Understanding BCNF: Boyce Codd Normal Form

Recall the definition of 3NF:

R is in 3NF if \( \forall X \rightarrow Y \), either \( X \) is a superkey

or \( Y \) is a prime attribute.

BCNF is stricter:

R is in BCNF if \( \forall X \rightarrow Y \), \( X \) is a superkey.

(BCNF eliminates second option)

Conditions for violating BCNF:

Consider \( R(A,B,C) \)

R is in 3NF but NOT in BCNF if all 5 of these conditions hold:

1) \( AB \rightarrow C \)  
   (required by the fact that \( AB \) is a Candidate Key)

2) \( A \nrightarrow C \)  
   (\( A \) does NOT determine \( C \): otherwise \( R \) is not in 2NF)

3) \( B \nrightarrow C \)  
   (similarly, otherwise \( R \) is not in 2NF)

4) \( C \rightarrow B \)  
   (violates BCNF)

5) \( C \nrightarrow A \)  
   (otherwise given 4, \( C \) would be a superkey)

We can normalize \( R \) into BCNF:

\[
R1(A,C) \\
R2(C,B)
\]
Consider:

StudentMajor(SID, Major, Advisor)

Note: a student can have more than one Major, and one Advisor for each of their Major, and note that Advisors only advise in one Major Advisor → Major

StudentMajor(SID, Major, Advisor)

is in 3NF since Major is a Prime Attribute

but it is NOT in BCNF because Advisor is not a superkey.

To Normalize into BCNF, replace:

StudentMajor(SID, Major, Advisor)

With:

StudentMajors(SID, Major)

Advises_in_Major(Advisor, Major)

(This is in BCNF but does not capture which Advisors a student has.)