BCNF (Boyce-Codd Normal Form)

BCNF Definition

- A relation is in BCNF if for every non-trivial functional dependency X→Y , X is a superkey.
- A candidate key is a minimal set of attributes that determines all attributes of the relation.

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Candidate Keys

1. **User(userid)**
   - Candidate Key: userid
2. **Payment(paymentid, userid)**
   - Candidate Key: paymentid
3. **Feedback(feedback_id, userid)**
   - Candidate Key: feedback_id
4. **Send(sender, receiver, package_id)**
   - Candidate Key: {sender, receiver, package_id} (assuming sender and receiver are attributes, not IDs)
5. **Package(package_id, shipment_id)**
   - Candidate Key: package_id
6. **Shipment(shipment_id, vehicle_id, driver_id)**
   - Candidate Key: shipment_id
7. **Tracking(tracking_id, shipment_id)**
   - Candidate Key: tracking_id
8. **Vehicle(vehicle_id)**
   - Candidate Key: vehicle_id
9. **Driver(driver_id, vehicle_id)**
   - Candidate Key: driver_id

Functional Dependencies and BCNF Check

- **User(userid)**: userid → all attributes (superkey: userid)
- **Payment(paymentid)**: paymentid → all attributes (superkey: paymentid)
- **Feedback(feedback_id)**: feedbackid → all attributes (superkey: feedback_id)
- **Send(sender, receiver, package_id)**: {sender, receiver, package_id} → all attributes (superkey: {sender, receiver, package_id})
- **Package(package_id)**: package_id → all attributes (superkey: package_id)
- **Shipment(shipment_id)**: shipment_id → all attributes (superkey: shipment_id)
- **Tracking(tracking_id)**: tracking_id → all attributes (superkey: tracking_id)
- **Vehicle(vehicle_id)**: vehicle_id → all attributes (superkey: vehicle_id)
- **Driver(driver_id)**: driver_id → all attributes (superkey: driver_id)

Since all functional dependencies have a superkey on the left-hand side, all relations are in BCNF.

Conclusion

The given schema satisfies BCNF, as there are no partial or transitive dependencies where a non-superkey determines another attribute.