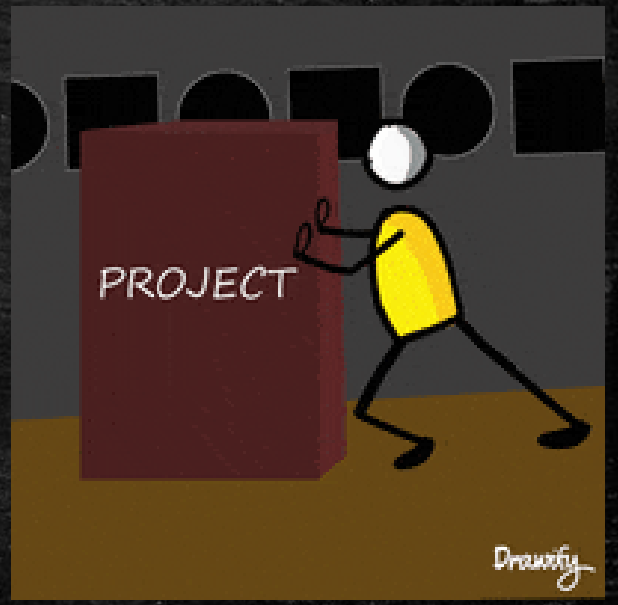
DTSA 5733 Relational Database Design Final Project

Project Objective & Learning Outcomes

- Relational Database Design
- Dealing with project assumptions
- Carrying out the project in 6 main steps



Business Background & Story

STEP

Business Background & Story

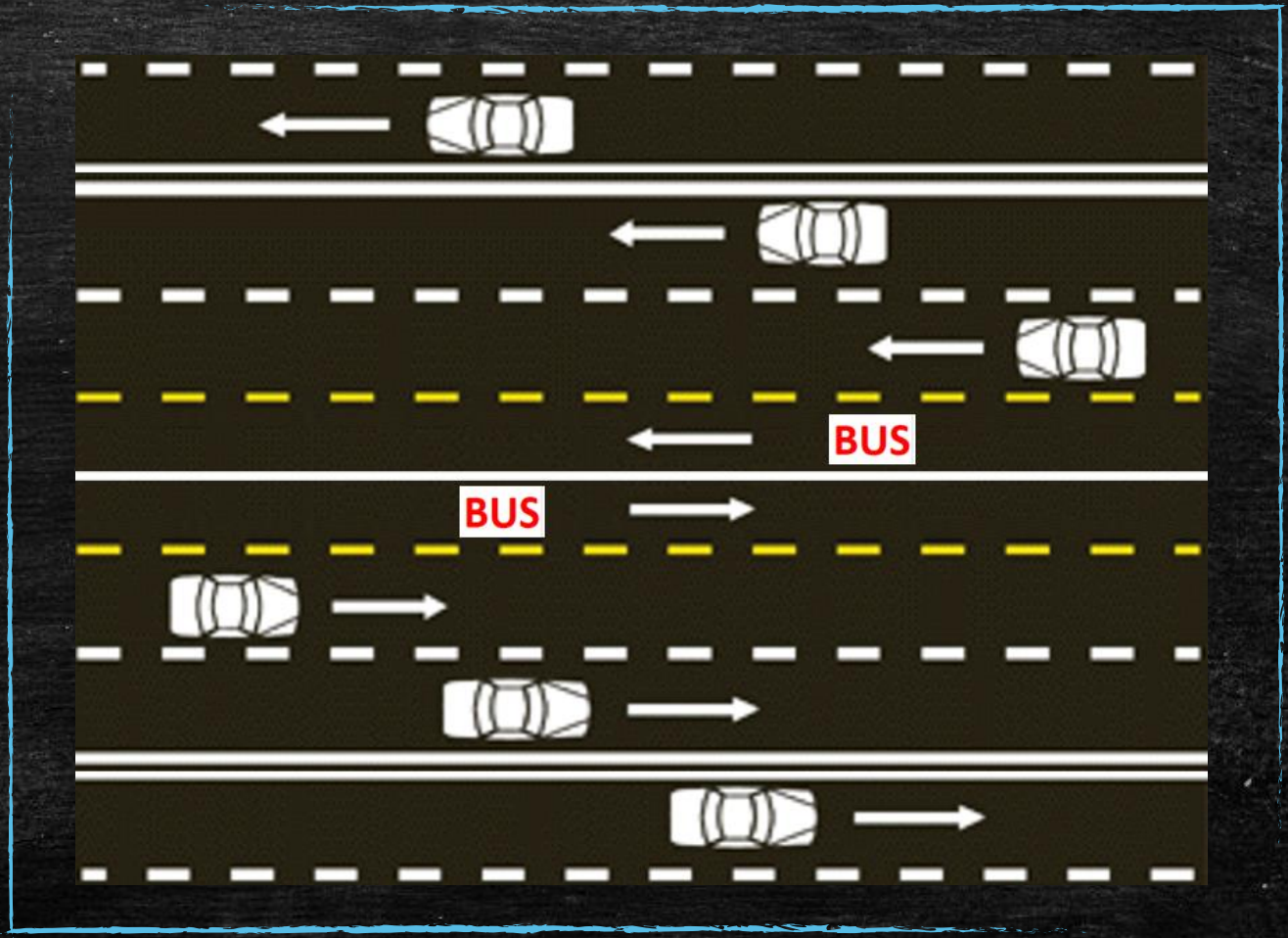
The first step is the describe the background story of our case here, such that I chose a project that is related to my BSc background which is Civil Engineering. I hope this idea reflects effectively my learning outcomes to the Peer Evaluation , and I hope also this final project be useful to my career as a Data Scientist with a Civil Engineering background.

I am going to design a Relational Database for a Traffic Management system that is connecting to IoT sensors that collect information about the current status of the highway, such that I am going to assume some entities and their attributes from my mind , then I am going to apply the next five steps to reach to my goal mentioned earlier in this paragraph.

Highway Conditions and Assumptions

1. We have two main sides in opposite directions for all vehicles.
2. We have two special sides in opposite directions for Amman Bus Rapid Transit
3. Refer to below image that describes directions of the vehicles.
4. please note that I used Amman Bus Rapid Transit project just as title to deliver this business case of my interest, other than the project name all information provided are only based on my own assumptions

Business Background & Story



Building the Entity Relationship Model (ER Model)

STEP

Building the Entity Relationship Model (ER Model)

- Highway: HighwayID, HighwayName, HighwayLocation,

  HighwayLength, LanesNumbers, ConstructionDate,

  MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed.

  HighwayID is the identifier.

- Segment: SegmentID, StartLocation, EndLocation, Length, Surafce,

  LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel,

  WeatherConditions. SegmentID is the identifier.

- IoT_Device: DeviceID, Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol. DeviceID is the identifier.

Building the Entity Relationship Model (ER Model)

- Traffic_Camera: CameraID, Location, InstalledDirection, FieldView, Resolution, CameraStatus. CameraID is the identifier.

- Traffic_Flow_Sensor: SensorID, Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus. SensorID is the identifier.

- Weather_Sensor: SensorID, Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus. SensorID is the identifier.

Building the Entity Relationship Model (ER Model)

- Maintenance: MaintenanceID, Location, StartTime, MaintenanceType, Description, ImpactOnTraffic. MaintenanceID is the identifier.

- Vehicle: VehicleID, PlateNumber, VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction. VehicleID, and PlateNumber are both identifiers

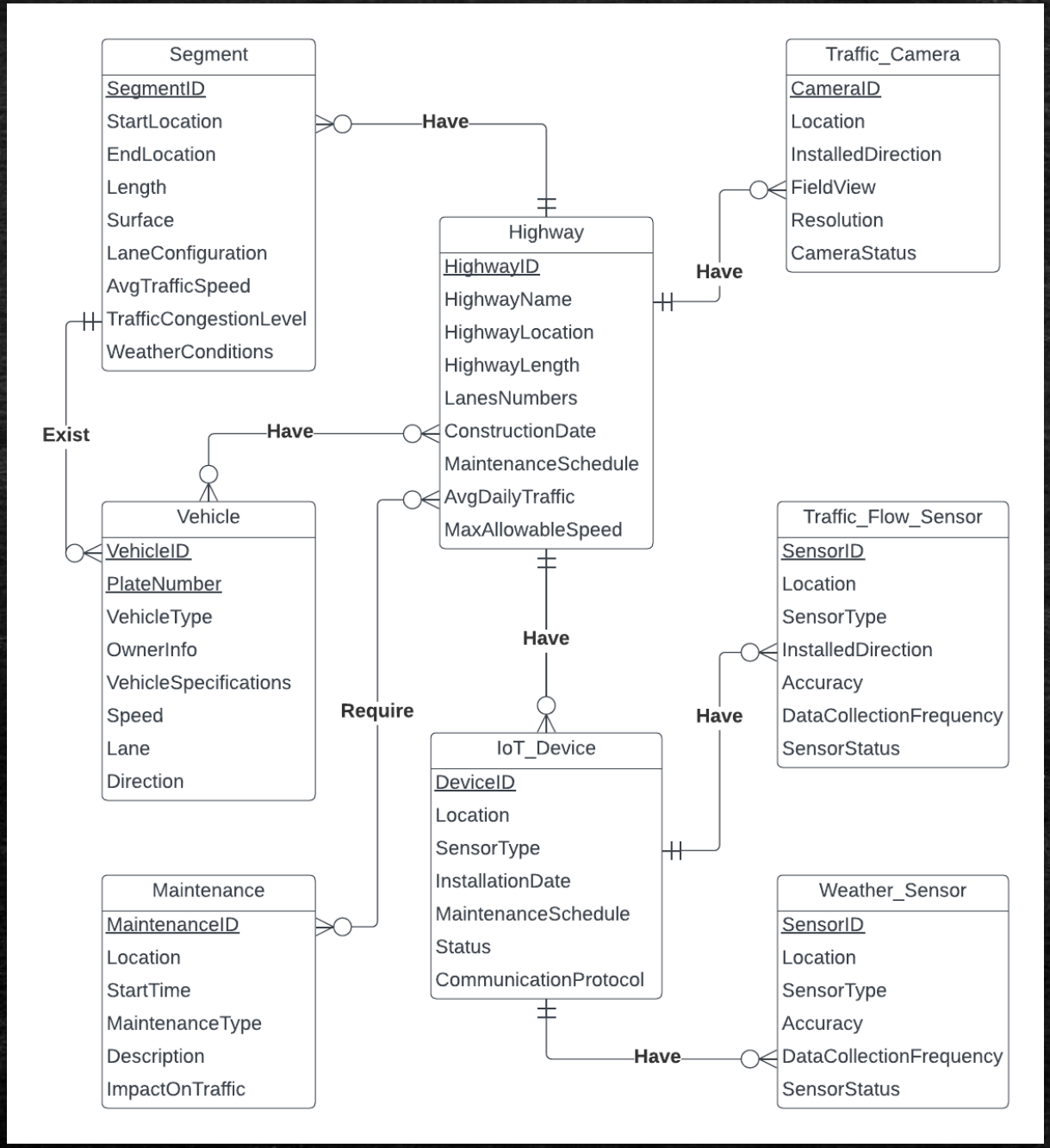
Building the Entity Relationship Model (ER Model)

The relationships are the following

- A highway may have one or more segments. A segment must belong to one and only one highway.
- An IoT Device may have one or more sensors. A sensor must belong to one and only one IoT Device.
- A highway may have one or more IoT Devices. An IoT Device must belong to one and only one highway.
- A highway may require one or more maintenance services. A maintenance may be implemented to one or more highways.
- A highway may have one or more (zero or more) vehicles. A vehicle may use one or more highways.
- A vehicle must exist in one and only one segment. A segment may contain one or more vehicles.
- A highway ma have one or more cameras. A camera must belong to one and only one highway.

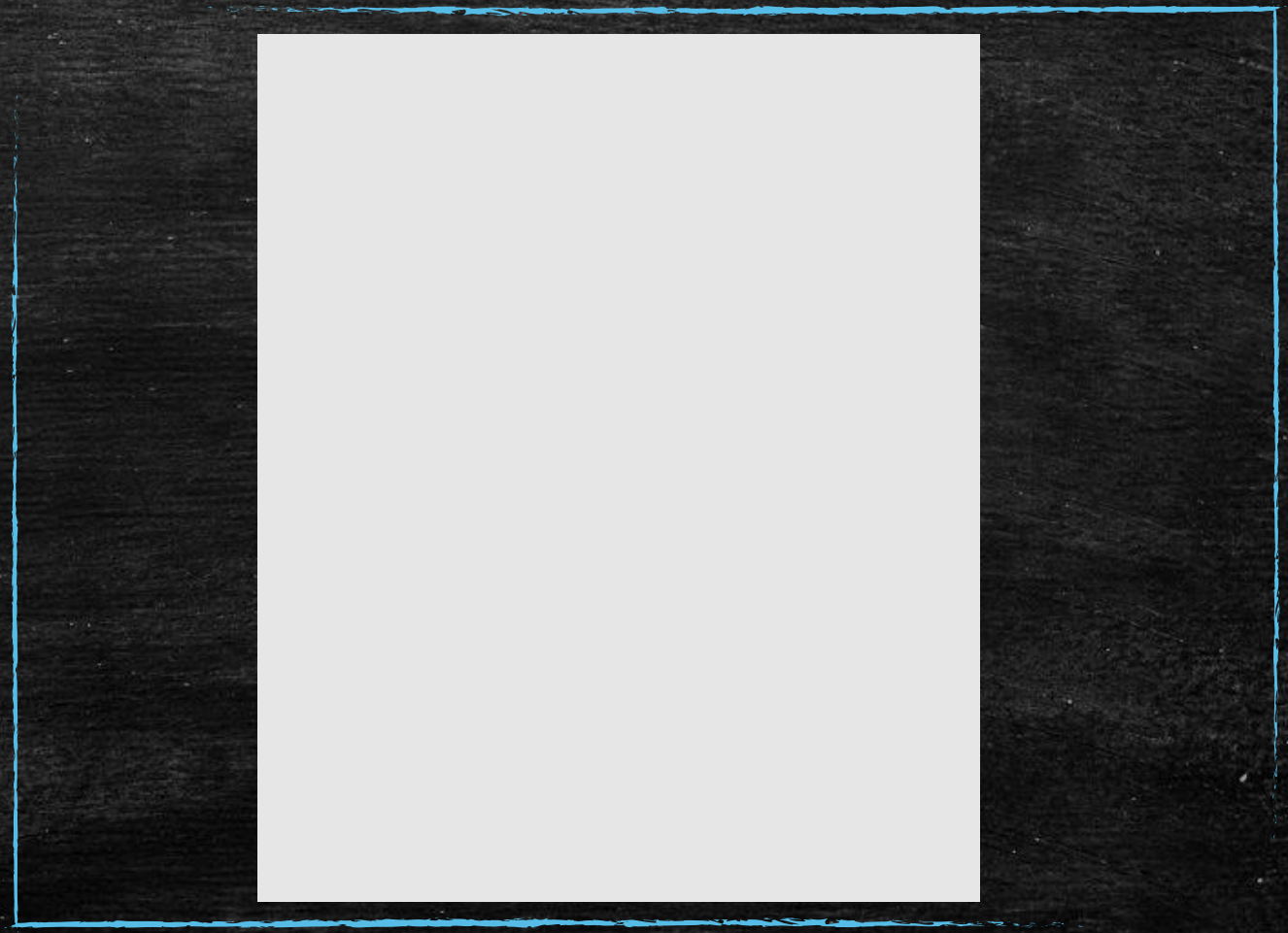
Drawing the Entity Relationship Diagram (ERD)

STEP


Segment
SegmentID
StartLocation
EndLocation
Length
Surface
LaneConfiguration
AvgTrafficSpeed
TrafficCongestionLevel
WeatherConditions
Have
Traffic_Camera
CameraID
Location
InstalledDirection
FieldView
Resolution
CameraStatus
Highway
HighwayID
HighwayName
HighwayLocation
HighwayLength
LanesNumbers
ConstructionDate
MaintenanceSchedule
AvgDailyTraffic
MaxAllowableSpeed
Have
Exist
Have
Vehicle
VehicleID
PlateNumber
VehicleType
OwnerInfo
VehicleSpecifications
Speed
Lane
Direction
Have
Require
IoT_Device
DeviceID
Location
SensorType
InstallationDate
MaintenanceSchedule
Status
CommunicationProtocol
Traffic_Flow_Sensor
SensorID
Location
SensorType
InstalledDirection
Accuracy
DataCollectionFrequency
SensorStatus
Have
Maintenance
MaintenanceID
Location
StartTime
MaintenanceType
Description
ImpactOnTraffic
Have
Weather_Sensor
SensorID
Location
SensorType
Accuracy
DataCollectionFrequency
SensorStatus

Converting the ERD into a Relational Model

STEP



Building the Entity Relationship Model (ER Model)

- Highway (HighwayID, HighwayName, HighwayLocation, HighwayLength, LanesNumbers, ConstructionDate, MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed).
- Segment (SegmentID, StartLocation, EndLocation, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions).
- IoT_Device (DeviceID, Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol).
- Traffic_Camera (CameraID, Location, InstalledDirection, FieldView, Resolution, CameraStatus).
- Traffic_Flow_Sensor (SensorID, Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus).
- Weather_Sensor (SensorID(fk), Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus).
- Maintenance (MaintenanceID, Location, StartTime, MaintenanceType, Description, ImpactOnTraffic).
- Vehicle (VehicleID, PlateNumber, VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction).

Normalization the Relational Model to the Third Normal Form (3NF)

STEP

Normalization the Relational Model to the Third Normal Form (3NF)

Step 5 is implemented in two steps as follows, the first is by understanding and collecting Functional Dependencies based on the business understanding according to stakeholders of the project.

The second step is by eliminating partial dependencies ending up with 2NF, then eliminating transitive dependencies reaching to 3NF as required.

The normalization process is implemented in the following slides

Normalization the Relational Model to the Third Normal Form (3NF)

1- Summarising the Functional Dependencies

Normalization the Relational Model to the Third Normal Form (3NF)

Highway (HighwayID, HighwayName, HighwayLocation, HighwayLength, LanesNumbers, ConstructionDate, MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed).

FD1: HighwayID → HighwayName, HighwayLocation, HighwayLength, LanesNumbers, ConstructionDate, MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed

IoT_Device (DeviceID, Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol).

FD1: DeviceID → Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol

FD2: Status → MaintenanceSchedule

Segment (SegmentID, StartLocation, EndLocation, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions).

FD1: SegmentID → StartLocation, EndLocation, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions

FD2: Length → StartLocation, EndLocation

Traffic_Camera (CameraID, Location, InstalledDirection, FieldView, Resolution, CameraStatus).

FD1: CameraID → Location, InstalledDirection, FieldView, Resolution, CameraStatus

Normalization the Relational Model to the Third Normal Form (3NF)

Traffic_Flow_Sensor (SensorID, Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus).

FD1: SensorID → Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus

Weather_Sensor (SensorID(fk), Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus).

FD1: SensorID → Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus

Maintenance (MaintenanceID, Location, StartTime, MaintenanceType, Description, ImpactOnTraffic).

FD1: MaintenanceID → Location, StartTime, MaintenanceType, Description, ImpactOnTraffic

Vehicle (VehicleID, PlateNumber, VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction).

FD1: VehicleID, PlateNumber → VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction

Normalization the Relational Model to the Third Normal Form (3NF)

2- Eliminating Partial and Transitive Dependencies

Normalization the Relational Model to the Third Normal Form (3NF)

The entities Highway, Traffic_Camera, Traffic_Flow_Sensor, Weather_Sensor, Maintenance, and Vehicle are all in 3NF, because they are in 1NF; they have no partial functional dependencies so they are in 2NF; and they have no transitive functional dependencies so they are in 3NF.

The entities Segment, and IoT_Device are in 2NF, because they are in 1NF, they have no partial functional dependencies so they are in 2NF, but they are not in 3NF, because FD2 in both entities is a transitive functional dependency, such that we need to normalize these two entities, so let’s start with normalization steps for Segment entity as follows :

Normalization the Relational Model to the Third Normal Form (3NF)

Segment Entity

Normalization the Relational Model to the Third Normal Form (3NF)

Segment (SegmentID, StartLocation, EndLocation, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions).

FD1: SegmentID → StartLocation, EndLocation, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions

FD2: Length → StartLocation, EndLocation

FD2 is a transitive functional dependency the we need to eliminate, so we need to create new relations to achieve that.

Normalization the Relational Model to the Third Normal Form (3NF)

- Segment (SegmentID, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions)

  FD1: SegmentID → Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions

- Segment_Length (Length, StartLocation, EndLocation)

  FD1: Length → StartLocation, EndLocation

Both new relations are now normalized to 3NF

Normalization the Relational Model to the Third Normal Form (3NF)

IoT_Device Entity

Normalization the Relational Model to the Third Normal Form (3NF)

- IoT_Device (DeviceID, Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol).

  FD1: DeviceID → Location, SensorType, InstallationDate, MaintenanceSchedule, Status, CommunicationProtocol

  FD2: Status → MaintenanceSchedule

  FD2 is a transitive functional dependency the we need to

  eliminate, so we need to create new relations to achieve that.

Normalization the Relational Model to the Third Normal Form (3NF)

- IoT_Device (DeviceID, Location, SensorType, InstallationDate, Status, CommunicationProtocol)

  FD1: DeviceID → Location, SensorType, InstallationDate, Status, CommunicationProtocol

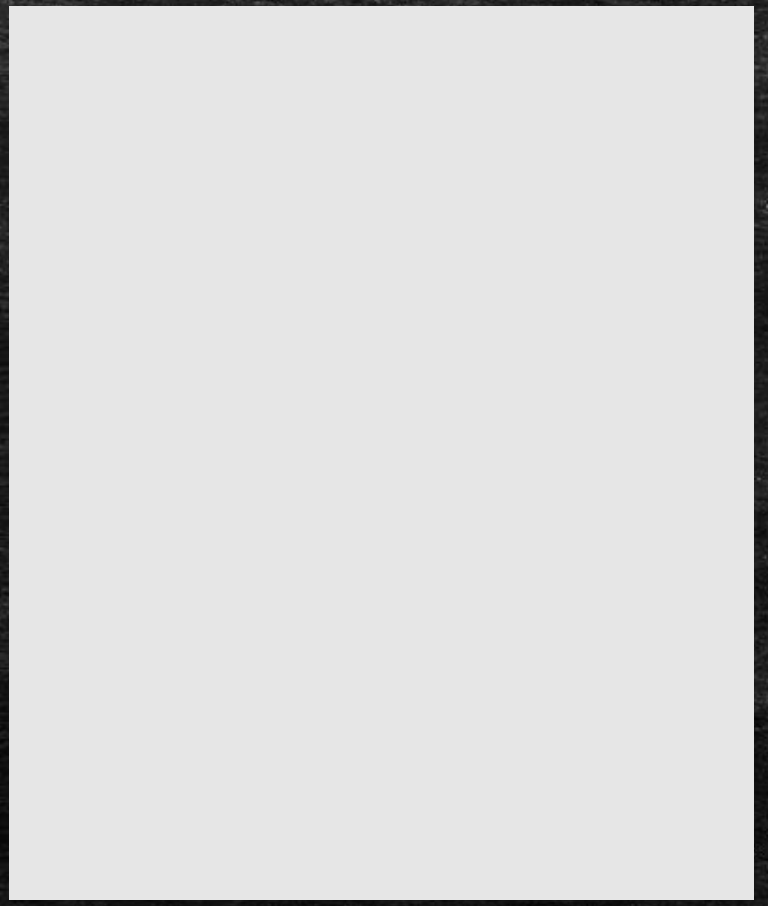
- IoT_Device_Status (Status, MaintenanceSchedule)

  FD1: Status → MaintenanceSchedule

Both new relations are now normalized to 3NF.

Final Output of the Relational Model in 3NF

STEP



Final Output of the Relational Model in 3NF

Highway (HighwayID, HighwayName, HighwayLocation, HighwayLength, LanesNumbers, ConstructionDate, MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed).

FD1: HighwayID → HighwayName, HighwayLocation, HighwayLength, LanesNumbers, ConstructionDate, MaintenaceSchedule, AvgDailyTraffic, MaxAllowableSpeed

IoT_Device (DeviceID, Location, SensorType, InstallationDate, Status, CommunicationProtocol)

FD1: DeviceID → Location, SensorType, InstallationDate, Status, CommunicationProtocol

IoT_Device_Status (Status, MaintenanceSchedule)

FD1: Status → MaintenanceSchedule

Segment (SegmentID, Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions)

FD1: SeqgmentID → Length, Surafce, LaneConfiguration, AvgTrafficSpeed, TrafficCongestionLevel, WeatherConditions

Segment_Length (Length, StartLocation, EndLocation)

FD1: Length → StartLocation, EndLocation

Traffic_Camera (CameraID, Location, InstalledDirection, FieldView, Resolution, CameraStatus).

FD1: CameraID → Location, InstalledDirection, FieldView, Resolution, CameraStatus

Final Output of the Relational Model in 3NF

Traffic_Flow_Sensor (SensorID, Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus).

FD1: SensorID → Location, SensorType, InstalledDirection, Accuracy, DataCollectionFrequency, SensorStatus

Weather_Sensor (SensorID(fk), Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus).

FD1: SensorID → Location, SensorType, Accuracy, DataCollectionFrequency, SensorStatus

Vehicle (VehicleID, PlateNumber, VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction).

FD1: VehicleID, PlateNumber → VehicleType, OwnerInfo, VehicleSpecifications, Speed, Lane, Direction

Maintenance (MaintenanceID, Location, StartTime, MaintenanceType, Description, ImpactOnTraffic).

FD1: MaintenanceID → Location, StartTime, MaintenanceType, Description, ImpactOnTraffic

DTSA 5733 Relational Database Design
Final Project

THE END

THANK YOU