**1. Refine schema**   
(Original Schema from Phase 1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Users** | | | | | |
| **username** | **email** | **age** | **rating** | **password** | **income** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Credit Cards** | | | |
| **username** | **card Number** | **expiration date** | **type** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **User Addresses** | | | | |
| **username** | **state** | **city** | **street** | **zip** |

|  |  |  |  |
| --- | --- | --- | --- |
| **Dealers** | | | |
| **dname** | **account** | **phone** | **rating** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Owns** | | | | |
| **dname** | **Vin** | **start time** | **type** | **status** |

|  |  |
| --- | --- |
| **Phones** | |
| **username** | **phone number** |

|  |  |  |
| --- | --- | --- |
| **Name** | | |
| **username** | **last name** | **first name** |

|  |  |
| --- | --- |
| **Cars** | |
| **vin** | **attributes…..** |

|  |  |
| --- | --- |
| **Buys** | |
| **username** | **vin** |

|  |  |
| --- | --- |
| **Bids** | |
| **username** | **vin** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dealer Addresses** | | | | |
| **dname** | **state** | **city** | **street** | **zip** |

After schema refinement:

Everything in green are the changes and updates, and everything in red are the objects to be removed.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **User** | | | | | | | | | | |
| **username** | **email** | dob | **rating** | **pwd** | **income** | Phone1 | Phone2 | last name | first name | addressid |

Instead of AGE, we have dob here so that we don’t need to update user age every year.

Addressid refers to the primary key in the Table Addresses to determine user’s address.

Table Phones is removed since we find it better as user attribute.

Table Name is removed, and the last name and first name are added as user attributes.

|  |  |  |  |
| --- | --- | --- | --- |
| **Credit Card** | | | |
| **username** | **card Number** | **expiration date** | **type** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Addresses | | | | |
| **addressid** | **zip** | **street** | **city** | **state** |

We have combined the two tables of the User Addresses, and the Dealer Addresses into one table named Addresses. Addressed is the primary key of the Table.

Zip can be determined by city and state. But city or state cannot be determined only by zip, example, 42223 can be Kentucky or Tennessee. And for city Gainesville, it can be in FL or VA (2 cities in different state named Gainesville).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dealers** | | | | |
| **dname** | **account** | **phone** | **rating** | addressid |

Addressid refers to the primary key in the Table Addresses to determine dealer’s address.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Owns** | | | | |
| **dname** | **vin** | **start time** | **type** | **status** |

|  |  |
| --- | --- |
| Phones | |
| username | phone number |

This table is removed; such entity has been added to table User as attribute.

|  |  |  |
| --- | --- | --- |
| Name | | |
| username | last name | first name |

This table is removed; such entity has been added to table User as attribute.

|  |  |  |
| --- | --- | --- |
| **Cars** | | |
| **vin** | **attributes…..** | current bid |

Current bid is added to this table since it reflects the current highest bid on the listing when the listing type is auction.

|  |  |  |  |
| --- | --- | --- | --- |
| **Buys** | | | |
| **username** | **vin** | price | time |

Price and time are added as attributes to the buying process.

|  |  |
| --- | --- |
| Bids | |
| username | Vin |

Table Bidding replaces the table Bids.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dealer Addresses | | | | |
| dname | state | city | street | zip |

Table Dealer is removed, and it is merged into the Addresses table.

|  |  |  |  |
| --- | --- | --- | --- |
| Bidding | | | |
| bidid | price | time | username |

Bidding table is created to reflect the bidding activities. The primary key bidid is the unique identifier for every bid buyer places on the cars owned by the dealer.

**2.Reduce to 1NF**

To be in 1NF:

A relation is in first normal form if and only if the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values, and the value of each attribute contains only a single value from that domain.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **User** | | | | | | | | | | |
| **username** | **email** | dob | **rating** | **pwd** | **income** | Phone1 | Phone2 | last name | first name | addressid |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| **Credit Cards** | | | |
| **username** | **card Number** | **expiration date** | **type** |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| Addresses | | | |
| **addressid** | **street** | **city** | **state** |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dealers** | | | | |
| **dname** | **account** | **phone** | **rating** | addressid |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Owns** | | | | |
| **dname** | **vin** | **start time** | **type** | **status** |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |
| --- | --- | --- |
| **Cars** | | |
| **vin** | **attributes…..** | current bid |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| **Buys** | | | |
| **username** | **vin** | price | time |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| Bidding | | | |
| bidid | price | time | username |

the [domain](https://en.wikipedia.org/wiki/Data_domain) of each [attribute](https://en.wikipedia.org/wiki/Column_(database)) contains only [atomic](https://en.wikipedia.org/wiki/First_normal_form#Atomicity)(indivisible) values 🡪check!

value of each attribute contains only a single value from that domain 🡪check!

**2.Reduce into 2NF**  
  
To be in 2NF:

A table is in 2NF if it is in 1NF and every non-prime attribute of the table is dependent on the whole of every candidate key.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **User** | | | | | | | | | | |
| **username** | **email** | dob | **rating** | **pwd** | **income** | Phone1 | Phone2 | last name | first name | addressid |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(Username🡪email dob rating pwd income phone lastname firstname addressed)

|  |  |  |  |
| --- | --- | --- | --- |
| Payment | | | |
| **username** | **card Number** | **expiration date** | **type** |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(Username🡪cardNumber expirationDate type)

|  |  |  |  |
| --- | --- | --- | --- |
| Addresses | | | |
| **addressid** | **street** | **city** | **state** |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(addressid🡪street city state)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dealers** | | | | |
| **dname** | **account** | **phone** | **rating** | addressid |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(dname🡪account phone rating addressid)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Owns** | | | | |
| **dname** | **vin** | **start time** | **type** | **status** |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪Uncheck!

Refine: put startTime, type, status into cars table, as attributes. Owns table changes into:

|  |  |
| --- | --- |
| **Owns** | |
| **vin** | **dname** |

Change to only have vin as primary key, then it satisfies every non-prime attribute of the table is dependent on the whole of every candidate key. 🡪check!

(vin🡪dname)

|  |  |  |
| --- | --- | --- |
| **Cars** | | |
| **vin** | **attributes…..** | current bid |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(vin🡪attributes currentBid)

|  |  |  |  |
| --- | --- | --- | --- |
| **Buys** | | | |
| **username** | **vin** | price | time |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(username🡪vin price time)

|  |  |  |  |
| --- | --- | --- | --- |
| Bidding | | | |
| bidid | price | time | username |

In 1NF 🡪check!

every non-prime attribute of the table is dependent on the whole of every candidate key.🡪check!

(bidid🡪 price time username)

**3.Reduce into 3NF**

To be in 3NF:

(1) the entity is in second normal form, and (2) all the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **User** | | | | | | | | | | |
| **username** | **email** | dob | **rating** | **pwd** | **income** | Phone1 | Phone2 | last name | first name | addressid |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪Uncheck!

Since email is unique, it can be used to determine the following attributes just like username.

So we decompose the User table into 2 table.

**User table:**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **User** | | | | | | | | | |
| **username** | dob | **rating** | **pwd** | **income** | Phone1 | Phone2 | last name | first name | addressid |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

**Reg table:**

|  |  |
| --- | --- |
| **User** | |
| **Username** | **email** |

The entity is in second normal form (username🡪email) 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| **Credit Cards** | | | |
| **username** | **card Number** | **expiration date** | **type** |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪Uncheck!

Since card Number can determine expiration date and type, and card number is a non-prime attributes. It is not a 3NF.

Decompose into 2 tables:

**Credit Cards table:**

|  |  |  |
| --- | --- | --- |
| **Credit Cards** | | |
| **card Number** | **expiration date** | **type** |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

**Payment table:**

|  |  |
| --- | --- |
| **Credit Cards** | |
| **Username** | **Card Number** |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| Addresses | | | |
| **addressid** | **street** | **city** | **state** |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dealers** | | | | |
| **dname** | **account** | **phone** | **rating** | addressid |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |
| --- | --- |
| **Owns** | |
| **vin** | **dname** |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes.

|  |  |  |
| --- | --- | --- |
| **Cars** | | |
| **vin** | **attributes…..** | current bid |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| **Buys** | | | |
| **username** | **vin** | price | time |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

|  |  |  |  |
| --- | --- | --- | --- |
| Bidding | | | |
| bidid | price | time | username |

The entity is in second normal form 🡪check!

All the attributes in a table are determined only by the candidate keys of that table and not by any non-prime attributes. 🡪check!

Now, every table is in 3NF, part 1 completed.