

# DAMG 6210 - DATA MANAGEMENT AND DATABASE DESIGN

## P2 - Database Design Document

# Power & Utilities Distribution Management System

Supply Chain Management system for an electric  
generation and distribution company

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## Abstract

Supply Chain can be seen in every product, procurement, or service that we get today. Despite the increasingly intense competitions, companies in this domain are still oblivious to the all-encompassing potential of Database management systems. Additionally, the key to enhancing supply chain processes lie in integrating the colossal amount of data available to these organizations and then deriving valuable business intelligence from these. At the most fundamental level, supply chain management consists of the management of flow of goods/services, data and finances related to a product or service from the procurement of raw materials to the delivery of the service at its destination.

## Problem Statement

For our project, we aim to build a centralized database which consists of all the data pertaining to an electric generation and distribution company viz-a-viz Customer Data, Asset Data, Outage data, Billing data, Metering data, Preventive maintenance data, Repair data, Crew data etc. We aim to create an intricate linked data lake with all these data which can be queried with ease and used to create valuable visualizations which can be used to optimize the supply chain and consequently, will translate to monetary gains for the company and immense satisfaction for the customer. This will be a breakthrough in the current legacy systems and decentralized and redundant data storage mechanisms used by the age-old organizations in this domain.

## Mission and Objectives

- ⇒ A one stop shop for all the information about the entire supply chain available to the organization leadership at a single glance.
- ⇒ Seamlessly integrating data from various systems such as Outage Management System, Crew Management System, Equipment management system, Billing system, Customer database, Mobile Dispatch system and Weather data in a secure and ensure availability, consistency, integrity, and durability of data.
- ⇒ Determining metering patterns and billing amounts to determine customers who need help paying bills.
- ⇒ Identifying old assets and equipment that need replacement or maintenance.
- ⇒ Planning and preventing outages in the event of adverse weather events.
- ⇒ Effectively dispatching repair crew to affected area avoiding long outages and hence keeping the customer satisfied.

## Proposed Solution and Outcomes

- ⇒ Most Power and Utility companies need some Key Performance Indicators (KPIs) to be able to make leadership level decisions. Our database system provides a uniform platform which links together all the data entities in a logical manner and enables seamlessly building a business intelligence platform on top of this database management system. Interactive reports and dashboards highlighting KPIs can be created and will help the organization make informed decisions about organizational changes.
- ⇒ Traditional. Power and Utilities companies still store data inefficiently in different databases and in unstructured forms. For example, Equipment installations are stored in form of requisition form files, Outage Management Systems and Employee Databases are all stored separately and sometimes contain redundant data such as Customer data, billing data etc. Our solution would integrate all these separate databases and remove redundancy to create a normalized database with only the essential entities and attributes and linked together extensively through explainable relationships.
- ⇒ Our proposed solutions will bring together Billing, Accounts, Payment and Customer information which are traditionally disparate systems in an efficient manner reducing inconsistencies and redundancies. Maintaining all this data in a single location also reduces security issues and inaccuracies in sensitive data such as bills.
- ⇒ Utilities companies usually lease or buy various equipment from different sources and fail to keep track of these equipment to be able to plan for efficient maintenance and repairs. Our solution brings together and stores all aspects of an Asset management system and helps the company keep track of assets that need immediate repairs or replacements.
- ⇒ An aspect that is very important to essential service providers such as electric and power companies is that their ultimate pathway to customer satisfaction is to guarantee maximum availability and reliability. Our solution brings together weather data into the database system so that it can be used to derive insights about future adverse weather events and accordingly plan for power outages and fast crew deployments and power restorations.
- ⇒ A very important part of the design of our database is the extensive entities that store and track employee/crew information. These tables store crew information, crew deployments as well as incident reports so that it is easy to check the schedules of crew members and assign a repair man to tend to customer complaints and resolve them within the earliest possible window of time.

## Key Design Decisions

Our Electric company management database will consist of an array of entities and be interlinked with relationships. Below are a few of the key relationships and the purpose they serve:

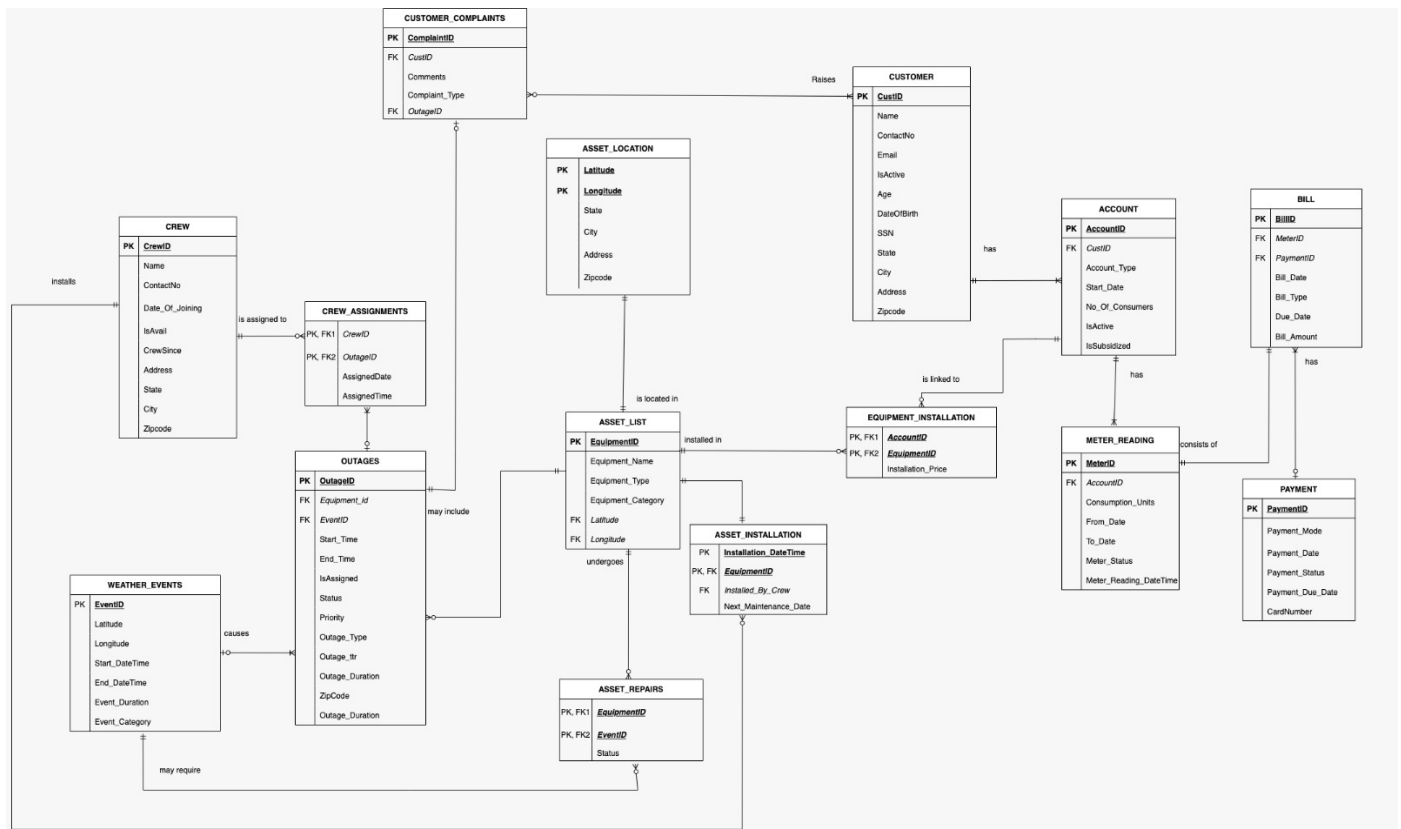
- ⇒ The CUSTOMER entity stores information about the customers of the company and apart from the usual attributes of Name, Contact, Email, Address, Gender, Social Security number, it also contains a multivalued entity called AccountID. A Customer may hold multiple service accounts and each of these accounts will have its own associated ACCOUNT entity which has Account\_type , start date, No of consumers and active flag.
- ⇒ Billing information is stored using the BILL and PAYMENT entity. The bill entity is identified by BillID and is associated with a certain AccountID. It contains information about billing period, due date and bill date. The payment entity references a given bill ID and stores information such as payment mode, credit card number.
- ⇒ Metering information is collected and stored within the METER\_READING entity which has important information such as Reading date, start reading, end reading, start date, end date as well as meter status which indicates whether the meter is active or inactive.
- ⇒ EQUIPMENT\_INSTALLATION an associative entity which maps accountIDs to EquipmentIDs. These equipment are stored in ASSET\_LIST entity and can range from something as small as a switch, meter to a transformer or substation. Alongside Asset data, our database system also stores the installation and upcoming maintenance details of each asset in ASSET\_INSTALLATION entity. ASSET\_LOCATION is a table that stores the location of each equipment.
- ⇒ One of the main tables in our system is OUTAGES table, this table stores information about outages, with respect to attributes such as ZIP code, start time, end time, outage type (Planned or Unplanned), equipment affected which is a multivalued attribute, status and priority. It additionally contains a calculated column called outage time to restore which will be calculated using UDFs.
- ⇒ CUSTOMER\_COMPLAINTS entity connects the complaints raised by customer to the respective outage about which the complaint was. This helps us track the outages on the basis of customer impact alongside equipment damage/impact.
- ⇒ The next aspect is the CREW table which stores the Crew data attributes such as name, contact, date of birth, address, gender, availability flag. There is an entity called CREW\_ASSIGNMENTS is an associative entity which tracks the assignments of the Crew members to various outages.

- ⇒ The final aspect of our solution is a WEATHER\_EVENTS table which holds information about Adverse weather events – these events are linked back to the OUTAGE table which has a foreign key to identify which weather event caused the outage.

In addition to these entities and relationships we will have some key functionalities in our database which will enable us to create a more organization centric easy to use database for our use case. Below are a few of these functionalities:

- ⇒ We have a few computed columns in our database entities. Columns such as Duration of Event, Age of customer, Years since customer joined etc., will not be manually stored but rather computed from the available data. For example, Age of the customer will be computed using a User Defined function which will make use of the Customer's Date of Birth to calculate their age.
- ⇒ We will making use of various stored procedures to query the database and retrieve outputs based on inputs given to the function. For example, we can retrieve the list of customers affected by a given outage by passing the zip code or outageID to the procedure.
- ⇒ We will be dealing with a bit of sensitive data in our database, Customer SSN and Credit Card numbers are sensitive data, and we will be using column level encryption to store these details in an encrypted form so as to ensure top security.
- ⇒ We will also be enabling CHECK constraints on our database to ensure data integrity and correctness. We will place check constraints on scenarios such as Date of Birth should not be ahead of current date, outage end time should not be before outage start time etc.
- ⇒ In order to enable efficient querying of the database we will be creating non-clustered indices on Customer Name and Crew Name so that the tables can be queried in a quick time not only on the PK but on the Name as well.
- ⇒ Our database system will also have triggers placed to intimate the customers affected due to an outage via email as soon as an outage is recorded in a given zip code.
- ⇒ Finally, one very important feature of any database management system are views. Our proposed solution will have multiple views implemented to have a single glance view of important statistics and reporting metrics. These can be List of customers affected by a given outage, List of available and unavailable crew members or Number of outages by area or date.

# Initial ER Diagram



## Database Components

### Entity 1 – CREW

Field Name	Description
CrewID	Primary Key and unique identifier holding Crew member's ID
Name	Name of the Crew member
ContactNo	Employee Contact number
Street	Street address of the crew
State	State where the crew member resides
City	City part of the Address
ZipCode	Zipcode part of the Address
Date_Of_Joining	Date of Joining of Crew
CrewSince	Number of year since the crew member has been working for the organization
isAvail	Flag indicating the availability of the crew member

### Entity 2 – CREW\_ASSIGNMENTS

Field Name	Description
CrewID	Foreign Key which is the unique identifier for each crew member this will be a part of the composite primary key
OutageID	Foreign key linking to an outage – this will be a part of the composite primary key
AssignedDate	Date when the task was assigned to the crew member
AssignedTime	Time when the task was assigned to the crew member

### Entity 3 – CUSTOMER

Field Name	Description
CustID	Primary Key which is unique customer ID
Name	Name of the Customer
SSN	Social Security number of Customer
ContactNo	Customer's Contact
Email	Customer's Email Address
Address	Street address part of Customer's Address
State	State part of Customer's address
City	City part of Customer's Address
ZipCode	ZipCode part of Customer's Address
DateOfBirth	Date of birth of Customer

Age	Age of the customer- this will be a computed column
isActive	Flag whether customer is active with the company or not

## Entity 4 – ACCOUNT

Field Name	Description
AccountID	Primary Key which stores unique Account ID
CustID	Foreign Key which links to CUSTOMER entity
Account_Type	Type of Account
Start_Date	Date when the account was opened
No_Of_Consumers	Number of Consumers under the given account
isActive	Flag whether Account is active or not
isSubsidized	Flag whether this account is eligible for subsidized billing

## Entity 5 – BILL

Field Name	Description
BillID	Primary Key which identifies each unique bill
Bill_Amount	Price Amount of Bill
Bill_Date	Date when Bill got generated
Bill_Type	Bill Type which indicates whether this is a monthly bill or annual bill or a special kind of bill
Due_Date	Last Date to pay the Bill
MeterID	Foreign Key which links to METER entity
PaymentID	Foreign key which links to the payment information for this bill

## Entity 6 – PAYMENT

Field Name	Description
PaymentID	Primary Key which identifies the particular payment
Payment_Mode	Mode of Payment
CardNumber	Stores the card number of the payment if applicable
Payment_Date	Date at which Payment is made
Payment_Status	Status of Payment (Pending/In-Progress/Completed)
Payment_Due_Date	Last Date when Payment can be made

## Entity 7 – METER\_READING

Field Name	Description
MeterID	Primary Key which identifies the particular meter reading



AccountID	Foreign Key which links to the account to which the meter belongs
Consumption_Units	Reading indicating total electricity consumption
From_Date	Start Date from when Meter Reading is calculated
To_Date	End Date till when Meter Reading is calculated
Meter_Status	Status of Meter (Working condition)

## Entity 8 – EQUIPMENT\_INSTALLATION

Field Name	Description
AccountID	Primary Key and Foreign Key that links the record to a given account
EquipmentID	Primary Key and Foreign Key that links the record to a given equipment
Installation_Price	Price at which this equipment was installed for the account

## Entity 9 – ASSET\_LOCATION

Field Name	Description
Latitude	Latitude of Asset's Location Coordinates. This is also part of the composite Primary Key.
Longitude	Longitude of Asset's Location Coordinates. This is also part of the composite Primary Key.
Street	Street address of the Asset's Location
State	State part of Asset's Location
City	City part of Asset's Location
Zipcode	Zipcode part of Asset's Location

## Entity 10 – ASSET\_LIST

Field Name	Description
EquipmentID	Primary Key which identifies the particular equipment
Equipment_Name	Name of the Equipment
Equipment_Type	Type of the Equipment
Equipment_Category	Category of the Equipment
Latitude	Foreign Key that links back to the equipment Location in ASSET_LOCATION table.
Longitude	Foreign Key that links back to the equipment Location in ASSET_LOCATION table.

## Entity 11 – ASSET\_INSTALLATION

Field Name	Description
EquipmentID	Foreign Key which links to the actual equipment details. This is also part of the composite Primary Key.
Installation_DateTime	Date time of Installation of the Equipment. This is also part of the composite Primary Key.
Installed_By_Crew	Installed by which Employee – this will have the crew ID and is a Foreign key to the CREW table
Next_Maintenance_Date	Date when next Maintenance is needed for the installed Equipment

## Entity 12 – ASSET\_REPAIRS

Field Name	Description
EquipmentID	Foreign Key which links to the asset list of which the given equipment is part of. This is also part of the composite Primary Key.
EventID	Foreign Key which links to the weather event because of which the given equipment needs repair. This is also part of the composite Primary Key.
Status	Status of Repairing the Asset

## Entity 13 – OUTAGES

Field Name	Description
OutageID	Primary Key which identifies a particular Outage
Zipcode	Zipcode of location where Outage occurred
Start_Time	Date when Outage started
End_Time	Date when Outage ended
Outage_Type	Type of Outage
Outage_duration	Duration of outage, this will be computed by a user defined function that will calculate this based on start time and end time
IsAssigned	Employee to which given Outage is Assigned
Equipment_ID	Foreign Key (ID of the Equipment involved in Outage)
Status	Current Status of Outage situation
Priority	Priority given to Outage
Outage_TimeToRestore	Time to restore the outage – this will be computed using a UDF as well.
EventID	Foreign which links to the event which caused the

	outage if any
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## Entity 14 – WEATHER\_EVENTS

Field Name	Description
EventID	Primary Key which identifies a particular weather event.
Latitude	Latitude of the event that occurred
Longitude	Longitude of the event that occurred
Start_Datetime	Start date and time of the event
End_Datetime	End date and time of the event
Event_Duration	Total duration of the event, this is a computed column which is populated by a UDF
Event_Category	Category of the event – Storm, Hail, Rain, Lightning etc.

## Entity 15 – CUSTOMER\_COMPLAINTS

Field Name	Description
ComplaintID	Primary Key which identifies a particular complaint.
CustID	Foreign Key which links to the Customer who has raised this complaint.
Comments	Comments (if any) regarding the complaint
Complaint_Type	Type of Complaint
OutageID	Foreign Key which links to the Outage for which this complaint was raised

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