Arrowhead Interface – Project course proposal

Background

Wind turbines are fundamental machines in the production of energy from renewable sources. A wind turbine contains a large variety of rotating mechanical components that require continuous monitoring to ensure proper operation. A failure in any of the components can lead to a sudden and unexpected stop in the wind turbine, which causes large losses to the company operating the wind turbine. Therefore, condition-monitoring boxes are typically installed within the wind turbine and use in the maintenance operations of the machine.

The condition-monitoring box aims to monitor and track the deterioration of the mechanical components within the wind turbine in real time. This tool manages the day-to-day maintenance operations and warns when abnormal behavior occurs. Furthermore, it communicates with remote diagnostic centers who are responsible for the analysis of the data generated by the wind turbine.

Inputs

There are 10 sensors connected to the condition-monitoring box.

- 1 speed sensor - tachometer
- 1 load sensor – 4-20 mA
- 8 accelerometers (locations listed below)
    - Main Bearing, radial direction – 250mV/g
    - High Speed Shaft, radial direction – 100mV/g
    - Low Speed Shaft, radial direction – 100mV/g
    - Main Bearing, axial direction – 250mV/g
    - High Speed Shaft, axial direction – 100mV/g
    - Planetary stage gearbox, radial direction – 250mV/g
    - Generator Drive End side, radial direction – 100mV/g
    - Generator Non-Drive End side, radial direction – 100mV/g

Settings

The operator (or remote diagnostics center technician) selects among four different options of sampling frequency. The selected sampling frequency affects the time window signal length. The buffer size remains constant at 16384 samples in all settings. These four options are:

Table 1: Sampling frequencies with equivalent time windows

Setting	Sampling frequency	Time window signal length
A	1600 Hz	10,24 seconds
B	3200 Hz	5,12 seconds
C	6400 Hz	2,56 seconds
D	12800 Hz	1,28 seconds

In addition, the operator (or remote diagnostics center technician) can set any number of alarms that are triggered whenever any of the sensors goes above or below the threshold values.

The final setting is the transmission frequency, which is typically set at 12 hours but can be modified by the operator (or remote diagnostics center technician). The transmission frequency defines how often the raw data signals (full 16384 samples buffer) are saved in a remote location database.

Outputs

The condition-monitoring box of each wind turbine in the wind park is connected via Ethernet to the park server that contains the database. At the end of every time window period (see Table 1), the flags raised by any of the alarms are transmitted together with the following measurements from all the sensors:

- Average value
- Minimum value
- Maximum value
- Initial segment value
- End segment value

In addition, at the end of each transmission frequency period, which is typically set at every 12 hours, the entire raw signal buffer is saved in the database for all the sensors. Therefore, statistics (and alarms) are not sent simultaneously with the raw buffer.

The operator can change the settings of any of the turbines and set/create any alarms that desires. The operator (or remote diagnostics center technician) transmits any change in the settings via Ethernet to the condition-monitoring box of the corresponding turbine. Not all turbines must have the same settings but it is recommended that all turbines have the same settings.

SoS architecture

A local cloud architecture is proposed for each wind mill, se Figure 1-3. below.

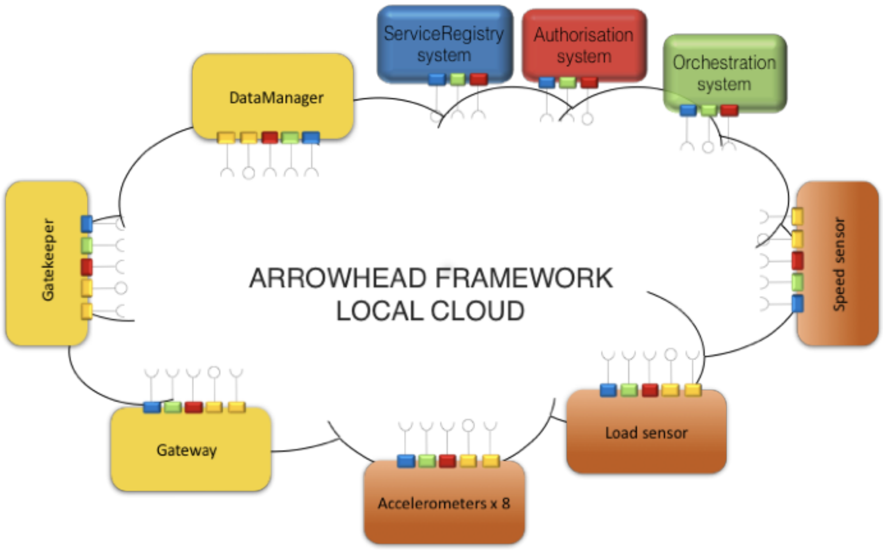

Figure 1: Local cloud architecture for a wind mill. All 10 sensors are connected to the wind mill.

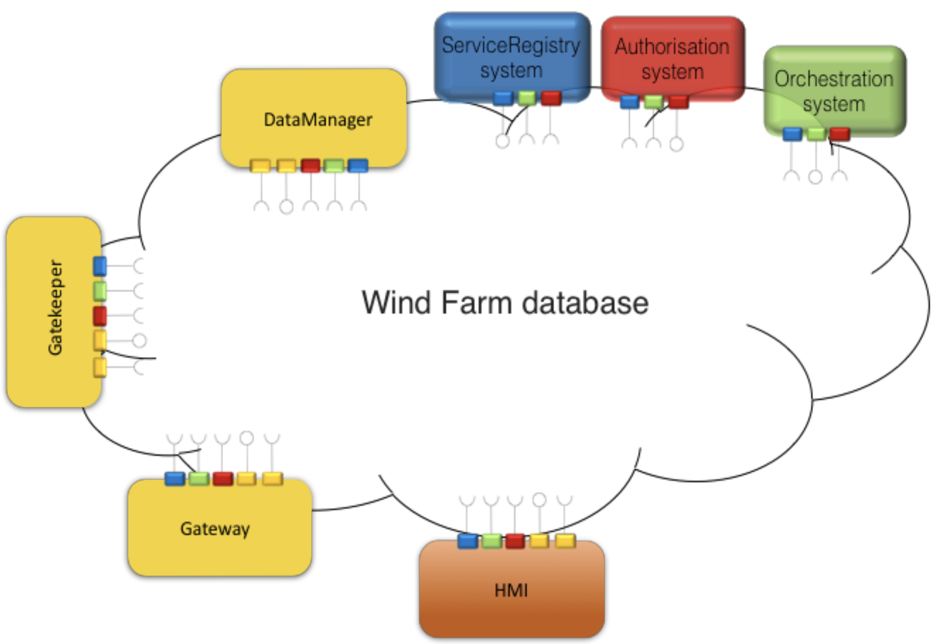

Figure 2: Local cloud for central wind farm operations. Each wind mill is connected to the wind farm database.

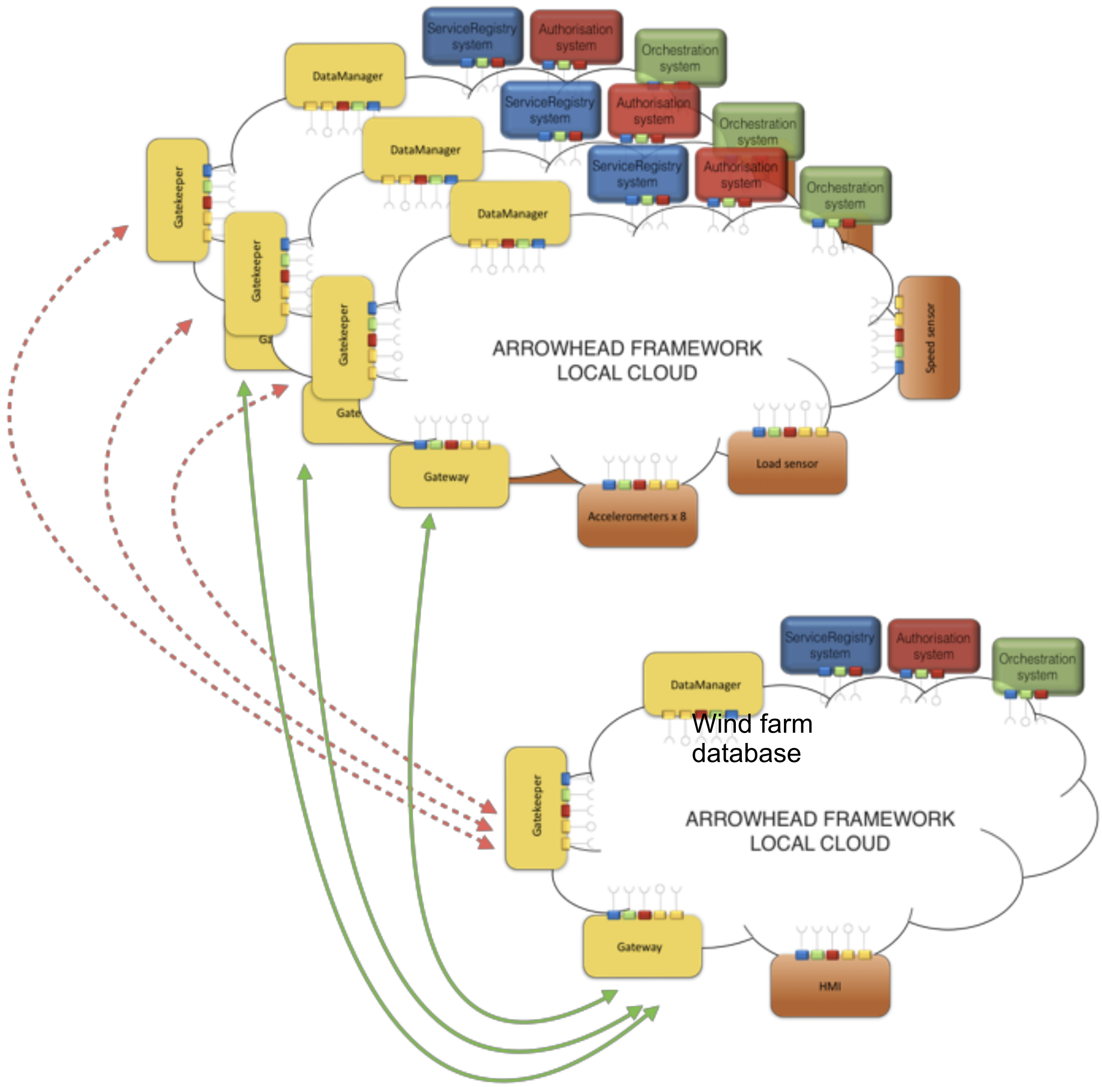

Figure 3: Local cloud architecture for a wind farm. Here three win mill local clouds (top) do feed data to the central wind farm local cloud (bottom). The HMI depicts the information (statistics and raised alarms) at the end of each time window period.

Assignments

This is split into 3 different assignments

1. Build wind mill local cloud. Data from sensors in the wind turbines is available in the following repository http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-70730. All three mandatory core systems shall be used. Wind turbine data to be provided by a sensor gateway system providiing a WindTurbineData service. Dato to be consumed and stored by the DataManager.

2. Build Central wind farm local cloud. HMI shall be able to visualise according to O**utput** above. All three mandatory core systems shall be used. Data from the DataManagers of multiple local clouds shall be consumed and visualised by a VisualisationDashBoard. Late binding of the producing local clouds shall be demonstrated.

3. Use inter cloud communication using Gatekeeper and Gateway systems such that data from the wind mill local cloud DataManagers can be transfered and stored at a DataManager in the Wind farm local cloud. Run-time security management shall be demonstrated.

4. Provide a SysML model of the combined 1-3 assignments. Here the SysML 1.6 profile shall be used. The Arrowhead SysML 1.6 library shall be used to create at least two wind turbine local clouds and the wind farm local cloud.