**Normalizing all the tables to Boyce-Codd Normal Form with explanation:**

🡪 For any tables to be in Boyce-Codd Normal form:

1. It should be in third normal form (3NF).

Detailed Explanation of Point 1:

For any tables to be in 3NF, it should be in 2NF, and it should not contain any transitive functional dependencies.

Transitive dependencies: This dependency occurs when non-key columns functionally determine other non-key columns of a relation.

For any table to be in 2NF, it should be in 1NF, and it should not contain any partial functional dependencies.

Partial Functional Dependencies: This dependency occurs when a column of a relation is functionally dependent on a component of a composite primary key.

A table is in 1NF if each row is unique and no column in any row contains multiple values. Every relational table is, by definition, in 1NF.

1. For any dependency A 🡪 B, A should be a super key.

It means for any dependency, A 🡪 B, A cannot be non-prime attribute while B being a prime attribute.

Let’s look at the Doctor Table:

Initially, the DOCTOR table looks like this:

**DOCTOR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **DocId** | **DocName** | **DocStartDate** | **DocSalary** | **DocBonus** | **DocSpecialization** |
| 601 | Pradip Dhakal | 2014-02-14 | 200000 | 10000 | Specialization1 Specialization2 |
| 602 | Richard Nixon | 2013-04-16 | 180000 | 8000 | Specialization2 Specialization3 |
| 603 | Denish Paudel | 2012-05-06 | 210000 | 9000 | Specialization2 Specialization5 |
| 604 | Sunita Subedi | 2017-08-26 | 220000 | 5000 | Specialization4 |
| 605 | Harry Brown | 2018-06-28 | 160000 | 6000 | Specialization5 |
| 606 | Jack Bieber | 2016-07-28 | 210000 |  | Specialization6 |
| 607 | Justin Sander | 2014-06-04 | 200000 | 1000 | Specialization2 |
| 608 | Mack Russel | 2016-10-01 | 220000 | 3000 | Specialization4 |
| 609 | Trent Morris | 2012-01-26 | 160000 | 1000 | Specialization1 |
| 610 | Daniel Kapoor | 2019-02-04 | 180000 | 4000 | Specialization2 |

All the dependencies in DOCTOR table are given below:

DocID 🡪 DocName, DocStartDate, DocSalary, DocBonus, DocSpecialization

First we normalize this table into 1NF. We create a new table **DOCTOR\_SPECIALIZATION** to normalize this table into 1NF.

**DOCTOR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DocId** | **DocName** | **DocStartDate** | **DocSalary** | **DocBonus** |
| 601 | Pradip Dhakal | 2014-02-14 | 200000 | 10000 |
| 602 | Richard Nixon | 2013-04-16 | 180000 | 8000 |
| 603 | Denish Paudel | 2012-05-06 | 210000 | 9000 |
| 604 | Sunita Subedi | 2017-08-26 | 220000 | 5000 |
| 605 | Harry Brown | 2018-06-28 | 160000 | 6000 |
| 606 | Jack Bieber | 2016-07-28 | 210000 |  |
| 607 | Justin Sander | 2014-06-04 | 200000 | 1000 |
| 608 | Mack Russel | 2016-10-01 | 220000 | 3000 |
| 609 | Trent Morris | 2012-01-26 | 160000 | 1000 |
| 610 | Daniel Kapoor | 2019-02-04 | 180000 | 4000 |

**DOCTOR\_SPECIALIZATION**

|  |  |
| --- | --- |
| **DocSpecialization** | **DocId** |
| Specialization1 | 601 |
| Specialization1 | 609 |
| Specialization2 | 601 |
| Specialization2 | 602 |
| Specialization2 | 603 |
| Specialization2 | 607 |
| Specialization2 | 610 |
| Specialization3 | 602 |
| Specialization4 | 604 |
| Specialization4 | 608 |
| Specialization5 | 603 |
| Specialization5 | 605 |
| Specialization6 | 606 |

Since each row is unique and no column in any row contains multiple values, it is in 1NF.

Next, we normalize this table into 2NF. We need to make sure that there are no partial functional dependencies.

There are no partial functional dependencies in the above tables. Hence, it is in 2NF

Next, we normalize this table into 3NF. We need to make sure that there are no transitive functional dependencies.

In the tables above, no non-key column functionally determines the other non-key columns, therefore it is in 3NF.

Next, Normalizing it into Boyce Codd Normal Form:

For all the dependencies in the above tables, there is no case of Non-Prime Attribute 🡪 Prime Attribute. Hence, the table is in Boyce Codd Normal Form.

i.e., DOCTOR Table in Boyce Codd Normal Form:

**DOCTOR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DocId** | **DocName** | **DocStartDate** | **DocSalary** | **DocBonus** |
| 601 | Pradip Dhakal | 2014-02-14 | 200000 | 10000 |
| 602 | Richard Nixon | 2013-04-16 | 180000 | 8000 |
| 603 | Denish Paudel | 2012-05-06 | 210000 | 9000 |
| 604 | Sunita Subedi | 2017-08-26 | 220000 | 5000 |
| 605 | Harry Brown | 2018-06-28 | 160000 | 6000 |
| 606 | Jack Bieber | 2016-07-28 | 210000 |  |
| 607 | Justin Sander | 2014-06-04 | 200000 | 1000 |
| 608 | Mack Russel | 2016-10-01 | 220000 | 3000 |
| 609 | Trent Morris | 2012-01-26 | 160000 | 1000 |
| 610 | Daniel Kapoor | 2019-02-04 | 180000 | 4000 |

**DOCTOR\_SPECIALIZATION**

|  |  |
| --- | --- |
| **DocSpecialization** | **DocId** |
| Specialization1 | 601 |
| Specialization1 | 609 |
| Specialization2 | 601 |
| Specialization2 | 602 |
| Specialization2 | 603 |
| Specialization2 | 607 |
| Specialization2 | 610 |
| Specialization3 | 602 |
| Specialization4 | 604 |
| Specialization4 | 608 |
| Specialization5 | 603 |
| Specialization5 | 605 |
| Specialization6 | 606 |

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Using the same process, we can normalize all our tables to Boyce Codd Normal Form.

All the tables are normalized to Boyce Codd Normal Form and are given below:

All the dependencies in DEPARTMENT table are given below:

DepId 🡪 DepartmentName, DepHead

DEPARTMENT Table in Boyce Codd Normal Form:

|  |  |  |
| --- | --- | --- |
| **DepId** | **DepName** | **DepHead** |
| 201 | Emergency | Richard Russel |
| 202 | Cardiology | Demi Lovato |
| 203 | Neurology | Nick Jonas |
| 204 | Oncology | Daniel Watson |
| 205 | ENT | Chris Brown |
| 206 | Surgery | Pradip Dhakal |
| 207 | Gynecology | Pawan Khanal |
| 208 | Nephrology | Abash Gaire |
| 209 | Radiotherapy | Trent Russel |
| 210 | Pharmacy | Taylor Brown |

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All the dependencies in NURSE table are given below:

NurseId 🡪 NurseName, NurseStartDate, NurseSalary, NurseBonus, NurseQualities

NURSE Table in Boyce Codd Normal Form:

**NURSE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NurseId** | **NurseName** | **NurseStartDate** | **NurseSalary** | **NurseBonus** |
| 101 | Emma Watson | 2014-02-23 | 5000 |  |
| 102 | Pratima Dhakal | 2012-04-13 | 6000 | 1000 |
| 103 | Martha Ballard | 2014-03-26 | 5000 | 500 |
| 104 | Mary Seacole | 2017-09-25 | 4500 | 500 |
| 105 | Florence Nightingale | 2016-02-16 | 6000 |  |
| 106 | Clarissa Barton | 2018-06-08 | 5500 | 250 |
| 107 | Linda Richards | 2012-11-16 | 4500 | 1500 |
| 108 | Martha Watson | 2014-01-01 | 3500 | 2000 |
| 109 | Nisha Bista | 2015-05-05 | 7000 |  |
| 110 | Shreya Hassan | 2014-06-16 | 5000 | 1000 |

**NURSE\_QUALITIES**

|  |  |
| --- | --- |
| **NurseQualities** | **NurseId** |
| Q1 | 101 |
| Q1 | 102 |
| Q1 | 104 |
| Q1 | 105 |
| Q1 | 106 |
| Q1 | 107 |
| Q1 | 108 |
| Q1 | 109 |
| Q1 | 110 |
| Q2 | 101 |
| Q2 | 104 |
| Q2 | 108 |
| Q3 | 103 |
| Q3 | 104 |
| Q3 | 105 |
| Q3 | 108 |
| Q3 | 110 |
| Q4 | 108 |
| Q4 | 110 |
| Q5 | 109 |

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All dependencies in the PATIENT table are given below:

PatId 🡪 PatName, PatStreetAddress, PatCity, PatState, PatZip, PatBloodType, PatAdmitedDate, PatReleaseDate, PatDob

PATIENT Table in Boyce Codd Normal Form:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PatId** | **PatName** | **PatStreetAddress** | **PatCity** | **Pat**  **State** | **PatZip** | **PatBloodType** | **PatAdmitedDate** | **PatReleasedDate** | **PatDob** |
| 701 | John Brown | 131 AB | X | YZ | 14564 | A positive | 2013-04-15 | 2013-04-20 | 1990-02-14 |
| 702 | Harry Guetta | 171 AB | X | YZ | 86485 | O positive | 2013-02-22 | 2013-02-28 | 1987-03-15 |
| 703 | Emily Hamilton | 161 AB | X | YZ | 35467 | B positive | 2017-02-25 | 2017-02-28 | 1980-03-25 |
| 704 | Randy Bista | 171 AB | X | YZ | 87563 | A positive | 2018-06-15 | 2018-06-20 | 1985-03-13 |
| 705 | Brian Pitt | 181 AB | X | YZ | 98567 | O negative | 2010-05-25 | 2010-05-28 | 1989-06-06 |
| 706 | John Dalton | 191 AB | X | YZ | 36485 | B positive | 2014-06-06 | 2014-06-10 | 1988-07-07 |
| 707 | Bradd Clayton | 122 AB | X | YZ | 45376 | A positive | 2013-12-05 | 2013-12-10 | 1987-03-02 |
| 708 | Justin Bieber | 123 AB | X | YZ | 45376 | B positive | 2013-11-25 | 2013-12-05 | 1980-05-04 |
| 709 | DJ Khalid | 124 AB | X | YZ | 45376 | A positive | 2013-12-05 | 2013-12-10 | 1982-04-16 |
| 710 | Mark Anthony | 125 AB | X | YZ | 45376 | O positive | 2013-12-05 | 2013-12-18 | 1980-01-01 |

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All the dependencies in the BILL table are given below:

BillId 🡪 BillDocCharge, BillNurseCharge, BillRoomCharge, BillMedsCharge, BillTestCharge

BILL Table in Boyce Codd Normal Form:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **BillId** | **BillDoc**  **Charge** | **BillNurse**  **Charge** | **BillRoom**  **Charge** | **BillMeds**  **Charge** | **BillTest**  **Charge** |
| 801 | 1500 | 500 | 800 | 900 | 500 |
| 802 | 1600 | 600 | 900 | 300 | 600 |
| 803 | 1300 | 700 | 700 | 500 | 700 |
| 804 | 1100 | 800 | 600 | 400 | 800 |
| 805 | 1300 | 600 | 500 | 800 | 900 |
| 806 | 1400 | 400 | 400 | 900 | 600 |
| 807 | 1600 | 500 | 500 | 700 | 700 |
| 808 | 1700 | 800 | 600 | 600 | 700 |
| 809 | 1500 | 500 | 700 | 500 | 500 |
| 810 | 1500 | 700 | 700 | 800 | 600 |

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All the dependencies in the BUILDING table are:

BuildId 🡪 BuildName, BuildNoOfFloors

BUILDING Table in Boyce Codd Normal Form:

|  |  |  |
| --- | --- | --- |
| **BuildId** | **BuildName** | **BuildNoOfFloors** |
| 1 | A | 3 |
| 2 | B | 4 |
| 3 | C | 3 |
| 4 | D | 2 |
| 5 | E | 3 |
| 6 | F | 4 |
| 7 | G | 4 |
| 8 | H | 3 |
| 9 | I | 5 |
| 10 | J | 3 |

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All the dependencies in the ROOM table are given below:

RoomId, BuildId 🡪 RoomType

ROOM Table in Boyce Codd Normal Form:

|  |  |  |
| --- | --- | --- |
| **RoomId** | **BuildId** | **RoomType** |
| 501 | 2 | General |
| 501 | 9 | Special |
| 502 | 2 | General |
| 502 | 9 | Special |
| 503 | 2 | General |
| 503 | 9 | Special |
| 504 | 2 | General |
| 504 | 9 | Special |
| 505 | 2 | General |
| 505 | 9 | Special |
| 506 | 2 | General |
| 507 | 2 | Special |
| 508 | 2 | Special |

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All the dependencies in the STAFF table are given below:

StaffId 🡪 StaffName, StaffPhoneNum, StaffAddress, StaffStartDate, StaffSalary

STAFF Table in Boyce Codd Normal Form:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **StaffId** | **StaffName** | **StaffPhoneNum** | **StaffAddress** | **StaffStartDate** | **StaffSalary** |
| 301 | David Brown | 1234567890 | 121 AB, X, YZ, 12345 | 2013-02-15 | 3000 |
| 302 | Justin Russel | 1230456789 | 123 AB, X, YZ, 23456 | 2014-02-20 | 2500 |
| 303 | Thomas Peng | 1235467890 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 304 | Yuting Peng | 1235476890 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 305 | Richard Russel | 1235468790 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 306 | Thomas Skinner | 1325467890 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 307 | Pat Roblee | 1235067894 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 308 | Keneeth Brown | 1230678945 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 309 | Shijia Peng | 1235498760 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |
| 310 | David Baker | 1287654390 | 131 AB, X, YZ, 34567 | 2015-02-15 | 2800 |

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All the dependencies in the TEST table are given below:

TestId 🡪 TesterName

TEST Table in Boyce Codd Normal Form:

|  |  |
| --- | --- |
| **TestId** | **TesterName** |
| 401 | Kelly Nash |
| 402 | Joanna Rohrback |
| 403 | Rob Ford |
| 404 | Chris Hadfield |
| 405 | Harry Hadfield |
| 406 | Chris Ford |
| 407 | Kelly Hudson |
| 408 | Rob Ford |
| 409 | Kelly Hudson |
| 410 | Chris Hadfield |

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All the dependencies in the TESTING table are given below:

PatId, TestId 🡪 TestDate

TESTING is an associative entity, and we have normalized this to Boyce Codd Normal Form.

TESTING Table in Boyce Codd Normal Form:

|  |  |  |
| --- | --- | --- |
| **TestDate** | **PatId** | **TestId** |
| 2013-04-16 | 701 | 401 |
| 2013-02-23 | 702 | 402 |
| 2017-02-26 | 703 | 403 |
| 2018-06-16 | 704 | 404 |
| 2010-05-26 | 705 | 405 |
| 2014-06-06 | 706 | 406 |
| 2013-12-06 | 707 | 407 |
| 2013-11-26 | 708 | 408 |
| 2013-12-06 | 709 | 409 |
| 2013-12-06 | 710 | 410 |
| 2016-02-20 | 701 | 408 |
| 2017-01-14 | 705 | 410 |