In20-S5-CS3501 Data Science and Engineering Project
Department of Computer Science and Engineering
University of Moratuwa

EcoTrack5G

Monitoring & Optimizing Energy in Next-gen Networks

Team Members:

KAJAANI B. 200279N
KARUNARATHNA J.P.N.D. 200294F
KARUNATHILAKE R.M.S.K. 200296M

Group ID:07
Project ID:07
Mentor:Dr. Charith Chitraranjan

1. Executive Summary:

This project aims to develop a machine learning-based model to address the energy consumption challenge in 5G networks. By estimating energy consumption for various base station products, the model will consider architectural differences, configuration parameters, traffic conditions, and energy-saving methods. The project targets achieving generalization capabilities across diverse products and configurations, thereby advancing energy-efficient 5G deployments.

2. Problem Statement:

The growing adoption of 5G networks has raised concerns about increased energy consumption. Despite 5G's efficiency goals, higher energy usage is attributed to a greater number of cells needed for coverage at higher frequencies and increased processing demands. This project aims to address this challenge by developing a machine learning-based model that accurately estimates energy consumption for diverse base station products and configurations. By achieving this, the project aims to promote the deployment of energy-efficient 5G networks. The beneficiaries include network operators and service providers striving to optimize energy usage while maintaining quality network performance, which is vital for sustainable and cost-effective operations.

3. Data Description:

The project will utilize datasets provided for the competition:

- Base Station Basic Information **(BSinfo.csv):** Contains configuration parameters and hardware attributes of base stations.

Label	Description
BS	Name of the base station
CellName	Name of the cell
RUType	Name of the radio unit type
Mode	Transmission mode
Frequency	Frequency of the cell
Bandwidth	Bandwidth of the cell
Antennas	Number of antennas of the base station
TXpower	Maximum transmit power of the cell

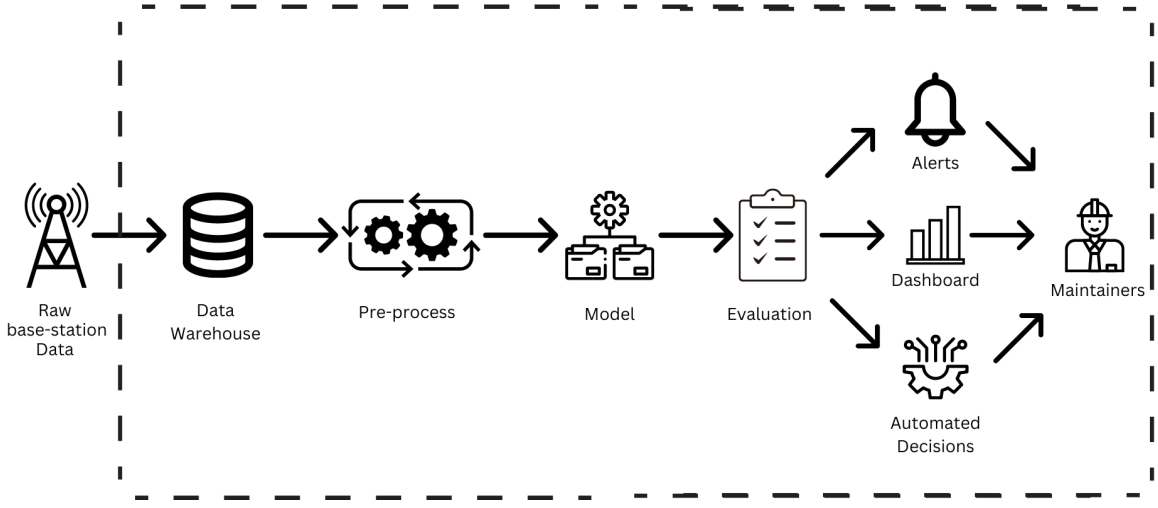
- Cell-Level Data **(CLdata.csv):** Includes hourly counters related to service compliance and energy-saving methods for specific base stations and cells.

Label	Description
Time	Date and time in which the measurement was collected
BS	Name of the base station
CellName	Name of the cell
Load	Load of the cell. It takes value in [0-1]
ESMode [1-6]	Intensity of the activation of different energy-saving modes. It takes value in [0-1]

- Energy Consumption Data **(ECdata.csv):** Provides hourly energy consumption measurements for specific base stations

Label	Description
Time	Date and time in which the measurement was collected
BS	Name of the base station
Energy	Energy consumption measurement

4. Methods



Data Usage Approach:

- Utilize Base Station Basic Information to understand base station attributes.
- Analyze Cell-Level Data to assess load patterns and energy-saving modes' impact.
- Use Energy Consumption Data for training the predictive model.

Model Development:

- Develop a regression model incorporating base station attributes, configuration parameters, load conditions, and energy-saving mode activations in order to achieve the competition's objectives.

Model Evaluation:

- Assess the model's performance using the provided evaluation metric (WMAPE).
- Test the model's generalization capabilities across different base station products and configurations.

5. Expected Outcomes and Success Criteria:

Expected Outcomes:

- Using the formatted data, it delivers visuals, statistics, and analytics to assist operators in tracking energy usage patterns, identifying inefficiencies, and coming up with informed optimization decisions.
- Base stations can use energy-saving strategies such as symbol shutdown, RF (Radio Frequency) shutdown, and component sleep mode. Software solutions enable operators to activate and manage these strategies based on network demand and traffic conditions.
- When energy consumption surpasses particular limits or when anomalies are found, the software sends automated alerts and notifications to operators. This enables operators to take timely actions to optimize energy usage.
- Reporting the leaderboard position in the Zindi competition and all the objectives that are mentioned in it.
    - Develop a model to estimate energy consumption for diverse base station products considering engineering configurations, traffic, and energy-saving methods.
    - Achieve model's ability to estimate new product energy consumption based on existing data, enhancing flexibility.
    - Enable model to predict energy usage for varied configurations using limited parameters, showcasing adaptability and accuracy.

Success Criteria:

The following standards will be used to determine the project's success:

- The software effectively presents visuals and statistics of real-time energy consumption data from base stations and network components.

- The software must suggest energy-saving strategies like symbol shutdown, RF shutdown, and component sleep mode when it is suitable.
- Automated alerts and notifications are promptly sent when energy consumption exceeds thresholds or anomalies are detected.
- The mean-absolute-error(MAE) must be less than 2.00.

6. Preliminary Bibliography:

N. Piovesan, D. López-Pérez, A. De Domenico, X. Geng, H. Bao, M. Debbah, “Machine Learning and Analytical Power Consumption Models for 5G Base Stations”, IEEE Communications Magazine, 60(10), 56-62, 2022

N. Piovesan, D. López-Pérez, A. De Domenico, X. Geng, H. Bao, “Power Consumption Modeling of 5G Multi-Carrier Base Stations: A Machine Learning Approach”, 2023 IEEE International Conference of Communications (ICC).