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
mysql> Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department from sailer as S where S.Sailer_ID NOT IN (Select Years_of_Service from service_history where Resignation_Date='2000-01-01' or Resignation_Date='2017-11-12');
+-----+-----+-----+
| Sailer_ID | Sailer_Rank | Sailer_Department |
+-----+-----+-----+
| NV084 | VA-02 | TD505 |
| NV124 | CA-03 | TD505 |
| NV198 | LT-01 | DD404 |
| NV234 | TF-01 | CD244 |
| NV777 | CA-03 | DD404 |
| NV987 | VA-02 | OD303 |
+-----+-----+-----+
6 rows in set (0.00 sec)

mysql>
```

- Division operation

```

mysql> Select * from service_history;
+-----+-----+-----+-----+-----+
| Sailer_ID | Service_Type | Resignation_Date | Registered_Date | Years_of_Service |
+-----+-----+-----+-----+-----+
| NV084    | As Captain   | 2000-01-01      | 1998-02-25      | 2          |
| NV084    | As Lieutenant | 2017-11-12      | 2000-07-15      | 17         |
| NV124    | As Vice Admiral | 2022-08-10      | 2018-05-13      | 4          |
| NV198    | As Lieutenant | 2022-01-03      | 2017-11-12      | 5          |
| NV234    | As Lieutenant | 2010-05-04      | 2007-08-11      | 3          |
| NV234    | As Vice Admiral | 2019-09-25      | 2007-08-11      | 12         |
| NV987    | As Captain   | 2009-04-10      | 2003-08-21      | 6          |
| NV987    | As Lieutenant | 2012-11-01      | 2005-12-25      | 7          |
+-----+-----+-----+-----+-----+
8 rows in set (0.00 sec)

mysql> select DISTINCT sailor_ID from service_history where Registered_Date ='1998-02-25' or Registered_Date ='2003-08-21';
+-----+
| sailor_ID |
+-----+
| NV084    |
| NV987    |
+-----+
2 rows in set (0.00 sec)

mysql> SELECT DISTINCT Service_Type from service_history as S1 where not exists (select distinct Sh.Sailer_ID from service_history as Sh where S1.Registered_Date ='2003-08-21' or S1.Registered_Date ='1998-02-25' AND Sh.sailer_ID not in (SELECT S2.Sailer_ID from service_history as S2 where S2.Service_Type=S1.Service_Type));
+-----+
| Service_Type |
+-----+
| As Lieutenant |
| As Vice Admiral |
+-----+
2 rows in set (0.00 sec)

mysql>
```



Representation of inner join, natural join, left outer join, right outer join, full outer join, and outer union relational algebraic operations by using user views are shown below with aliasing.

- Inner join operation

```
mysql> CREATE VIEW UV2 as SELECT Sailer_ID,First_Name,Last_Name,Sailer_Department,Sailer_Rank from sailer;
Query OK, 0 rows affected (0.02 sec)

mysql> select * from UV2;
+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Rank |
+-----+-----+-----+-----+-----+
| NV084    | Indunil   | Iduwara  | TD505          | VA-02        |
| NV124    | Pramod    | Madusha   | TD505          | CA-03        |
| NV198    | Jagath    | Ahangama  | DD404          | LT-01        |
| NV234    | Sunil     | Perera    | CD244          | TF-01        |
| NV777    | Zeek      | Johanas   | DD404          | CA-03        |
| NV987    | John      | James     | OD303          | VA-02        |
+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> CREATE VIEW UV3 as SELECT Rank_ID from _Rank_;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV3;
+-----+
| Rank_ID |
+-----+
| CA-03  |
| LT-01  |
| RA-52  |
| TF-01  |
| VA-02  |
+-----+
```

```
mysql> select View2.*,View3.Rank_ID from UV2 as View2 inner join UV3 as View3 on View2.Sailer_Rank=View3.Rank_ID where first_name ='Indunil' or first_name ='Pramod' or first_name ='Sunil';
+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Rank | Rank_ID |
+-----+-----+-----+-----+-----+-----+
| NV084    | Indunil   | Iduwara  | TD505          | VA-02        | VA-02    |
| NV124    | Pramod    | Madusha   | TD505          | CA-03        | CA-03    |
| NV234    | Sunil     | Perera    | CD244          | TF-01        | TF-01    |
+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)
```

- Natural join operation

```
mysql> CREATE VIEW UV4 AS SELECT Weapon_ID,Weapon_Name,Average_Weight from weapon;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV4;
+-----+-----+-----+
| Weapon_ID | Weapon_Name | Average_Weight |
+-----+-----+-----+
| AT_00 | Mortars | 135.7 |
| AT_90 | Anti-Tank Missile | 45.91 |
| FA_77 | Shotgun | 3.6 |
| MG_26 | MMG | 9.78 |
| MG_68 | LongMAG | 6.88 |
+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> CREATE VIEW UV5 AS SELECT Ship_Type,Ship_Name,Ship_Owner from ship;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV5;
+-----+-----+-----+
| Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+
| Battleship | WARHAWK-55 | Naval Command |
| Heavy Carrier | PHOENIX-77 | A. Johnson |
| Mini Carrier | SEAGULL-9 | B. Jagath |
| Passenger | OCEANIA-12 | Lexer Ltd. |
| Passenger | CITY CRUISER | SL Routers |
+-----+-----+-----+
5 rows in set (0.00 sec)
```

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```
mysql> select * from UV5 where Ship_Owner = "Naval Command";
+-----+-----+-----+
| Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+
| Battleship | WARHAWK-55 | Naval Command |
+-----+-----+-----+
1 row in set (0.00 sec)

mysql> SELECT DISTINCT view5.* , view4.* from UV4 as View4 natural join UV5 as View5 where view5.Ship_Owner = "Naval Command";
+-----+-----+-----+-----+-----+-----+
| Ship_Type | Ship_Name | Ship_Owner | Weapon_ID | Weapon_Name | Average_Weight |
+-----+-----+-----+-----+-----+-----+
| Battleship | WARHAWK-55 | Naval Command | AT_00 | Mortars | 135.7 |
| Battleship | WARHAWK-55 | Naval Command | AT_90 | Anti-Tank Missile | 45.91 |
| Battleship | WARHAWK-55 | Naval Command | FA_77 | Shotgun | 3.6 |
| Battleship | WARHAWK-55 | Naval Command | MG_26 | MMG | 9.78 |
| Battleship | WARHAWK-55 | Naval Command | MG_68 | LongMAG | 6.88 |
+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> |
```

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- Right outer join operation

```
mysql> CREATE VIEW UV6 as SELECT * from SAILER;
Query OK, 0 rows affected (0.02 sec)

mysql> select * from UV6;
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+
| NV084    | Indunil   | Iduwara  | TD505      | B609S     | VA-02      | NV198      |
| NV124    | Pramod    | Madusha   | TD505      | B609S     | CA-03      | NV084      |
| NV198    | Jagath    | Ahangama  | DD404      | P518S     | LT-01      | NV987      |
| NV234    | Sunil     | Perera    | CD244      | H101C     | TF-01      | NULL       |
| NV777    | Zeek      | Johanas   | DD404      | B609S     | CA-03      | NV084      |
| NV987    | John      | James     | OD303      | MH02C     | VA-02      | NULL       |
+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> CREATE VIEW UV7 as SELECT Department_ID,Department_Name from DEPARTMENT;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from UV7;
+-----+-----+
| Department_ID | Department_Name |
+-----+-----+
| CD244        | Communications Department |
| DD404        | Deck Department |
| OD303        | Operations Department |
| TD505        | Training Department |
+-----+-----+
4 rows in set (0.00 sec)

mysql>
```

```
mysql> select * from UV7 where Department_Name="Deck Department" or Department_Name="Training Department" ;
+-----+-----+
| Department_ID | Department_Name |
+-----+-----+
| DD404        | Deck Department |
| TD505        | Training Department |
+-----+-----+
2 rows in set (0.00 sec)

mysql> SELECT * from UV6 as view6 right outer join uv7 as view7 on view6.Sailer_Department=view7.Department_ID where Department_Name="Deck Department" or Department_Name="Training Department";
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor | Department_ID | Department_Name |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| NV198    | Jagath    | Ahangama | DD404      | P518S     | LT-01      | NV987      | DD404      | Deck Department |
| NV777    | Zeek      | Johanas  | DD404      | B609S     | CA-03      | NV084      | DD404      | Deck Department |
| NV084    | Indunil   | Iduwara  | TD505      | B609S     | VA-02      | NV198      | TD505      | Training Department |
| NV124    | Pramod    | Madusha  | TD505      | B609S     | CA-03      | NV084      | TD505      | Training Department |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql>
```

- Left outer join operation

```
mysql> select * from UV6;
+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+
| NV084    | Indunil    | Iduwara   | TD505          | B609S      | VA-02       | NV198        |
| NV124    | Pramod     | Madusha    | TD505          | B609S      | CA-03       | NV084        |
| NV198    | Jagath     | Ahangama   | DD404          | P518S      | LT-01       | NV987        |
| NV234    | Sunil      | Perera    | CD244          | H101C      | TF-01       | NULL         |
| NV777    | Zeek       | Johanas   | DD404          | B609S      | CA-03       | NV084        |
| NV987    | John       | James     | OD303          | M402C      | VA-02       | NULL         |
+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> select * from UV6 where last_name like 'a%' or last_name like 'm%';
+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+
| NV124    | Pramod     | Madusha    | TD505          | B609S      | CA-03       | NV084        |
| NV198    | Jagath     | Ahangama   | DD404          | P518S      | LT-01       | NV987        |
+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> select * from UV7;
+-----+-----+
| Department_ID | Department_Name |
+-----+-----+
| CD244        | Communications Department |
| DD404        | Deck Department |
| OD303        | Operations Department |
| TD505        | Training Department |
+-----+-----+
```

```
mysql> SELECT * from UV6 as view6 left outer join uv7 as view7 on view6.Sailer_Department=view7.Department_ID where view6.last_name like 'a%' or last_name like 'm%';
+-----+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor | Department_ID | Department_Name |
+-----+-----+-----+-----+-----+-----+-----+-----+
| NV124    | Pramod     | Madusha    | TD505          | B609S      | CA-03       | NV084        | TD505        | Training Department |
| NV198    | Jagath     | Ahangama   | DD404          | P518S      | LT-01       | NV987        | DD404        | Deck Department |
+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql>
```

- Full outer join operation

```

mysql> /*full Outer Join*/
mysql> CREATE VIEW RIGHT_OUTER as SELECT * from UV6 as view6 right outer join uv7 as view7 on view6.Sailer_Department=view7.Department_ID;
Query OK, 0 rows affected (0.01 sec)

mysql> select * from RIGHT_OUTER;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor | Department_ID | Department_Name |
+-----+-----+-----+-----+-----+-----+-----+-----+
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL | CD244 | Communications Department |
| NV198 | Jagath | Ahangama | DD404 | P518S | LT-01 | NV987 | DD404 | Deck Department |
| NV777 | Zeek | Johanas | DD404 | B669S | CA-03 | NV084 | DD404 | Deck Department |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL | OD303 | Operations Department |
| NV084 | Indunil | Iduwara | TD505 | B669S | VA-02 | NV198 | TD505 | Training Department |
| NV124 | Pramod | Madusha | TD505 | B669S | CA-03 | NV084 | TD505 | Training Department |
+-----+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)

mysql> CREATE VIEW LEFT_OUTER as SELECT * from UV6 as view6 left outer join uv7 as view7 on view6.Sailer_Department=view7.Department_ID where view6.Sailer_Rank='TF-01' or view6.Sailer_Rank='VA-02' or view6.Sailer_Rank='CA-03';
Query OK, 0 rows affected (0.02 sec)

```

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```

mysql> CREATE VIEW LEFT_OUTER as SELECT * from UV6 as view6 left outer join uv7 as view7 on view6.Sailer_Department=view7.Department_ID where view6.Sailer_Rank='TF-01' or view6.Sailer_Rank='VA-02' or view6.Sailer_Rank='CA-03';
Query OK, 0 rows affected (0.02 sec)

mysql> select * from LEFT_OUTER;
+-----+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor | Department_ID | Department_Name |
+-----+-----+-----+-----+-----+-----+-----+-----+
| NV124 | Pramod | Madusha | TD505 | B669S | CA-03 | NV084 | TD505 | Training Department |
| NV777 | Zeek | Johanas | DD404 | B669S | CA-03 | NV084 | DD404 | Deck Department |
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL | CD244 | Communications Department |
| NV084 | Indunil | Iduwara | TD505 | B669S | VA-02 | NV198 | TD505 | Training Department |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL | OD303 | Operations Department |
+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> (SELECT * from RIGHT_OUTER) UNION (SELECT * from LEFT_OUTER);
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor | Department_ID | Department_Name |
+-----+-----+-----+-----+-----+-----+-----+
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL | CD244 | Communications Department |
| NV198 | Jagath | Ahangama | DD404 | P518S | LT-01 | NV987 | DD404 | Deck Department |
| NV777 | Zeek | Johanas | DD404 | B669S | CA-03 | NV084 | DD404 | Deck Department |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL | OD303 | Operations Department |
| NV084 | Indunil | Iduwara | TD505 | B669S | VA-02 | NV198 | TD505 | Training Department |
| NV124 | Pramod | Madusha | TD505 | B669S | CA-03 | NV084 | TD505 | Training Department |
+-----+-----+-----+-----+-----+-----+-----+

```

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- Outer union operation

```

mysql> select * from Base;
+-----+-----+-----+-----+
| Base_ID | Base_Department | Base_Name      | Country | State   |
+-----+-----+-----+-----+
| CD_01   | CD244        | WestPointCoast | Sri Lanka | Hambanthota |
| DD_44   | DD404        | NorthWest      | Australia | North Wales  |
| OD_87   | OD303        | SouthBase      | UK        | England   |
| SD_11   | DD404        | NorthBase      | USA       | Florida    |
| TD_11   | TD505        | NorthSouth     | Sri Lanka | Trincomalee |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> select * from Department;
+-----+-----+-----+-----+
| Department_ID | Department_Name | Country | State   | Department_Email |
+-----+-----+-----+-----+
| CD244        | Communications Department | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| DD404        | Deck Department      | UK        | England   | Deck404@gmail.com |
| OD303        | Operations Department | Australia | New South Wales | OpsDept303@gmail.com |
| TD505        | Training Department   | Sri Lanka | Trincomalee | TrainDP123@gmail.com |
+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> SELECT Base_ID, Base_Department AS Department_Name, Base_Name, Country, State, NULL AS Department_Email FROM Base
-> UNION ALL
-> SELECT Department_ID AS Base_ID, Department_Name, NULL AS Base_Name, Country, State, Department_Email FROM Department;
+-----+-----+-----+-----+-----+
| Base_ID | Department_Name | Base_Name      | Country | State   | Department_Email |
+-----+-----+-----+-----+-----+
| CD_01   | CD244        | WestPointCoast | Sri Lanka | Hambanthota | NULL             |
| DD_44   | DD404        | NorthWest      | Australia | North Wales | NULL             |
| OD_87   | OD303        | SouthBase      | UK        | England   | NULL             |
| SD_11   | DD404        | NorthBase      | USA       | Florida    | NULL             |
| TD_11   | TD505        | NorthSouth     | Sri Lanka | Trincomalee | NULL             |
| CD244        | Communications Department | NULL          | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| DD404        | Deck Department      | NULL          | UK        | England   | Deck404@gmail.com |
| OD303        | Operations Department | NULL          | Australia | New South Wales | OpsDept303@gmail.com |
| TD505        | Training Department   | NULL          | Sri Lanka | Trincomalee | TrainDP123@gmail.com |
+-----+-----+-----+-----+-----+

```

Nested queries in combination with any other relational algebraic operation are demonstrated below with aliasing.

- Nested query 1

```
mysql> SELECT * FROM sailer;
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+
| NV884 | Indunil | Iduwara | TD505 | B609S | VA-02 | NV198 |
| NV124 | Pramod | Madusha | TD505 | B609S | CA-03 | NV084 |
| NV198 | Jagath | Ahangama | DD404 | P518S | LT-01 | NV987 |
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL |
| NV777 | Zeek | Johanas | DD404 | B609S | CA-03 | NV084 |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL |
+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.00 sec)
```

```
mysql> SELECT * FROM Department;
+-----+-----+-----+-----+
| Department_ID | Department_Name | Country | State | Department_Email |
+-----+-----+-----+-----+
| CD244 | Communications Department | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| DD404 | Deck Department | UK | England | Deck404@gmail.com |
| OD303 | Operations Department | Australia | New South Wales | OpsDept303@gmail.com |
| TD505 | Training Department | Sri Lanka | Trincomalee | TrainDP123@gmail.com |
+-----+-----+-----+-----+
4 rows in set (0.00 sec)
```

```
mysql> SELECT * FROM Department WHERE state = 'Hambanthota' or state = 'England' or state = 'New South Wales';
+-----+-----+-----+-----+
| Department_ID | Department_Name | Country | State | Department_Email |
+-----+-----+-----+-----+
| CD244 | Communications Department | Sri Lanka | Hambanthota | CommDept202@gmail.com |
| DD404 | Deck Department | UK | England | Deck404@gmail.com |
| OD303 | Operations Department | Australia | New South Wales | OpsDept303@gmail.com |
+-----+-----+-----+-----+
3 rows in set (0.00 sec)
```

```
mysql> SELECT * FROM sailer WHERE Sailer_Department in ( SELECT Department_ID FROM Department WHERE state = 'Hambanthota' or state = 'England' or state = 'New South Wales');
+-----+-----+-----+-----+-----+-----+-----+
| Sailer_ID | First_Name | Last_Name | Sailer_Department | Sailer_Ship | Sailer_Rank | Sailer_Mentor |
+-----+-----+-----+-----+-----+-----+-----+
| NV234 | Sunil | Perera | CD244 | H101C | TF-01 | NULL |
| NV198 | Jagath | Ahangama | DD404 | P518S | LT-01 | NV987 |
| NV777 | Zeek | Johanas | DD404 | B609S | CA-03 | NV084 |
| NV987 | John | James | OD303 | M402C | VA-02 | NULL |
+-----+-----+-----+-----+-----+-----+-----+
```

- Nested query 2

```
mysql> SELECT * FROM ship;
+-----+-----+-----+-----+
| Ship_ID | Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+-----+
| B609S | Battleship | WARHAWK-55 | Naval Command |
| H101C | Heavy Carrier | PHOENIX-77 | A. Johnson |
| M402C | Mini Carrier | SEAGULL-9 | B. Jagath |
| P306S | Passenger | OCEANIA-12 | Lexer Ltd. |
| P518S | Passenger | CITY CRUISER | SL Routers |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> SELECT * FROM weapon;
+-----+-----+-----+-----+
| Weapon_ID | Ship_ID | Weapon_Name | Average_Weight | _Range_ |
+-----+-----+-----+-----+
| AT_00 | B609S | Mortars | 135.7 | Long |
| AT_90 | B609S | Anti-Tank Missile | 45.91 | Long |
| FA_77 | P306S | Shotgun | 3.6 | Short |
| MG_26 | M402C | MMG | 9.78 | Medium |
| MG_68 | H101C | LongMAG | 6.88 | Medium |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> SELECT * FROM certificate;
+-----+-----+-----+-----+
| Weapon_ID | Certificate_Name | Expiration_Date | Certificate_Type |
+-----+-----+-----+-----+
| AT_90 | Military Licenses | 2035-01-01 | Local |
| FA_77 | Specialized Licenses | 2030-09-12 | Local |
| MG_26 | CCP | 2025-09-07 | Local |
| MG_26 | Security Guard License | 2030-12-07 | Local |
| MG_68 | Enforcement Licenses | 2035-10-07 | International |
| MG_68 | Security Guard License | 2025-09-07 | International |
+-----+-----+-----+-----+
6 rows in set (0.00 sec)
```

21°C Partly cloudy Search Baidu Microsoft Edge OneDrive Mail File Explorer Task View Control Panel File History Snipping Tool Task Scheduler Task Manager File Explorer Task View Control Panel File History Snipping Tool Task Scheduler Task Manager ENG 10:34 PM 9/10/2023

```
mysql> SELECT * FROM certificate WHERE Expiration_Date > '2030-09-07';
+-----+-----+-----+-----+
| Weapon_ID | Certificate_Name | Expiration_Date | Certificate_Type |
+-----+-----+-----+-----+
| AT_90 | Military Licenses | 2035-01-01 | Local |
| FA_77 | Specialized Licenses | 2030-09-12 | Local |
| MG_26 | Security Guard License | 2030-12-07 | Local |
| MG_68 | Enforcement Licenses | 2035-10-07 | International |
+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> Select * from ship where Ship_ID in (SELECT W.Ship_ID FROM weapon as W WHERE W.Weapon_ID IN ( SELECT C.Weapon_ID FROM certificate as C WHERE Expiration_Date > '2030-09-07'));
+-----+-----+-----+-----+
| Ship_ID | Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+-----+
| B609S | Battleship | WARHAWK-55 | Naval Command |
| P306S | Passenger | OCEANIA-12 | Lexer Ltd. |
| M402C | Mini Carrier | SEAGULL-9 | B. Jagath |
| H101C | Heavy Carrier | PHOENIX-77 | A. Johnson |
+-----+-----+-----+-----+
```

21°C Partly cloudy Search Baidu Microsoft Edge OneDrive Mail File Explorer Task View Control Panel File History Snipping Tool Task Scheduler Task Manager ENG 10:35 PM 9/10/2023

- Nested query 3

```
mysql> SELECT * FROM ship;
+-----+-----+-----+-----+
| Ship_ID | Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+-----+
| B609S | Battleship | WARHAWK-55 | Naval Command |
| H101C | Heavy Carrier | PHOENIX-77 | A. Johnson |
| M402C | Mini Carrier | SEAGULL-9 | B. Jagath |
| P306S | Passenger | OCEANIA-12 | Lexer Ltd. |
| P518S | Passenger | CITY CRUISER | SL Routers |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> SELECT * FROM Weapon;
+-----+-----+-----+-----+
| Weapon_ID | Ship_ID | Weapon_Name | Average_Weight | _Range_ |
+-----+-----+-----+-----+
| AT_00 | B609S | Mortars | 135.7 | Long |
| AT_90 | B609S | Anti-Tank Missile | 45.91 | Long |
| FA_77 | P306S | Shotgun | 3.6 | Short |
| MG_26 | M402C | MMG | 9.78 | Medium |
| MG_68 | H101C | LongMAG | 6.88 | Medium |
+-----+-----+-----+-----+
5 rows in set (0.00 sec)
```



```
mysql> SELECT * FROM Weapon where Average_Weight>5;
+-----+-----+-----+-----+
| Weapon_ID | Ship_ID | Weapon_Name | Average_Weight | _Range_ |
+-----+-----+-----+-----+
| AT_00 | B609S | Mortars | 135.7 | Long |
| AT_90 | B609S | Anti-Tank Missile | 45.91 | Long |
| MG_26 | M402C | MMG | 9.78 | Medium |
| MG_68 | H101C | LongMAG | 6.88 | Medium |
+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> Select * from Ship where Ship_ID in(Select W.Ship_ID from Weapon as W where Weapon_ID in(Select Weapon_ID from weapon where Average_Weight>5));
+-----+-----+-----+
| Ship_ID | Ship_Type | Ship_Name | Ship_Owner |
+-----+-----+-----+
| B609S | Battleship | WARHAWK-55 | Naval Command |
| M402C | Mini Carrier | SEAGULL-9 | B. Jagath |
| H101C | Heavy Carrier | PHOENIX-77 | A. Johnson |
+-----+-----+-----+
3 rows in set (0.00 sec)
```



5 Chapter 5 - Database Tuning

Tuning complex queries in Chapter 5 involved several key steps to enhance their performance using indexing techniques. Here is a detailed breakdown of the process, which provides a clear understanding:

1. Removing Existing Indexes: Initially, any externally created indexes on the relevant tables were dropped. This step ensures that we start with a clean slate and can assess the impact of creating new indexes.
2. Displaying Table Indexes (Before): The current state of indexes on the tables was examined using the "SHOW INDEX" command. This allowed us to see the existing indexes on the tables before any modifications.
3. Analyzing Access Patterns (Before): The "EXPLAIN" command was used to determine the number of rows accessed when executing the query without any new indexes. This served as a baseline to measure the query's performance.
4. Creating Suitable Index: A new index, tailored to the specific query, was created. The goal was to optimize the query's execution time and resource usage.
5. Displaying Table Indexes (After): Post-index creation, the "SHOW INDEX" command was used again to confirm the existence and structure of the newly created index.
6. Analyzing Access Patterns (After): The "EXPLAIN" command was once again employed to evaluate the number of rows accessed when executing the query with the newly created index in place.

Tuning a query was determined by comparing the number of accessed rows in the "EXPLAIN" output before and after the index creation. If there was a reduction in the number of accessed rows after creating the index, it indicated a successful query optimization. This means that the query's performance had improved, as fewer rows were being processed to fetch the desired results.

In all the screenshots provided below, you can observe that the number of accessed rows decreased after the suitable index was created, confirming the successful tuning of the query. This optimization ensures that the query executes more efficiently and with improved speed.

- Tuning of Intersect operation

```

MySQL 8.0 Command Line Client
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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or 'h' for help. Type '\c' to clear the current input statement.

mysql> use nav;
Database changed
mysql> SHOW INDEX FROM service_history;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Sailer_ID | A | 5 | NULL | NULL | BTREE | YES | NULL |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.02 sec)

ERROR:
No query specified

mysql> EXPLAIN(Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department,H.Service_Type,H.Registered_Date,H.Resignation_Date from Sailer as S inner join service_history as H on S.Sailer_ID=H.Sailer_ID where Years_of_Service>5);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | H | NULL | ALL | PRIMARY | NULL | NULL | NULL | 8 | 33.33 | Using where |
| 1 | SIMPLE | S | NULL | eq_ref | PRIMARY | PRIMARY | 22 | navy.H.Sailer_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX year_idx on service_history(Years_of_Service);
Query OK, 0 rows affected (0.06 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM service_history;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Sailer_ID | A | 5 | NULL | NULL | BTREE | YES | NULL |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | year_idx | 1 | Years_of_Service | A | 8 | NULL | NULL | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.01 sec)

mysql> EXPLAIN(Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department,H.Service_Type,H.Registered_Date,H.Resignation_Date from Sailer as S inner join service_history as H on S.Sailer_ID=H.Sailer_ID where Years_of_Service>5);
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | S | NULL | ALL | PRIMARY | NULL | NULL | NULL | 6 | 100.00 | NULL |
| 1 | SIMPLE | H | NULL | ref | PRIMARY | PRIMARY | 22 | navy.S.Sailer_ID | 1 | 50.00 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>

```

- Tuning of Set difference operation

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM service_history;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Sailer_ID | A | 5 | NULL | NULL | BTREE | YES | NULL |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | year_idx | 1 | Years_of_Service | A | 8 | NULL | NULL | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> EXPLAIN(Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department from sailor as S where S.Sailer_ID NOT IN (Select Years_of_Service from service_history where Resignation_Date='2000-01-01' or Resignation_Date='2017-11-12'));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | S | NULL | ALL | NULL | NULL | NULL | NULL | 6 | 100.00 | Using where |
| 2 | SUBQUERY | service_history | NULL | ALL | year_idx | NULL | NULL | NULL | 8 | 23.44 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX Resigdate_idx on service_history(Resignation_Date);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM service_history;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Sailer_ID | A | 5 | NULL | NULL | BTREE | YES | NULL | |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | Resigdate_idx | 1 | Resignation_Date | A | 8 | NULL | NULL | YES | BTREE | YES | NULL |
| service_history | 1 | year_idx | 1 | Years_of_Service | A | 8 | NULL | NULL | YES | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> EXPLAIN(Select S.Sailer_ID,S.Sailer_Rank,S.Sailer_Department from sailor as S where S.Sailer_ID NOT IN (Select Years_of_Service from service_history where Resignation_Date='2000-01-01' or Resignation_Date='2017-11-12'));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | S | NULL | ALL | NULL | NULL | NULL | NULL | 6 | 100.00 | Using where |
| 2 | SUBQUERY | service_history | NULL | range | Resigdate_idx,year_idx | Resigdate_idx | 4 | NULL | 2 | 100.00 | Using index condition |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>

```

- Tuning of Set Division operation

```

MySQL 8.0 Command Line Client
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Saller_ID | A | 5 | NULL | NULL | BTREE | YES | NULL |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | Resigdate_idx | 1 | Resignation_Date | A | 8 | NULL | YES | BTREE | YES | NULL |
| service_history | 1 | year_idx | 1 | Years_of_Service | A | 8 | NULL | NULL | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set (0.00 sec)

mysql> EXPLAIN SELECT DISTINCT Service_Type from service_history as S1 where not exists (select distinct Sh.Saller_ID from service_history as Sh where S1.Registered_Date = '2003-08-21' or S1.Registered_Date = '1998-02-25' AND Sh.saller_ID not in (SELECT S2.Saller_ID from service_history as S2 where S2.Service_Type=S1.Service_Type));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | S1 | NULL | ALL | PRIMARY,Resigdate_idx,year_idx | NULL | NULL | NULL | 8 | 100.00 | Using temporary |
| 1 | PRIMARY | Sh | NULL | index | NULL | Resigdate_idx | 4 | NULL | 8 | 100.00 | Using where; Not exists; Using index; Distinct; Using join buffer |
| 3 | DEPENDENT SUBQUERY | S2 | NULL | unique_subquery | PRIMARY | PRIMARY | 84 | func,navy.S1.Service_Type | 1 | 100.00 | Using index |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 4 warnings (0.00 sec)

mysql> CREATE INDEX Servie_idx on service_history(Registered_Date);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM service_history;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| service_history | 0 | PRIMARY | 1 | Saller_ID | A | 5 | NULL | NULL | BTREE | YES | NULL |
| service_history | 0 | PRIMARY | 2 | Service_Type | A | 8 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | Resigdate_idx | 1 | Resignation_Date | A | 8 | NULL | YES | BTREE | YES | NULL |
| service_history | 1 | Servie_idx | 1 | Registered_Date | A | 7 | NULL | NULL | BTREE | YES | NULL |
| service_history | 1 | year_idx | 1 | Years_of_Service | A | 8 | NULL | NULL | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.01 sec)

mysql> EXPLAIN SELECT DISTINCT Service_Type from service_history as S1 where not exists (select distinct Sh.Saller_ID from service_history as Sh where S1.Registered_Date = '2003-08-21' or S1.Registered_Date = '1998-02-25' AND Sh.saller_ID not in (SELECT S2.Saller_ID from service_history as S2 where S2.Service_Type=S1.Service_Type));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | PRIMARY | S1 | NULL | index | PRIMARY,Resigdate_idx,Servie_idx,year_idx | Servie_idx | 4 | NULL | 8 | 100.00 | Using index; Using temporary |
| 1 | PRIMARY | Sh | NULL | index | NULL | Resigdate_idx | 4 | NULL | 8 | 100.00 | Using where; Not exists; Using index; Distinct; Using join buffer (hash join) |
| 3 | DEPENDENT SUBQUERY | S2 | NULL | unique_subquery | PRIMARY | PRIMARY | 84 | func,navy.S1.Service_Type | 1 | 100.00 | Using index |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 4 warnings (0.00 sec)

mysql>
```

- Tuning of Inner join operation

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql> SHOW INDEX FROM sailler;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| sailler | 0 | PRIMARY | 1 | Saller_ID | A | 6 | NULL | NULL | BTREE | YES | NULL |
| sailler | 1 | FK_Mentor | 1 | Saller_Mentor | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Ship | 1 | Saller_Ship | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Rank | 1 | Saller_Rank | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Department | 1 | Saller_Department | A | 4 | NULL | YES | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> EXPLAINN select View2.* ,View3.Rank_ID from UV2 as View2 inner join UV3 as View3 on View2.Saller_Rank=View3.Rank_ID where first_name = 'Indunil' or first_name = 'Pramod' or first_name = 'Sunil';
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | sailler | NULL | ALL | FK_Rank | NULL | NULL | 6 | 42.13 | Using where |
| 1 | SIMPLE | _rank_ | NULL | eq_ref | PRIMARY | PRIMARY | 22 | func | 1 | 100.00 | Using where; Using index |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX ft_name on sailler(First_Name);
Query OK, 0 rows affected (0.06 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM sailler;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| sailler | 0 | PRIMARY | 1 | Saller_ID | A | 6 | NULL | NULL | BTREE | YES | NULL | |
| sailler | 1 | FK_Mentor | 1 | Saller_Mentor | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Ship | 1 | Saller_Ship | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Rank | 1 | Saller_Rank | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | FK_Department | 1 | Saller_Department | A | 4 | NULL | YES | BTREE | YES | NULL |
| sailler | 1 | ft_name | 1 | First_Name | A | 6 | NULL | NULL | YES | BTREE | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
6 rows in set (0.01 sec)

mysql> EXPLANIN select View2.* ,View3.Rank_ID from UV2 as View2 inner join UV3 as View3 on View2.Saller_Rank=View3.Rank_ID where first_name = 'Indunil' or first_name = 'Pramod' or first_name = 'Sunil';
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | sailler | NULL | range | FK_Rank,ft_name | ft_name | 63 | NULL | 3 | 100.00 | Using index condition; Using where |
| 1 | SIMPLE | _rank_ | NULL | eq_ref | PRIMARY | PRIMARY | 22 | func | 1 | 100.00 | Using where; Using index |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>
```

- Tuning of Natural join operation

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM Ship;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed |
| ship |          0 | PRIMARY |          1 | Ship_ID | A |           5 |       NULL |    NULL |
| ship |          1 |          |          1 | Ship_Owner | A |           5 |       NULL |    NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
1 row in set (0.00 sec)

mysql> EXPLAINN(SELECT DISTINCT view5.* ,view4.* From UV4 as view4 natural join UV5 as view5 where view5.Ship.Owner = "Naval Command");
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref |
| 1 | SIMPLE | ship |      NULL | ALL | NULL | NULL | NULL | NULL |
| 1 | SIMPLE | weapon |      NULL | ALL | NULL | NULL | NULL | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX ship_owner_ix on Ship(Ship_Owner);
Query OK, 0 rows affected (0.63 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM Ship;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed |
| ship |          0 | PRIMARY |          1 | Ship_ID | A |           5 |       NULL |    NULL |
| ship |          1 | ship_owner_ix |          1 | Ship_Owner | A |           5 |       NULL |    NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> EXPLAINN(SELECT DISTINCT view5.* ,view4.* From UV4 as view4 natural join UV5 as view5 where view5.Ship.Owner = "Naval Command");
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref |
| 1 | SIMPLE | ship |      NULL | ref | ship_owner_ix | ship_owner_ix | 83 | const |
| 1 | SIMPLE | weapon |      NULL | ALL | NULL | NULL | NULL | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> -

```

- Tuning of Right outer join operation

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM Department;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed |
| department |          0 | PRIMARY |          1 | Department_ID | A |           4 |       NULL |    NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
1 row in set (0.00 sec)

mysql> EXPLAINN(SELECT * From UV6 as view6 right outer join uv7 as view7 on view6.Sailor_Department=view7.Department_ID where Department_Name="Deck Department" or Department_Name="Training Department");
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref |
| 1 | SIMPLE | department |      NULL | ALL | NULL | NULL | NULL | NULL |
| 1 | SIMPLE | sailor |      NULL | ref | FK_Department | FK_Department | 23 | navy.department.Department_ID |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX dp_name_idx on Department(Department_Name);
Query OK, 0 rows affected (0.07 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM Department;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed |
| department |          0 | PRIMARY |          1 | Department_ID | A |           4 |       NULL |    NULL |
| department |          1 | dp_name_idx |          1 | Department_Name | A |           4 |       NULL |    NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> EXPLAINN(SELECT * from UV6 as view6 right outer join uv7 as view7 on view6.Sailor_Department=view7.Department_ID where Department_Name="Deck Department" or Department_Name="Training Department");
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref |
| 1 | SIMPLE | department |      NULL | range | dp_name_idx | dp_name_idx | 12 | NULL |
| 1 | SIMPLE | sailor |      NULL | ref | FK_Department | FK_Department | 23 | navy.department.Department_ID |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> -

```

- Tuning of Left Outer Join Operation

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM Sailor;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| sailor | 0 | PRIMARY | 1 | Sailor_ID | A | 6 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Mentor | 1 | Sailor_Mentor | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Rank | 1 | Sailor_Rank | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Department | 1 | Sailor_Department | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | ft_name | 1 | First_Name | A | 6 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
5 rows in set (0.00 sec)

mysql> EXPLAIN(SELECT * from UV6 as view6 left outer join uv7 as view7 on view6.Sailor_Department=view7.Department_ID where view6.last_name like 'a%' or last_name like 'm%');
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | sailor | NULL | ALL | possible_keys | key | key_len | ref | rows | filtered | Extra |
| 1 | SIMPLE | department | NULL | eq_ref | PRIMARY | PRIMARY | PRIMARY | 22 | navy.sailor.Sailor_Department | 6 | 30.56 | Using where |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX last_name_idx on Sailor(Last_Name);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM Sailor;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| sailor | 0 | PRIMARY | 1 | Sailor_ID | A | 6 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Mentor | 1 | Sailor_Mentor | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Rank | 1 | Sailor_Rank | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | FK_Department | 1 | Sailor_Department | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | ft_name | 1 | First_Name | A | 6 | NULL | NULL | YES | BTREE |  | YES | NULL |
| sailor | 1 | last_name_idx | 1 | Last_Name | A | 6 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
7 rows in set (0.00 sec)

mysql> EXPLAIN(SELECT * from UV6 as view6 left outer join uv7 as view7 on view6.Sailor_Department=view7.Department_ID where view6.last_name like 'a%' or last_name like 'm%');
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | sailor | NULL | range | last_name_idx | last_name_idx | 63 | NULL | 2 | 100.00 | Using index condition |
| 1 | SIMPLE | department | NULL | eq_ref | PRIMARY | PRIMARY | PRIMARY | 22 | navy.sailor.Sailor_Department | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>

```

- Tuning of Nested query 1

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql> SHOW INDEX FROM Department;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| department | 0 | PRIMARY | 1 | Department_ID | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| department | 1 | dp_name_idx | 1 | Department_Name | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> EXPLAIN(SELECT * FROM sailor WHERE Sailor_Department in ( SELECT Department_ID FROM Department WHERE state = 'Hambantota' or state = 'England' or state = 'New South Wales'));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | Department | NULL | ALL | PRIMARY | PRIMARY | PRIMARY | 23 | navy.Department.Department_ID | 4 | 57.81 | Using where |
| 1 | SIMPLE | sailor | NULL | ref | FK_Department | FK_Department | FK_Department | 23 | navy.Department.Department_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>
mysql> CREATE INDEX state_idx on Department(state);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM Department;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| department | 0 | PRIMARY | 1 | Department_ID | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| department | 1 | dp_name_idx | 1 | Department_Name | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
| department | 1 | state_idx | 1 | State | A | 4 | NULL | NULL | YES | BTREE |  | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.01 sec)

mysql> EXPLAIN(SELECT * FROM sailor WHERE Sailor_Department in ( SELECT Department_ID FROM Department WHERE state = 'Hambantota' or state = 'England' or state = 'New South Wales'));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | Department | NULL | range | PRIMARY,state_idx | state_idx | PRIMARY | 23 | navy.Department.Department_ID | 3 | 100.00 | Using where; Using index |
| 1 | SIMPLE | sailor | NULL | ref | FK_Department | FK_Department | FK_Department | 23 | navy.Department.Department_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set, 1 warning (0.00 sec)

mysql>

```

- Tuning of Nested query 2

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM certificate;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_Index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| certificate | 0 | PRIMARY | 1 | Weapon_ID | A | 4 | NULL | NULL | BTREE | | YES | NULL |
| certificate | 0 | PRIMARY | 2 | Certificate_Name | A | 6 | NULL | NULL | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> EXPLAINN(Select * from ship where Ship_ID in (SELECT W.Ship_ID FROM weapon as W WHERE W.Weapon_ID IN ( SELECT C.Weapon_ID FROM certificate as C WHERE Expiration_Date > '2030-09-07')));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | C | NULL | ALL | PRIMARY | NULL | NULL | NULL | 6 | 33.33 | Using where; Start temporary |
| 1 | SIMPLE | W | NULL | eq_ref | PRIMARY,FK_CarrierShip | PRIMARY | 22 | navy.C.Weapon_ID | 1 | 100.00 | Using where |
| 1 | SIMPLE | ship | NULL | eq_ref | PRIMARY | PRIMARY | 22 | navy.W.Ship_ID | 1 | 100.00 | End temporary |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX exp_date_idx on certificate(Expiration_Date);
Query OK, 0 rows affected (0.02 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM certificate;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_Index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| certificate | 0 | PRIMARY | 1 | Weapon_ID | A | 4 | NULL | NULL | BTREE | | YES | NULL |
| certificate | 0 | PRIMARY | 2 | Certificate_Name | A | 6 | NULL | NULL | BTREE | | YES | NULL |
| certificate | 1 | exp_date_idx | 1 | Expiration_Date | A | 5 | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> EXPLAINN(Select * from ship where Ship_ID in (SELECT W.Ship_ID FROM weapon as W WHERE W.Weapon_ID IN ( SELECT C.Weapon_ID FROM certificate as C WHERE Expiration_Date > '2030-09-07')));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | W | NULL | index | PRIMARY,FK_CarrierShip | FK_CarrierShip | 23 | NULL | 5 | 80.00 | Using where; Using index; LooseScan |
| 1 | SIMPLE | C | NULL | ref | PRIMARY,exp_date_idx | PRIMARY | 22 | navy.W.Weapon_ID | 1 | 66.67 | Using where; FirstMatch(W) |
| 1 | SIMPLE | ship | NULL | eq_ref | PRIMARY | PRIMARY | 22 | navy.W.Ship_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> -

```

- Tuning of Nested query 3

```

MySQL 8.0 Command Line Client
mysql>
mysql>
mysql>
mysql> SHOW INDEX FROM weapon;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_Index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| weapon | 0 | PRIMARY | 1 | Weapon_ID | A | 5 | NULL | NULL | BTREE | | YES | NULL |
| weapon | 1 | FK_CarrierShip | 1 | Ship_ID | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
2 rows in set (0.00 sec)

mysql> EXPLAINN(Select * from Ship where Ship_ID in (Select W.Ship_ID from Weapon as W where Weapon_ID in (Select Weapon_ID from weapon where Average_Weight>5)));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | <subquery2> | NULL | ALL | NULL | NULL | NULL | NULL | 1 | 100.00 | Using where |
| 1 | SIMPLE | Ship | NULL | eq_ref | PRIMARY | PRIMARY | 22 | <subquery2>.Ship_ID | 1 | 100.00 | NULL |
| 2 | MATERIALIZED | weapon | NULL | ALL | PRIMARY | NULL | NULL | NULL | 5 | 33.33 | Using where |
| 2 | MATERIALIZED | W | NULL | eq_ref | PRIMARY,FK_CarrierShip | PRIMARY | 22 | navy.weapon.Weapon_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
4 rows in set, 1 warning (0.00 sec)

mysql> CREATE INDEX avg_wei_idx on weapon(Average_Weight);
Query OK, 0 rows affected (0.03 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> SHOW INDEX FROM weapon;
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Table | Non_unique | Key_name | Seq_in_Index | Column_name | Collation | Cardinality | Sub_part | Packed | Null | Index_type | Comment | Index_comment | Visible | Expression |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| weapon | 0 | PRIMARY | 1 | Weapon_ID | A | 5 | NULL | NULL | BTREE | | YES | NULL | |
| weapon | 1 | FK_CarrierShip | 1 | Ship_ID | A | 4 | NULL | NULL | YES | BTREE | | YES | NULL |
| weapon | 1 | avg_wei_idx | 1 | Average_Weight | A | 5 | NULL | NULL | YES | BTREE | | YES | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.01 sec)

mysql> EXPLAINN(Select * from Ship where Ship_ID in (Select W.Ship_ID from Weapon as W where Weapon_ID in (Select Weapon_ID from weapon where Average_Weight>5)));
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | <subquery2> | NULL | index | PRIMARY,FK_CarrierShip | FK_CarrierShip | 23 | NULL | 5 | 80.00 | Using where; Using index; LooseScan |
| 1 | SIMPLE | weapon | NULL | eq_ref | PRIMARY,avg_wei_idx | PRIMARY | 22 | navy.W.Weapon_ID | 1 | 80.00 | Using where; FirstMatch(W) |
| 1 | SIMPLE | Ship | NULL | eq_ref | PRIMARY | PRIMARY | 22 | navy.W.Ship_ID | 1 | 100.00 | NULL |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set, 1 warning (0.00 sec)

mysql> -

```