⚙️ Challenge #1 - Predictive maintenance

Outline

The increasing popularity of electric vehicles (EVs), has raised the bar for Charging Point Operators (CPO) in providing EV owners with reliable, safe and readily-available charging points. As a CPO, **Powerdot** faces the challenge of ensuring the smooth operation of charging infrastructure and of minimising charger downtime, which can arise from unexpected circumstances.

Each charger is equipped with communication protocols (e.g. Open Charge Point Protocol (OCPP)), which generate logs detailing charger-customer interactions.

To mitigate these challenges, a predictive maintenance system that anticipates charger malfunctions - which can deteriorate charger performance - needs to be developed, leveraging charger communication logs and overall network performance. For instance, could a decline in network performance be an adequate predictor in charger malfunction? Or can a specific error event be a predictor for lower performance?

Problem Statement

⚡ **Powerdot's Challenge**

- Ensure **smooth charger operation** and minimize **unexpected downtime**
- Chargers generate **logs via OCPP** detailing charger-customer interactions
- Downtime can result from **technical failures, network issues, or external factors**

🔧 **Need for Predictive Maintenance**

- Develop a system that **anticipates malfunctions** before they occur
- Leverage **charger logs & network performance** to detect early warning signs

Data Provided

Sessions

- 442 644 records
- 5 features

> Each row represents the **total number of sessions** and **failed sessions** on a given tuple `(charge_date, charger_id, connector_id)`. Note that a single charging station can have multiple connectors.
>
> **Failed sessions** are sessions that didn't deliver energy to the vehicle and are considered faulty. Important to note that `sessions` represent **total** number of sessions which include `failed sessions`.

Sample:

charge_date	charger_id	connector_id	sessions	failed_sessions
2023-01-16	34406128	5	4	0
2023-01-23	37A80B4D	3	3	3
2023-01-18	AA92D18E	2	2	0
2023-01-28	FF15DC0B	3	2	0
2023-01-19	06B95C56	2	1	0

OCPP Logs

OCPP also known as Open Charge Point Protocol is the mechanism that allows charging stations to communicate with its Charging Station Management System, enabling remote control and auditing operations

- 1 029 301 records
- 6 features

Each row of this dataset represents an error message on a given `(charger_id, connector_id, error_at)` tuple. The record also contains:

- `supplier` → charging station manufacturer
- `error_code` → a high level grouping of the error message
- `vendor_error_code` → the specific error occurred

supplier	charger_id	connector_id	error_code	vendor_error_code	error_at
513B5F6A	AFE79784	1	HighTemperature	TRANSFORMER_OVERHEAT	2023-08-21
513B5F6A	0DAF7992	3	OtherError	RemoteStart	2023-09-05
513B5F6A	DD37CC5F	3	InternalError	sessmgr.emvPaymentController	2023-10-11
513B5F6A	4365B1B8	8	InternalError	sessmgr.emvPaymentController	2023-09-07
513B5F6A	4365B1B8	4	EVCommunicationError	COMMUNICATION_ERROR	2023-12-09

Observations

Charging Station Performance relates to the total number of successful sessions a charging station is able to generate. Take in consideration that reliability it's only one of the components that might impact performance. General demand, competition, pricing also are factors that can affect performance. Nonetheless, if performance subtly changes in a given period of time, it should be flagged for analysis.

Moreover, while the `vendor_error_code` list is large, not all the errors will deteriorate performance in the same way. We are looking to determine what are the patterns that generate significant periods of lower to no performance on a given `charger` or `(charger, connector_id)`. These patterns can be used to trigger maintenance interventions that can keep charger performance at its best.

Your Mission

🚀 **Implement a data-driven predictive maintenance to enhance reliability and uptime**

Deliverables

🚀 **Predictive Maintenance Model**

- Uses provided datasets to **forecast charger malfunctions**
- Leverages existing features and **extracts new relevant indicators**

💻 **Monitoring Framework**

- Continuously **tracks charger performance** and **detects anomalies**
- **Flags malfunctioning chargers** needing intervention

📊 **Presentation**

- Explains **methodology**, **model approach**, and **key findings**
- Provides real-world implementation strategy & recommendations