Assignment 6

Adam Karl

November 12, 2020

1 Assignment 6

1.1 Synthesis

Given FDs:

- f1: $AB \to E$
- f2: $B \to DE$
- f3: $E \to D$
- f4: $DF \to A$
- f5: $C \to F$
- f6: $DC \to A$

Use Decomposition (IR4) on f2 so that all FDs are in canonical form (only 1 dependent in each FD):

- f1: $\cancel{AB \to E}$ (from f8 we know $B \to E$, so A is redundant)
- f7: $B \to D$
- f8: $B \to E$
- f3: $E \to D$
- f4: $DF \to A$
- f5: $C \to F$
- f6: $DC \to A$

then

- f7: $\cancel{B \to D}$ (since $B \to E$ and $E \to D$, $B \to D$ is implied so f7 is redundant)
- f8: $B \to E$
- f3: $E \to D$
- f4: $DF \to A$
- f5: $C \to F$
- f6: $DC \to A$

Using Pseudotransitivity, Composition (IR6) on f4: $DF \to A$ and f5: $C \to F$ yields $DC \to A$ which is the same as f6, so f6 is redundant. We remove f6 from consideration.

- f8: $B \to E$
- f3: $E \to D$
- f4: $DF \to A$

- f5: $C \rightarrow F$

Now that we have the canonical cover, we would group FDs with same determinant, but in this case there aren't any. Therefore we can construct the relations with one FD each.

- R1($\underline{\text{B}}$,E)
- R2($\underline{\text{E}}$,D)
- R3(A,$\underline{\text{D}}$,$\underline{\text{F}}$)
- R4($\underline{\text{C}}$,F)

Since we weren't given the key for the original relation, this is our final solution. R1, R2, R3, and R4 are in 3NF and BCNF.

1.2 Decomposition

Initial dependencies

- $A \rightarrow B$
- $B \rightarrow CD$
- $A \rightarrow D$
- $B \rightarrow C$
- $AB \rightarrow CD$

Transform all FDs to canonical form (removing duplicates)

- $A \rightarrow B$
- $B \rightarrow C$
- $B \rightarrow D$
- $A \rightarrow D$
- $\cancel{B \rightarrow C}$ duplicate
- $AB \rightarrow C$
- $AB \rightarrow D$

Drop extraneous attributes:

- $A \rightarrow B$
- $B \rightarrow C$
- $B \rightarrow D$
- $A \rightarrow D$
- $\cancel{AB \rightarrow C}$ already have $B \rightarrow C$
- $\cancel{AB \rightarrow D}$ already have $B \rightarrow D$

Drop redundant FDs:

- $A \rightarrow B$
- $B \rightarrow C$
- $B \rightarrow D$

- $\cancel{A \to D}$ implied by $A \to B$ and $B \to D$

Therefore the canonical cover of R is:

- $A \to B$
- $B \to C$
- $B \to D$

Observation: A does not appear in the right hand side of any FDs, so it must appear in any key of R.
$A+ : A \to AB$ (since $A \to B$) $\to ABC$ (since $B \to C$) $\to ABCD$ (since $B \to D$)
We don't need to consider any other combination since any other combination containing A is a super key and not minimal.
R:(A,B,C,D)
A is the only key we need for R.

1.3 Table Method

Our initial table with all columns is:

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1															
R2															
R3															

Fill in table based on:

- R1: (ProductID, Length, Width, Height, Weight, OrderID, OrderDate, CustomerID, TotalPrice)
- R2: (CustomerID, Address, City, State, ZipCode, PhoneNumber)
- R3: (ProductID, OrderID, ProductQuantity)

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1	K	K	K	K	K	K	K	K	K	U	U	U	U	U	U
R2	U	U	U	U	U	U	U	K	U	K	K	K	K	K	U
R3	K	U	U	U	U	K	U	U	U	U	U	U	U	U	K

- FD1: ProductID $\to$ Length, Width, Height, Weight

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1	K	K	K	K	K	K	K	K	K	U	U	U	U	U	U
R2	U	U	U	U	U	U	U	K	U	K	K	K	K	K	U
R3	K	K	K	K	K	K	U	U	U	U	U	U	U	U	K

- FD2: OrderID $\to$ OrderDate, CustomerID, TotalPrice

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1	K	K	K	K	K	K	K	K	K	U	U	U	U	U	U
R2	U	U	U	U	U	U	U	K	U	K	K	K	K	K	U
R3	K	K	K	K	K	K	K	K	K	U	U	U	U	U	K

- FD3: CustomerID $\to$ Address, City, State, ZipCode, PhoneNumber

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1	K	K	K	K	K	K	K	K	K	K	K	K	K	K	U
R2	U	U	U	U	U	U	U	K	U	K	K	K	K	K	U
R3	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K

- FD4: ProductID, OrderID → ProductQuantity

	PID	Len	Wdth	Hght	Wght	OID	ODate	CID	TotPrice	Addr	City	State	Zip	Phone	PQtty
R1	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K
R2	U	U	U	U	U	U	U	K	U	K	K	K	K	K	U
R3	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K

Since row 1 (also row 3) consists of all known values, **the decomposition is lossless.** However, we must still check if all dependencies are preserved. To do this, we will find the canonical FDs and check if they span across tables.

Our given FDs are:

- ProductID → Length, Width, Height, Weight
- OrderID → OrderDate, CustomerID, TotalPrice
- CustomerID → Address, City, State, ZipCode, PhoneNumber
- ProductID, OrderID → ProductQuantity

Transform all FDs to canonical form:

1. ProductID → Length
2. ProductID → Width
3. ProductID → Height
4. ProductID → Weight
5. OrderID → OrderDate
6. OrderID → CustomerID
7. OrderID → TotalPrice
8. CustomerID → Address
9. CustomerID → City
10. CustomerID → State
11. CustomerID → ZipCode
12. CustomerID → PhoneNumber
13. ProductID, OrderID → ProductQuantity

Remember the given decomposition relations are:

- R1: (ProductID, Length, Width, Height, Weight, OrderID, OrderDate, CustomerID, TotalPrice)
- R2: (CustomerID, Address, City, State, ZipCode, PhoneNumber)
- R3: (ProductID, OrderID, ProductQuantity)

When considering these canonical dependencies to the given relations:

- the key for FDs 1-7 appear both in R1 and R3, but only have the dependents in R1.
- the key for FDs 8-12 appear in R2 along with each dependent. No issue
- the key for FD 13 appears both in R1 and R3, but only has the dependent in R3.

Since canonical FDs 1-7 and 13 span across tables, this decomposition is non-dependency preserving.
Since we have shown this decomposition is lossless but non-dependency preserving, **it is an ugly decomposition.**
(Note: simply removing R3 would be sufficient for a good decomposition)