CSA09: DATABASE MANAGEMENT SYSTEMS-ASSIGNMENT QUESTIONS
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Question 1:

ER Diagram Question: Traffic Flow Management System (TFMS)

Scenario

You are tasked with designing an Entity-Relationship (ER) diagram for a Traffic Flow Management System (TFMS) used in a city to optimize traffic routes, manage intersections, and control traffic signals. The TFMS aims to enhance transportation efficiency by utilizing real-time data from sensors and historical traffic patterns.

The city administration has decided to implement a TFMS to address growing traffic congestion issues. The system will integrate real-time data from traffic sensors, cameras, and historical traffic patterns to provide intelligent traffic management solutions. Key functionalities include:

1. **Road Network Management**:
    - **Roads**: The city has a network of roads, each identified by a unique RoadID. Roads have attributes such as RoadName, Length (in meters), and SpeedLimit (in km/h).
2. **Intersection Control**:
    - **Intersections**: These are key points where roads meet and are crucial for traffic management. Each intersection is uniquely identified by IntersectionID and has attributes like IntersectionName and geographic Coordinates (Latitude, Longitude).
3. **Traffic Signal Management**:
    - **Traffic Signals**: Installed at intersections to regulate traffic flow. Each signal is identified by SignalID and has attributes such as SignalStatus (Green, Yellow, Red) indicating current state and Timer (countdown to next change).
4. **Real-Time Data Integration**:
    - **Traffic Data**: Real-time data collected from sensors includes TrafficDataID, Timestamp, Speed (average speed on the road), and CongestionLevel (degree of traffic congestion).
5. **Functionality Requirements**:
    - **Route Optimization**: Algorithms will be implemented to suggest optimal routes based on current traffic conditions.
    - **Traffic Signal Control**: Adaptive control algorithms will adjust signal timings dynamically based on real-time traffic flow and congestion data.
    - **Historical Analysis**: The system will store historical traffic data for analysis and planning future improvements.

ER Diagram Design Requirements

1. **Entities and Attributes**:
    - Clearly define entities (Roads, Intersections, Traffic Signals, Traffic Data) and their attributes based on the scenario provided.
    - Include primary keys (PK) and foreign keys (FK) where necessary to establish relationships between entities.
2. **Relationships**:
    - Illustrate relationships between entities (e.g., Roads connecting to Intersections, Intersections hosting Traffic Signals).
    - Specify cardinality (one-to-one, one-to-many, many-to-many) and optionality constraints (mandatory vs. optional relationships).
3. **Normalization Considerations**:
    - Discuss how you would ensure the ER diagram adheres to normalization principles (1NF, 2NF, 3NF) to minimize redundancy and improve data integrity.

Tasks

Task 1: Entity Identification and Attributes

Identify and list the entities relevant to the TFMS based on the scenario provided (e.g., Roads, Intersections, Traffic Signals, Traffic Data).

Define attributes for each entity, ensuring clarity and completeness.

Task 2: Relationship Modeling

Illustrate the relationships between entities in the ER diagram (e.g., Roads connecting to Intersections, Intersections hosting Traffic Signals).

Specify cardinality (one-to-one, one-to-many, many-to-many) and optionality constraints (mandatory vs. optional relationships).

Task 3: ER Diagram Design

Draw the ER diagram for the TFMS, incorporating all identified entities, attributes, and relationships.

Label primary keys (PK) and foreign keys (FK) where applicable to establish relationships between entities.

Task 4: Justification and Normalization

Justify your design choices, including considerations for scalability, real-time data processing, and efficient traffic management.

Discuss how you would ensure the ER diagram adheres to normalization principles (1NF, 2NF, 3NF) to minimize redundancy and improve data integrity.

Deliverables

1. **ER Diagram**: A well-drawn ER diagram that accurately reflects the structure and relationships of the TFMS database.
2. **Entity Definitions**: Clear definitions of entities and their attributes, supporting the ER diagram.
3. **Relationship Descriptions**: Detailed descriptions of relationships with cardinality and optionality constraints.
4. **Justification Document**: A document explaining design choices, normalization considerations, and how the ER diagram supports TFMS functionalities.

Task 1: Entity Identification and Attributes

The following entities are relevant to the TFMS:

1.Roads
RoadID (PK)
RoadName
Length (in meters)
SpeedLimit (in km/h)

2.Intersections
IntersectionID (PK)
IntersectionName
Latitude
Longitude

3.Traffic Signals
SignalID (PK)
IntersectionID (FK referencing Intersections)
SignalStatus (Green, Yellow, Red)
Timer (countdown to next change)

4.Traffic Data
TrafficDataID (PK)
Timestamp
RoadID (FK referencing Roads)
Speed (average speed on the road)
CongestionLevel (degree of traffic congestion)

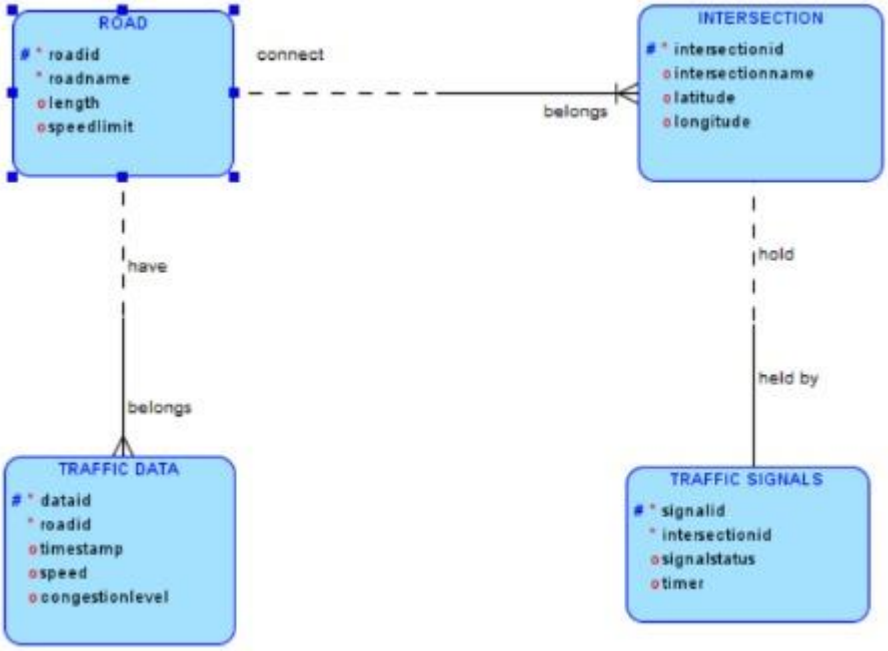
Task 2: Relationship Modeling

The relationships between entities are:

1.A road can have multiple intersections (one-to-many).
Roads -> Intersections (RoadID -> IntersectionID)
2.An intersection can have multiple roads (many-to-many).
Intersections -> Roads (IntersectionID -> RoadID)
3.An intersection can have one traffic signal (one-to-one).
Intersections -> Traffic Signals (IntersectionID -> SignalID)
4.A traffic signal is associated with one intersection (one-to-one).
Traffic Signals -> Intersections (SignalID -> IntersectionID)
5.A road can have multiple traffic data entries (one-to-many).
Roads -> Traffic Data (RoadID -> TrafficDataID)
6.A traffic data entry is associated with one road (one-to-one).
Traffic Data -> Roads (TrafficDataID -> RoadID)

Task 3: ER Diagram Design

Here is the ER diagram for the TFMS:



Task 4: Justification and Normalization

The ER diagram design choices are justified as follows:

Scalability: The design allows for easy addition of new roads, intersections, traffic signals, and traffic data entries without affecting the overall structure.

Real-time data processing: The design enables efficient querying and analysis of real-time traffic data, which is critical for traffic management.

Efficient traffic management: The design supports the key functionalities of route optimization, traffic signal control, and historical analysis.

To ensure normalization, the following principles are adhered to:

1NF: Each attribute has a single value.

2NF: Each non-key attribute depends on the entire primary key.

3NF: If a table has a composite primary key, then no non-key attribute depends on only one part of the primary key.

The ER diagram is normalized to minimize redundancy and improve data integrity. For example, the Traffic Signals table has a foreign key referencing the Intersections table, ensuring that each traffic signal is associated with a unique intersection. Similarly, the Traffic Data table has a foreign key referencing the Roads table, ensuring that each traffic data entry is associated with a unique road.