

CPS 510 - Assignment 8

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Below are all relations with their FDs. Each FD shows the single-attribute primary key determining all non-key attributes. No transitive or partial dependencies remain.

R_1 (CustomerID, Name, Age, Address, Balance, Rating)

FD: CustomerID → Name, Age, Address, Balance, Rating

R_2 (DriverID, Name, LicenseNo, Contact, Rating)

FD: DriverID → Name, LicenseNo, Contact, Rating

R_3 (VehicleID, DriverID, Make, Model, Color, LicensePlate, InsuranceExpiry)

FD: VehicleID → DriverID, Make, Model, Color, LicensePlate, InsuranceExpiry

Notes: LicensePlate → VehicleID was avoided by using VehicleID as the identifier and enforcing uniqueness on LicensePlate.

R_4 (OrderID, CustomerID, DriverID, VehicleID, MerchantID, PickupLocationID, DropoffLocationID, Fare, Status, Timestamp)

FD: OrderID → CustomerID, DriverID, VehicleID, MerchantID, PickupLocationID, DropoffLocationID, Fare, Status, Timestamp

R_5 (LocationID, Address, Latitude, Longitude)

FD: LocationID → Address, Latitude, Longitude

R_6 (PaymentID, OrderID, Method, Amount, PaymentDate, CompletionStatus)

FD: PaymentID → OrderID, Method, Amount, PaymentDate, CompletionStatus

R_7 (MerchantID, Name, Category, Address, ContactInfo)

FD: MerchantID → Name, Category, Address, ContactInfo

Notes: Name → Category was treated as a possible business rule but not enforced as an FD since different merchants may share a name.

R_8 (RatingID, OrderID, CustomerID, DriverID, Stars, Comments)

FD: RatingID → OrderID, CustomerID, DriverID, Stars, Comments

Notes: (OrderID, CustomerID) → Stars was avoided by using a surrogate key RatingID to allow multiple ratings and updates without anomalies.

Each determinant is a key → every table already satisfies BCNF.

R_6 (Address_ID, Country, Province, City, street_address, postalCode)

FD: Address → Country, Province, City, street_address, postalCode

We apply the BCNF algorithm to one representative relation (R_4). The same logic applies to all others.

Input: R_4 (OrderID, CustomerID, DriverID, VehicleID, MerchantID, PickupLocationID, DropoffLocationID, Fare, Status, Timestamp)

$F = \{ \text{OrderID} \rightarrow \text{CustomerID}, \text{DriverID}, \text{VehicleID}, \text{MerchantID}, \text{PickupLocationID}, \text{DropoffLocationID}, \text{Fare}, \text{Status}, \text{Timestamp} \}$

Step 1 – Find Candidate Keys: $(\text{OrderID})^+ = \text{all attributes} \Rightarrow \text{OrderID is a key.}$

Step 2 – Test BCNF Condition: For each FD $X \rightarrow Y$, is X a (super)key? Yes. $X = \text{OrderID}$ (a key) \rightarrow passes.

Step 3 – Decompose if Violated: No violations \rightarrow no split required.

Step 4 – Verify All Relations: Every relation's determinant is its key \rightarrow all are BCNF.

If future business rules add new FDs (for example, LicensePlate \rightarrow VehicleID or MerchantName \rightarrow Category), those specific tables would require decomposition. Under the current design, however, all relations pass the BCNF test.

Note: a majority of the tables that were unchanged in 3NF when in 1NF originally are also unchanged for BCNF. The reason is because there are no redundant FDs and there is already a superkey shown that is able to represent all relationships when a closure is formed. Ex. The customer table (FD: CustomerID \rightarrow Name, Age, Address, Balance, Rating) has no transitivity seen, $\text{CustomerID}^+ = \{\text{Name}, \text{Age}, \text{Address}, \text{Balance}, \text{Rating}\}$, and no subset can be made that still makes this closure hold. More complicated examples that did have transitivity are more likely to have change when going to BCNF

R_4 (OrderID, CustomerID, DriverID, VehicleID, MerchantID, PickupLocationID, DropoffLocationID, Fare, Status, Timestamp)

FD: $[\text{OrderID} \rightarrow \text{CustomerID}, \text{DriverID}, \text{VehicleID}, \text{MerchantID}, \text{PickupLocationID}, \text{DropoffLocationID}, \text{Fare}, \text{Status}, \text{Timestamp}], [\text{Timestamp} \rightarrow \text{Fare}]$

* $\text{Timestamp}^+ = \{\text{Timestamp}, \text{Fare}\}$ violates BCNF because it doesn't include all attributes. This relation must be decomposed

$R_{4.1}$ (Timestamp, Fare)

$R_{4.2}$ (OrderID, CustomerID, DriverID, VehicleID, MerchantID, PickupLocationID, DropoffLocationID, Status, Timestamp)

R_5 (LocationID, Address, Latitude, Longitude)

FD: $[\text{LocationID} \rightarrow \text{Address}, \text{Latitude}, \text{Longitude}], [\text{Latitude}, \text{Longitude} \rightarrow \text{Address}]$

$*(\text{Latitude}, \text{Longitude})+ = \{\text{Latitude}, \text{Longitude}, \text{Address}\}$ violates BCNF because they are non key attributes and Location is not included in the closure. This means the relationship must be decomposed into two separate ones.

$R_{5.1} (\text{Latitude}, \text{Longitude}, \text{Address})$

$R_{5.2} (\text{Location}, \text{Latitude}, \text{Longitude})$

$R_6 (\text{Address_ID}, \text{Country}, \text{Province}, \text{City}, \text{street_address}, \text{postalCode})$

FD: $[\text{Address} \rightarrow \text{Country}, \text{Province}, \text{City}, \text{street_address}, \text{postalCode}]$, $[\text{Country} \rightarrow \text{Province}]$,
 $[\text{Province} \rightarrow \text{City}]$, $[\text{City} \rightarrow \text{street_address}]$, $[\text{street_address} \rightarrow \text{PostalCode}]$

$*\text{Country}+ = \{\text{Country}, \text{Province}, \text{City}, \text{street_address}, \text{PostalCode}\}$ violates BCNF due to Address_ID not being included. Each of the following FDs must be broken down

$R_{6.1} (\text{Country}, \text{Province})$

$R_{6.2} (\text{Province}, \text{City})$

$R_{6.3} (\text{City}, \text{street_address})$

$R_{6.4} (\text{street_address}, \text{PostalCode})$

$R_{6.5} (\text{Address_ID}, \text{street_address})$