Boyce Codd Normal Form

Watch video: https://youtu.be/rFMEZG3UZM8?t=48m27s

Boyce–Codd Normal Form (BCNF)

- When a relation has more than one candidate key, anomalies may result even though the relation is in 3NF.

- 3NF does not deal satisfactorily with the case of a relation with overlapping candidate keys
  - i.e. composite candidate keys with at least one attribute in common.

Boyce–Codd Normal Form (BCNF)

- Boyce–Codd normal form (BCNF)
  - **A relation is in BCNF if and only if every determinant is a candidate key.**

- Recall, a determinant is any attribute (simple or composite) on which some other attribute is fully functionally dependent.

Boyce–Codd Normal Form (BCNF)

- Difference between 3NF and BCNF is that for a functional dependency A $\rightarrow$ B, 3NF allows this dependency in a relation if *B* is a primary-key attribute and *A* is not a candidate key. Whereas, BCNF insists that for this dependency to remain in a relation, *A* must be a candidate key.

- Every relation in BCNF is also in 3NF. However, a relation in 3NF is not necessarily in BCNF.

Boyce–Codd Normal Form (BCNF)

- Violation of BCNF is quite rare.
- The potential to violate BCNF may occur in a relation that:
  - contains two (or more) composite candidate keys;
  - the candidate keys overlap, that is have at least one attribute in common.

Boyce–Codd Normal Form (BCNF)

- Consider the following relation R(A, B, C, D)
- Functional dependencies:
  - A → B, C, D
  - B, C → A, D
  - D → B
- Candidate keys: A and B, C.
- Primary key: A
- So the determinant D is not a candidate key and therefore relation R is not in BCNF.

Boyce–Codd Normal Form (BCNF)

- Hence we can break our relation into two relations

  R1(D, B)
  Primary key D

  R2(A, C, D)
  Primary key A
  Foreign key D references R1(D)

Review of Normalization (UNF to BCNF)

DreamHome
Property Inspection Report

DreamHome
Property Inspection Report

Property Number *PG4*

Property Address *6 Lawrence St, Glasgow*

Inspection Date	Inspection Time	Comments	Staff no	Staff Name	Car Registration
18-Oct-12	10.00	Need to replace crockery	SG37	Ann Beech	M231 JGR
22-Apr-13	09.00	In good order	SG14	David Ford	M533 HDR
1-Oct-13	12.00	Damp rot in bathroom	SG14	David Ford	N721 HFR

Review of Normalization (UNF to BCNF)

- The following example includes property inspections by members of staff for a property letting agency. When staff are required to undertake these inspections, they are allocated a company car for use on the day of the inspection. However, a car may be allocated to several members of staff as required throughout the day.

- A member of staff may inspect several properties on a given date, but a property is inspected only once on a given date.

StaffPropertyInspection

propertyNo	pAddress	iDate	iTime	comments	staffNo	sName	carReg
PG4	6 Lawrence St, Glasgow	18-Oct-12 22-Apr-13 1-Oct-13	10.00 09.00 12.00	Need to replace crockery In good order Damp rot in bathroom	SG37 SG14 SG14	Ann Beech David Ford David Ford	M231 JGR M533 HDR N721 HFR
PG16	5 Novar Dr, Glasgow	22-Apr-13 24-Oct-13	13.00 14.00	Replace living room carpet Good condition	SG14 SG37	David Ford Ann Beech	M533 HDR N721 HFR

Review of Normalization (UNF to BCNF)

- The following relation is unnormalized (UNF), and so we will bring it into 3NF and identify why one of the relations is not in BCNF and then bring that relation into BCNF.

StaffPropertyInspection(propertyNo, pAddress, {propertyInspections(iDate, iTime, comments, staffNo, sName, carReg)})

Primary key propertyNo

Review of Normalization (UNF to BCNF)

- **UNF to 1NF**
  - We put the attribute(s) that are functionally dependent on the primary key (propertyNo) and the primary key into one table.
  - We put the attribute(s) that are not functionally dependent on the primary key and a copy of the primary key into the other table. The posted primary key is a foreign key value.

Property(propertyNo, pAddress)
Primary key propertyNo

PropertyInspection(propertyNo, iDate, iTime, comments, staffNo, sName, carReg)
Primary key propertyNo, iDate
Foreign key propertyNo references Property(propertyNo)

Review of Normalization (UNF to BCNF)

- **1NF to 2NF**

- We can see Property is automatically in 2NF because the Primary key is only made up of one attribute so no partial key dependency can exist in this table.

- When we check PropertyInspection, we can see that there are no partial key dependencies so PropertyInspection is also in 2NF.

Review of Normalization (UNF to BCNF)

- **2NF to 3NF**

- We can see Property is automatically in 3NF as there is only one non key attribute.

- When we check PropertyInspection, we can see that there is a Transitive dependency as

  propertyNo, iDate → staffNo; and
  staffNo → sName; therefore
  propertyNo, iDate → sName

Review of Normalization (UNF to BCNF)

- **2NF to 3NF**

- We remove staffNo and sName into a table of their own and a copy of staffNo stays in PropertyInspection as a foreign key.

Staff(staffNo, sName)
Primary key staffNo

PropertyInspection(propertyNo, iDate, iTime, comments, staffNo, carReg)
Primary key propertyNo, iDate
Foreign key propertyNo references Property(propertyNo)
Foreign key staffNo references Staff(staffNo)

Review of Normalization (UNF to BCNF)

- At this point, we have 3 tables in 3NF:

  Property(propertyNo, pAddress)
  Primary key propertyNo

  Staff(staffNo, sName)
  Primary key staffNo

  PropertyInspection(propertyNo, iDate, iTime, comments, staffNo, carReg)
  Primary key propertyNo, iDate
  Foreign key propertyNo references Property(propertyNo)
  Foreign key staffNo references Staff(staffNo)

Review of Normalization (UNF to BCNF)

- The functional dependencies for the Property and Staff tables are as follows:

- Property:
  propertyNo → pAddress

- Staff
  staffNo → sName

- We can see that these tables are already in BCNF, as the determinant in each of these tables is also the candidate key.

Review of Normalization (UNF to BCNF)

- PropertyInspection table with sample data:

propertyNo	iDate	iTime	Comments	staffNo	carReg
PG4	18-Oct-12	10:00	Need to replace crockery	SG37	M231 JGR
PG4	22-Apr-13	09:00	In good order	SG14	M533 HDR
PG4	1-Oct-13	12:00	Damp rot in bathroom	SG14	N721 HFR
PG16	22-Apr-13	13:00	Replace living room carpet	SG14	M533 HDR
PG16	24-Oct-13	14:00	Good condition	SG37	N721 HFR

Review of Normalization (UNF to BCNF)

- The functional dependencies for the PropertyInspection are as follows:

- propertyNo, iDate → iTime, comments, staffNo, carReg

  iDate, staffNo → carReg

  iDate, iTime, carReg → propertyNo, comments, staffNo

  iDate, iTime, staffNo → propertyNo, comments

- The functional dependency iDate, staffNo → carReg is not a candidate key so table PropertyInspection is not in BCNF.

Review of Normalization (UNF to BCNF)

- To transform the PropertyInspection table into BCNF, we must remove the dependency that violates BCNF by removing the functional dependency
(iDate, staffNo → carReg) into a new relation as follows:

- StaffCar(iDate, staffNo , carReg)
  Primary key iDate, staffNo
  Foreign key staffNo references Staff(staffNo)

Review of Normalization (UNF to BCNF)

- Full set of BCNF tables:

  Property(propertyNo, pAddress)
  Primary key propertyNo

  Staff(staffNo, sName)
  Primary key staffNo

- StaffCar(iDate, staffNo, carReg)
  Primary key iDate, staffNo
  Foreign key staffNo references Staff(staffNo)

  PropertyInspection(propertyNo, iDate, iTime, comments, staffNo)
  Primary key propertyNo, iDate
  Foreign key propertyNo references Property(propertyNo)
  Foreign key staffNo references Staff(staffNo)
  Foreign key (iDate, staffNo) references StaffCar(iDate, staffNo)

Exercise

- The following table (**ClientInterviews**) has 5 columns clientNo, interviewDate, interviewTime, staffNo, and roomNo

  ClientInterviews(clientNo, interviewDate, interviewTime, staffNo, roomNo)

  Primary key clientNo, interviewDate

clientNo	interviewDate	interviewTime	staffNo	roomNo
C001	01 FEB 2018	10:00	007	W10A
C002	01 FEB 2018	11:00	007	W10A
C003	01 FEB 2018	12:00	009	C35
C004	01 FEB 2018	14:00	007	W10A
C005	01 FEB 2018	15:00	007	W10A
C006	01 FEB 2018	17:00	009	W10A
C001	02 FEB 2018	10:00	011	B07
C002	02 FEB 2018	13:00	007	B07
C003	02 FEB 2018	15:00	007	B07

ClientInterviews

Exercise

- As you can see:
  - Each client will only be interviewed once on any given day. But maybe have other interviews on other days.
  - Each staff member is allocated on a given date to in a particular room to interview clients.
    - Many staff can use the same room throughout the day.
    - Staff member can only conduct one interview at a given time on a particular day.
    - Likewise, a room can only to used at a particular time on a given date to interview a Client.

Exercise

- The relation (CollegeEnrollment) is not in Boyce Codd Normal Form)

  i. Why? *The determinant staffNo, interviewDate is not a candidate key*

  ii. Explain the steps involved in transforming the relation into Boyce Codd Normal Form (BCNF).

  iii. Transform the relation into a set of Boyce Codd Normal Form (BCNF) relations.

Exercise

StaffRoom(staffNo, interviewDate, roomNo)
Primary key staffNo, interviewDate

ClientInterviews(clientNo, interviewDate, interviewTime, staffNo)
Primary key clientNo, interviewDate
Foreign key (staffNo, interviewDate) references StaffRoom(staffNo, interviewDate)