Wind Turbine Anomaly Detection

Daniel Henriksen (s171833)
Tomas Balsevičius (s181960)
Román Cárdenas (s182004)

Part I: Goals

Narrative

Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies. Among all the renewable technologies, wind energy has gained immense importance in Denmark.
One main problem of wind turbines is their complexity: if a part of the system breaks, the repairment process will be long and costly.
We propose an anomaly detection system that foresees possible failures, reducing the Mean Time to Repair and repair expenses.

Project goals

1. Show how machine learning can detect anomalous behaviors and all the possible faults do not have to be thought of beforehand.
2. Create a rule-based system for simulating wind turbine functioning.
3. Establish a communication system between wind turbines and a centralised server

Key Performance Indicators

1. False positive rate of anomaly detections below 5%.
2. Mean Time to Repair reduced at least 50%.
3. System simulator mockup created (yes/no).

Part II: System breakdown

Use case / functional description

- Each wind turbine has attached several sensors that will enable the system to monitor the current status of the turbine.
- The system gathers data from all the different turbines. Data is analysed in order to detect anomalies.
- The owner of the wind turbines (the energy provider) will be able of get the information of the current status of the system.
- If the system detects that a given wind turbine is functioning awkwardly, it will stop the turbine in order not to provoke greater damages to the engines.
- The system will also inform to the maintenance staff which wind turbine appears to function anomalously.

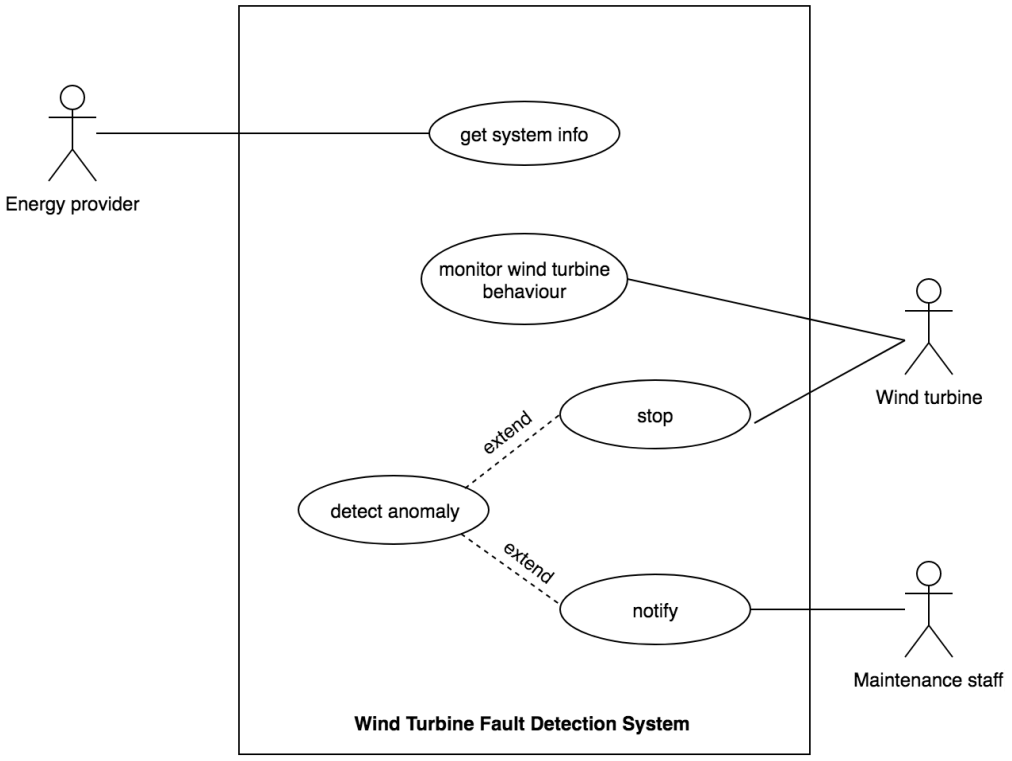

Figure I: Wind Turbine Fault Detection System Use Case Diagram

Structural description

- **Wind:** outside environment under study.
- **Wind turbines:** device to be analysed. It creates electrical energy out of wind.
- **Sensors:** items for monitoring different wind turbine parameters.
- **Sensor hub:** collects the information from all the sensors and acts as interface between wind turbines and communication system.
- **Server:** gathers data from all the wind turbines and analyses it in order to detect anomalies. It also shows overall status to energy provider.
- **Broker[1]:** handles the publish-subscribe communication status between sensor hubs and central server.

Interfaces description

- External interfaces:
    - Sensors: gets information from the wind turbine environment.
    - Web interface: connects energy provider to the server in order to get overall system information.
- Internal interfaces
    - Sensor-hub interface: Physical interface to connect the sensors to the hub. For this project, this interface is not important, as the wind turbine will consist of a simulation.
    - Publish-subscribe protocol[1]: *a priori*, MQTT[2] is the technology selected for it.

[1] If we decide to stick to the publish-subscribe communication, this structure will be necessary.
[2]MQTT machine-to-machine (M2M)/"Internet of Things" connectivity protocol: http://mqtt.org

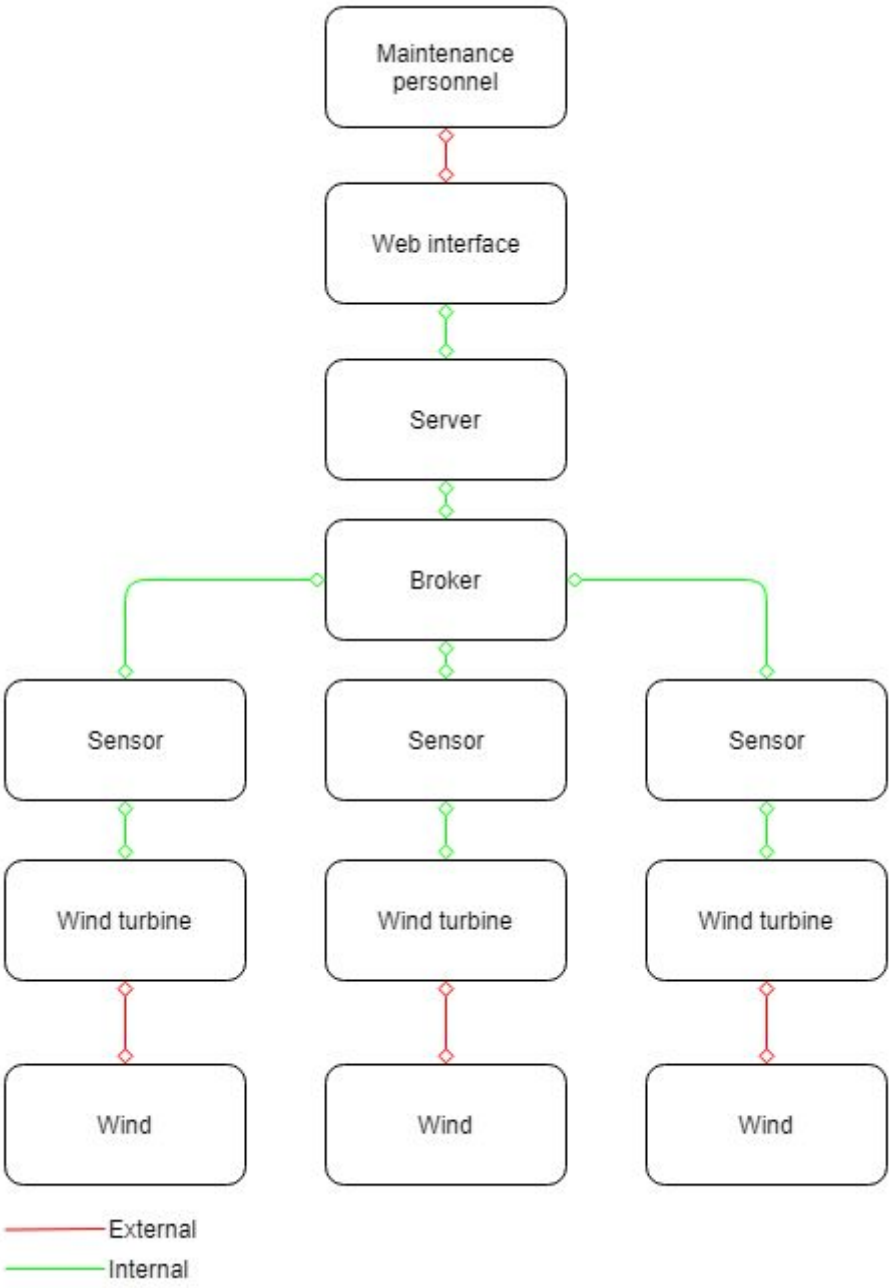

Figure II: System Interfaces and Structure

Part III: Project breakdown and people

Required overall tasks

The following tasks has been identified:

1. Acquire data for the normal operation of a wind turbine.
2. Model the wind turbine (simulation).
3. Train an artificial neural network that simulates wind turbine operation (server).
4. Rule-based system for monitoring and controlling wind turbines (server).
5. Communication system between server and turbines (server and wind turbines).

Break down project by system parts and tasks

The project can be divided into five parts where the model, communication and data cleaning will be addressed first and can work be worked on independently. The machine learning and rule-based system is dependent on the first three points and will be addressed in the end.

- Wind turbine model.
- Communication.
- Data cleaning.
- Machine Learning for anomaly detection.
- Rule-based system for the interaction between the server and the wind turbine.

Project focus

The main focus should be on communication, as a similar system could monitor not only the abnormal behaviour of wind turbines, but also other machines. That being said, it is very important to also implement the abnormal behaviour detection algorithm, which could be either ML-based, rule-based or a mixture of both..

Assign responsibility

Román: communication system.
Daniel: wind turbine model and Machine Learning.
Tomas: data cleaning and rule-based system.

Part IV: Half-time check

We think we must at least have the first iteration of our communication system and make sure it is working.
We also expect to have some data on wind speed and a viable model for simulation.
Machine Learning and rule-based system will be explored for the second half of the project, as well as a better communication system.