**N&N** Hospital is facing problems in its data organization. As database analyst, you have to normalize following N&N Hospital data up to **4NF**. Elaborate each step you perform with logic and state clearly any other **VALID** assumption that you make.

| Doc no. | Name | Address | Phone | Department Id | Designation | Charges Per hour | Patient No. | Patient Name | CNIC | Phone | Room No. | Room Type | Bed No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | Dr.Nadeem | Abc 123 | 0333-123, 042-123 | Neurology | Professor | 5000 | P1 | Kahlid | 12345-1 | 042-1 | R2 | Normal | B1 |
| | | | | | | | P5 | Ahmed | 12345-2 | 042-2 | | | |
| | | | | | | | P7 | Anum | 12345-3 | 042-3 | Nill | | Nill |
| D2 | Dr.Nadeem | Kb13 | 0334-124, 0300-123 | Orthopedic | Professor | 5000 | P4 | Mehmood | 12345-4 | 042-4 | R2 | Normal | B1 |
| | | | | | | | P7 | Anum | 12345-3 | 042-3 | R4 | Two bed | B5 |
| | | | | | | | P9 | Khawar | 12345-6 | 042-5 | | | B7 |
| D4 | Dr.Erum | Ak123 | 0321-123 | ENT/ Neurology | Astt. Professor | 3000 | P10 | Tanweer | 12345-7 | 042-6 | Nill | | Nill |
| | | | | | | | P1 | Khalid | 12345-1 | 042-1 | R5 | Special | B8 |
| D5 | Dr.Hafeez | Nd123 | 0321-124 | Skin/ Orthopedic | Astt. Professor | 3000 | P12 | Sohail | 12345-9 | 042-8 | Nill | | Nill |
| | | | | | | | P13 | Ahmed | 12346-0 | 042-9 | R6 | Special | B9 |

# a) 1NF:

changes required -

1. change 'Name' to: (Salutaion, FName)
2. change multiple phone number to Phone_1 & Phone_2. If a doctor has only one number we put Null in Phone_2.
3. Also keep the multivalued attribures like PatientNo., PAtirentName, CNIC, Phone, RoomNo., RoomType, BedNo. in separate tupples. (change the 'Phone' (of the patient) to 'P_Phone' to avoid confusion)
4. Assumption – the 'Nill' or empty values in RoomNo., RoomType or BedNo. are assumed to be 'NoRoom', 'NoType', 'NoBed'.

The functional dependencies in the given data are ->

**FD1:** (DocNo.) -> (Salutaion, FName, Address,Phone_1, Phone_2, Dept.Id, Designation, Charges per hour)

**FD2:** (Patient No.) -> (PatientName, CNIC, P_Phone)

**FD3:** (DocNo., PatientNo.) -> (RoomNo., RoomType, BedNo)

**FD4:** (RoomNo.) -> (RoomType)

The table will look like the following after applying above changes:

| Doc no. | Salutation | FName | Address | Phone_1 | Phone_2 | Department Id | Designation | Charges Per hour | Patient No. | Patient Name | CNIC | P_Phone | RoomNo. | RoomType | BedNo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | Dr. | Nadeem | Abc123 | 0333-123 | 042-123 | Neurology | Professor | 5000 | P1 | Khalid | 12345-1 | 042-1 | R2 | Normal | B1 |
| D1 | Dr. | Nadeem | Abc123 | 0333-123 | 042-123 | Neurology | Professor | 5000 | P5 | Ahmed | 12345-2 | 042-2 | R2 | Normal | B1 |
| D1 | Dr. | Nadeem | Abc123 | 0333-123 | 042-123 | Neurology | Professor | 5000 | P7 | Anum | 12345-3 | 042-3 | NoRoom | NoType | NoBed |
| D2 | Dr. | Nadeem | Kb13 | 0334-124 | 0300-123 | Orthopedic | Professor | 5000 | P4 | Mehmood | 12345-4 | 042-4 | R2 | Normal | B1 |
| D2 | Dr. | Nadeem | Kb13 | 0334-124 | 0300-123 | Orthopedic | Professor | 5000 | P7 | Anum | 12345-3 | 042-3 | R4 | Two Bed | B5 |
| D2 | Dr. | Nadeem | Kb13 | 0334-124 | 0300-123 | Orthopedic | Professor | 5000 | P9 | Khawar | 12345-6 | 042-5 | R4 | Two Bed | B7 |
| D4 | Dr. | Erum | Ak123 | 0321-123 | Null | ENT/Neurology | Astt. Professor | 3000 | P10 | Tanweer | 12345-1 | 042-6 | NoRoom | NoType | NoBed |
| D4 | Dr. | Erum | Ak123 | 0321-123 | Null | ENT/Neurology | Astt. Professor | 3000 | P1 | Khalid | 12345-6 | 042-1 | R5 | special | B8 |
| D5 | Dr. | Hafeez | Nd123 | 0321-124 | Null | Skin/Orthopedic | Astt. Professor | 3000 | P12 | Sohali | 12345-9 | 042-8 | NoRoom | NoType | NoBed |
| D5 | Dr. | Hafeez | Nd123 | 0321-124 | Null | Skin/Orthopedic | Astt. Professor | 3000 | P13 | Ahmed | 12346-0 | 042-9 | R6 | Special | B9 |

# b) 2NF:

In above table the Primary key is : (DocNo.+PatientNo)

But the Relation is not in 2NF as there are partial dependencies on the primary key (Candidate key) due to functional depenedies FD1 and FD2 listed above.

So we split the above table as shown:

**Original Table :   T( Doc no., Desgnation, FName,  Address,  Phone, Department Id, Designation, Charges Per hour, Patient No., Patient Name, CNIC, P_Phone, RoomNo., RoomType, BedNo )**

**New Tables : T1(Doc no., Desgnation, FName,  Address,  Phone_1, Phone_2, Department Id, Designation, Charges Per hour);**

**T2(Patient No., Patient Name, CNIC, P_Phone) ;**

**T3: (Doc no , Patient No., RoomNo., RoomType, BedNo);**

**T1:**

| Doc no. | Salutation | FName | Address | Phone_1 | Phone_2 | Department Id | Designation |
|---------|------------|-------|---------|---------|---------|---------------|-------------|
| D1 | Dr. | Nadeem | Abc123 | 0333-123 | 042-123 | Neurology | Professor |
| D2 | Dr. | Nadeem | Kb13 | 0334-124 | 0300-123 | Orthopedic | Professor |
| D4 | Dr. | Erum | Ak123 | 0321-123 | Null | ENT/Neurology | Astt. Professor |
| D5 | Dr. | Hafeez | Nd123 | 0321-124 | Null | Skin/Orthopedic | Astt. Professor |

**T2:**

| Patient No. | Patient Name | CNIC | P_Phone |
|-------------|--------------|------|---------|
| P1 | Khalid | 12345-1 | 042-1 |
| P5 | Ahmed | 12345-2 | 042-2 |
| P7 | Anum | 12345-3 | 042-3 |
| P1 | Khalid | 12345-1 | 042-1 |
| P5 | Ahmed | 12345-2 | 042-2 |
| P7 | Anum | 12345-3 | 042-3 |
| P4 | Mehmood | 12345-4 | 042-4 |
| P7 | Anum | 12345-3 | 042-3 |
| P9 | Khawar | 12345-6 | 042-5 |
| P4 | Mehmood | 12345-4 | 042-4 |
| P7 | Anum | 12345-3 | 042-3 |
| P9 | Khawar | 12345-6 | 042-5 |
| P10 | Tanweer | 12345-1 | 042-6 |
| P1 | Khalid | 12345-1 | 042-1 |
| P12 | Sohali | 12345-9 | 042-8 |
| P13 | Ahmed | 12346-0 | 042-9 |

**T3:**

| Doc no. | Patient No. | RoomNo. | RoomType | BedNo |
|---------|-------------|---------|----------|-------|
| D1 | P1 | R2 | Normal | B1 |
| D1 | P5 | R2 | Normal | B1 |
| D1 | P7 | NoRoom | NoType | NoBed |
| D2 | P4 | R2 | Normal | B1 |
| D2 | P7 | R4 | Two Bed | B5 |
| D2 | P9 | R4 | Two Bed | B7 |
| D4 | P10 | NoRoom | NoType | NoBed |
| D4 | P1 | R5 | special | B8 |
| D5 | P12 | NoRoom | NoType | NoBed |
| D5 | P13 | R6 | Special | B9 |

# c) 3NF:

There should be no transitive dependencies in 3NF & relation should be in 2NF.

Tables T1 & T2 have no transitive dependencies so they are in 3NF.

It states that for a dependency A->B, A should be a super key or B should be a prime attribute.

Now, due to **FD4 in** table which states that (RoomNo.) -> (RoomType) there is a transitive dependency.

So we modify T3 and make a new relation T4 as shown –

**T3:** (Doc no , Patient No., RoomNo., BedNo)**;**

**T4:** (RoomNo., RoomType,)**;**

**T3**(modified)**:**

| Doc no. | Patient No. | RoomNo. | BedNo |
|---------|-------------|---------|-------|
| D1 | P1 | R2 | B1 |
| D1 | P5 | R2 | B1 |
| D1 | P7 | NoRoom | NoBed |
| D2 | P4 | R2 | B1 |
| D2 | P7 | R4 | B5 |
| D2 | P9 | R4 | B7 |
| D4 | P10 | NoRoom | NoBed |
| D4 | P1 | R5 | B8 |
| D5 | P12 | NoRoom | NoBed |
| D5 | P13 | R6 | B9 |

# T4:

| RoomNo. | RoomType |
|---------|----------|
| R2 | Normal |
| R4 | Two Bed |
| R5 | Special |
| R6 | Special |
| NoRoom | NoType |

# d) BCNF:

It states that for each dependency A->B, A should be a super key. And the relations should be 3NF.

Clearly, all the dependencies are in BCNF. So finally we have following relations for N&N Hospital Data:

**T1: (**<u>Doc no.,</u> Desgnation, FName,  Address,  Phone_1, Phone_2, Department Id, Designation, Charges Per hour**);**

**T2: (**<u>Patient No.,</u> Patient Name, CNIC, P_Phone**) ;**

**T3: (**<u>Doc no , Patient No.,</u> RoomNo., BedNo)**;**

**T4: (**<u>RoomNo</u>., RoomType,)**;**