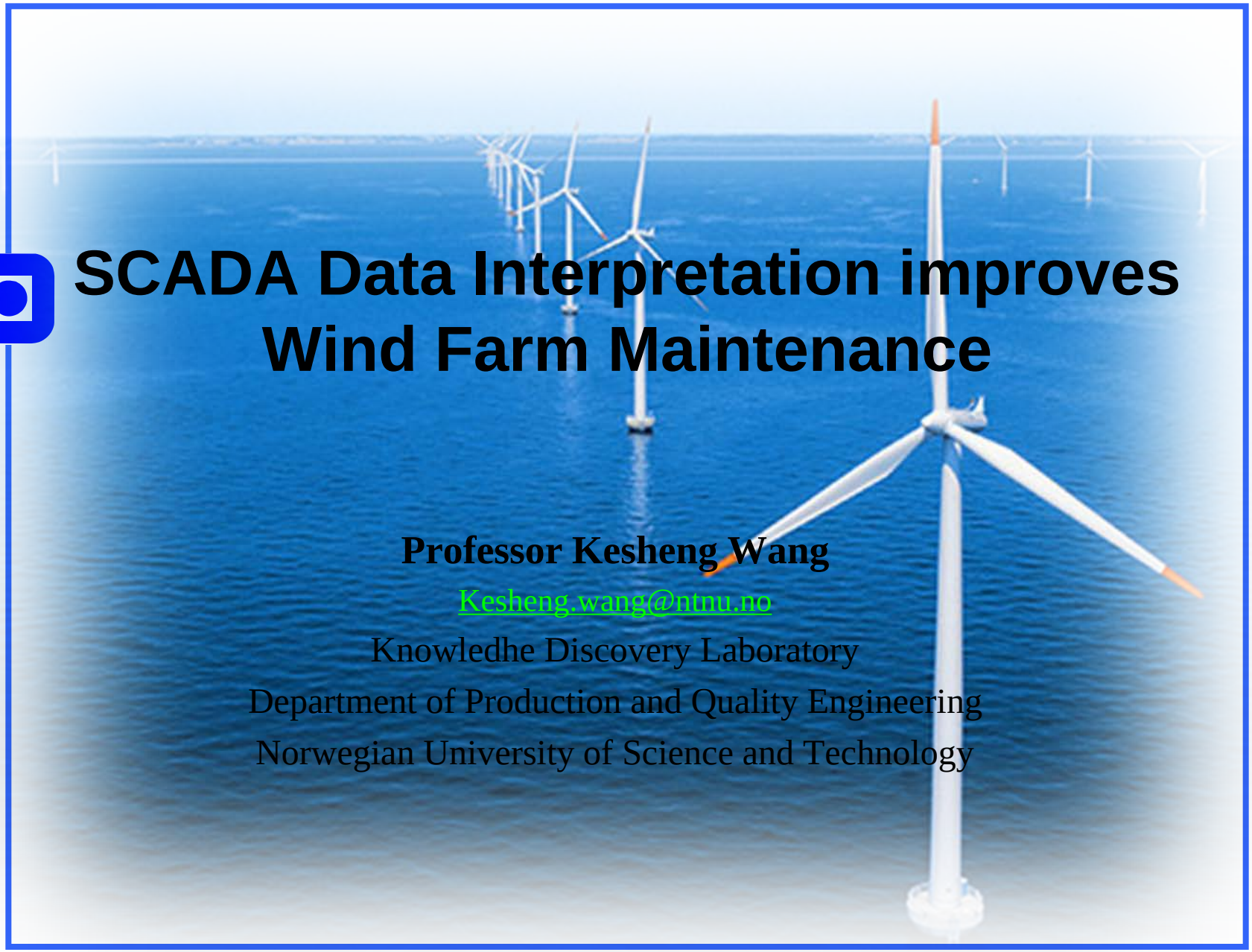

SCADA Data Interpretation improves Wind Farm Maintenance

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Outlines

- Introduction
- Predictive Maintenance
- Framework of WINDSENSE Project
- SCADA Data Based CMS
- Case study
- Conclusions

Introduction

- Renewable energy sources are playing an important role in the global energy mix, as a means of reducing the impact of energy production on climate change. Wind energy is most developed renewable energy techniques.
- The management of wind farms is challenging because it involves several difficult tasks, such as wind forecasting and the operations and maintenance of turbines.
- The maintenance of wind turbines has received attention in recent years due to its impact on the cost of generating power from wind. The main tendency of maintenance policy is changing from Preventive Maintenance (PM) and Corrective Maintenance (CM), to Predictive Maintenance (PdM).

Classification of Maintenance Policy

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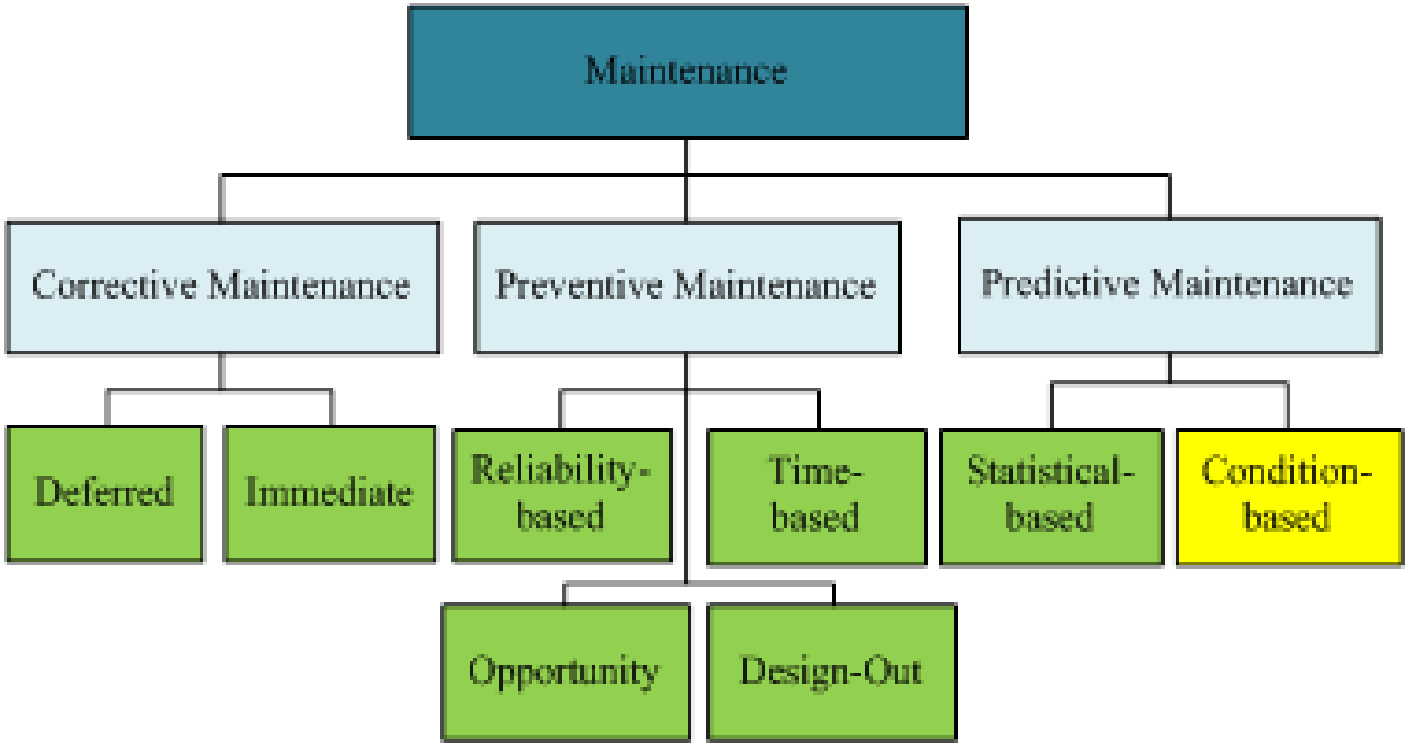
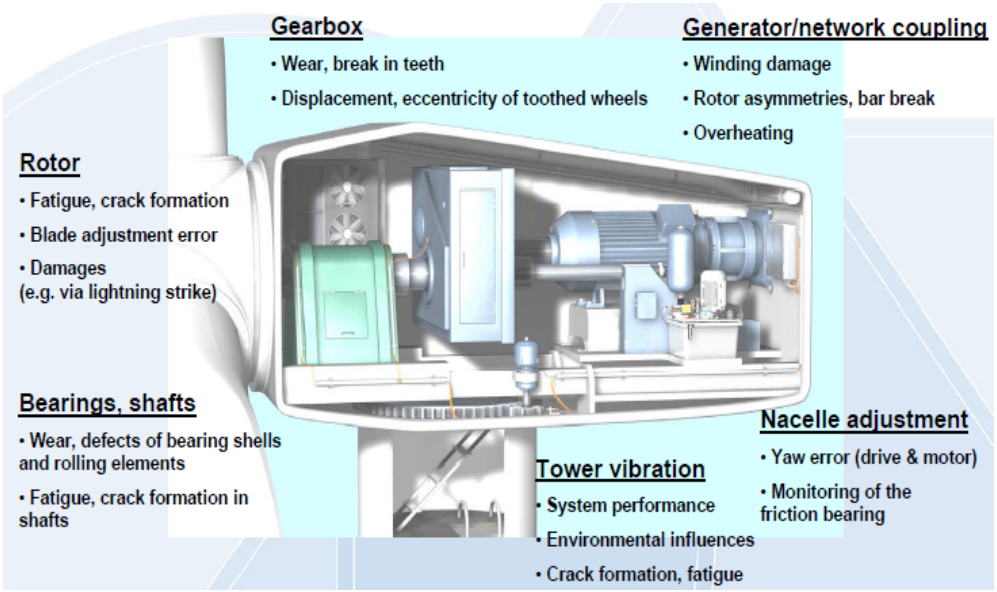


Fault Diagnosis and Prognosis Systems on Wind Turbines

- Major Failures on Wind Turbines:

http://www.ifm.com/obj/ifm_wind_power_CMS_EN.pdf

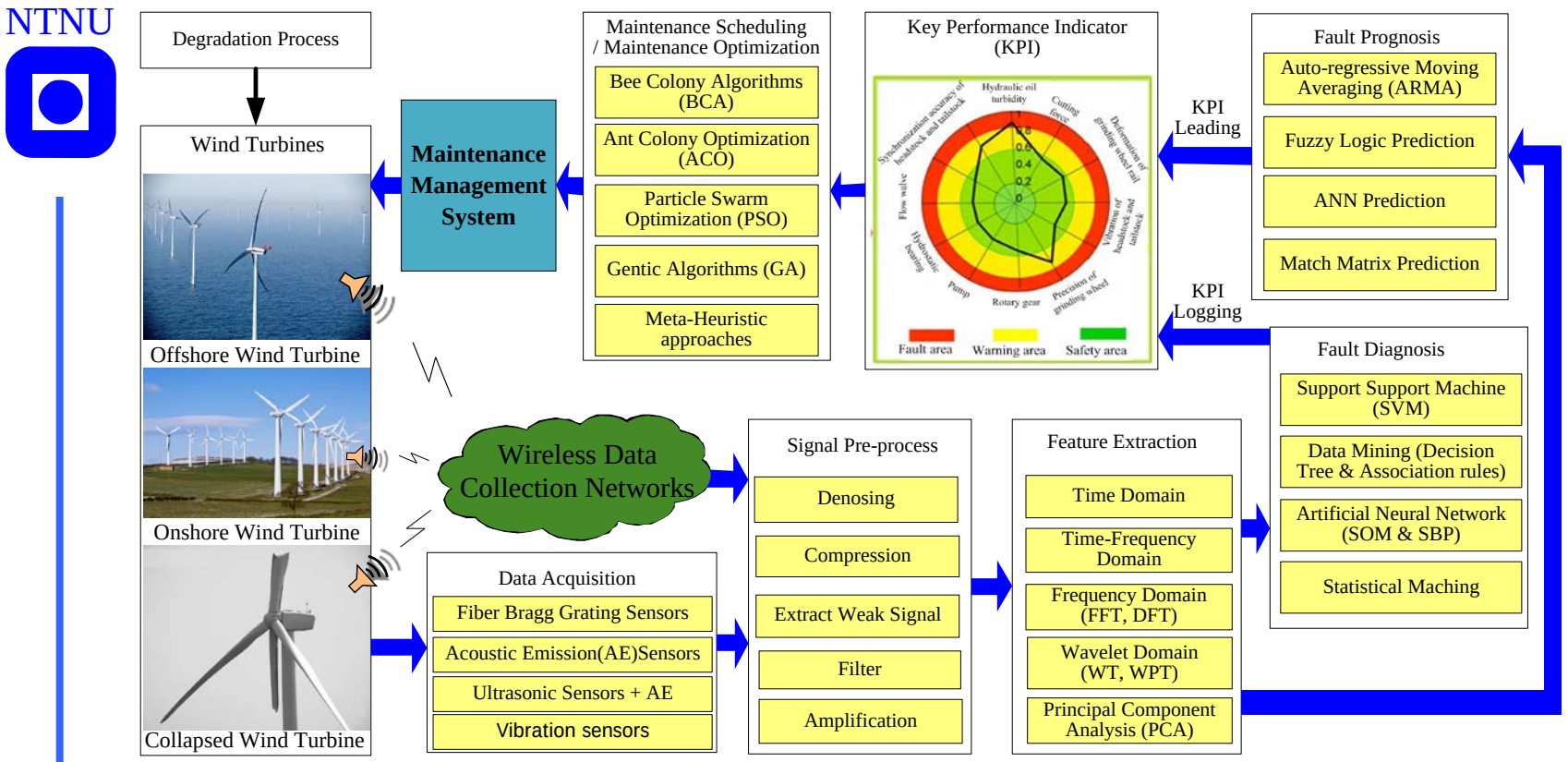


Mechanical component	Failure percentage
Main Gearbox	32 %
Generator	23 %
Main Bearing	11 %
Rotor Blades*	<10%

*Blade resonances lead to fatigue failures

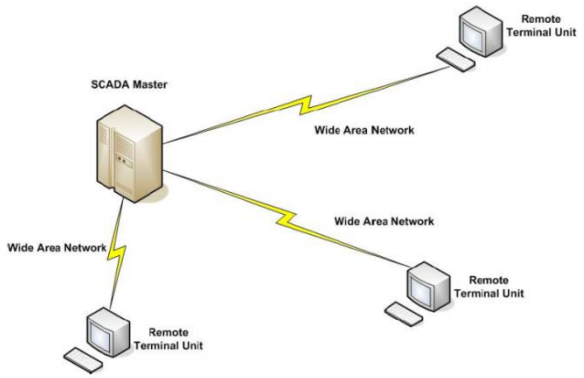
Framework for WINDSENSE

- (Add-on instrumentation system for wind trubines)

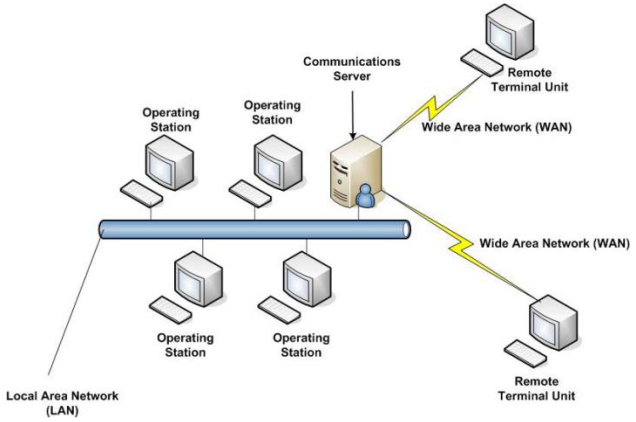


SCADA Data Based CMS for WT

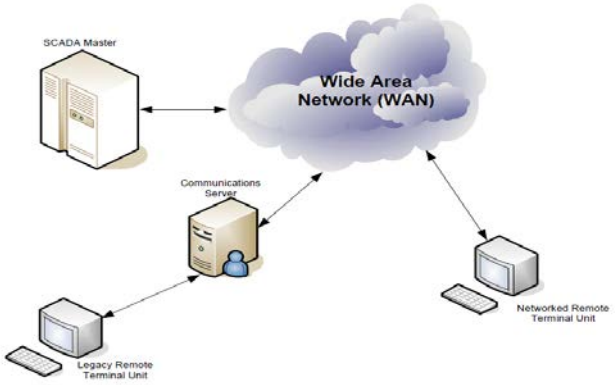
- SCADA System:



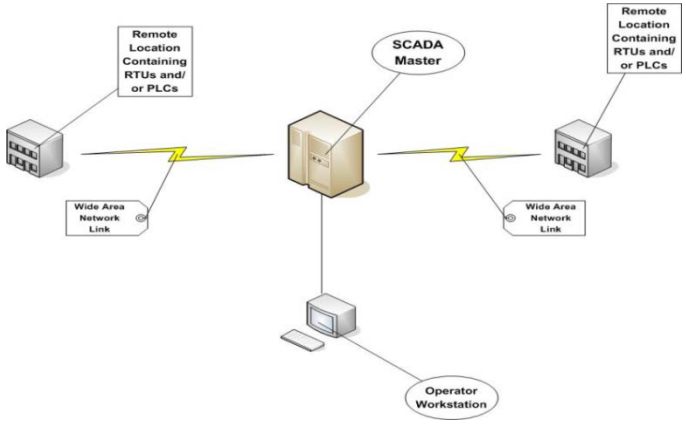
First Generation SCADA Architecture



Second Generation SCADA Architecture

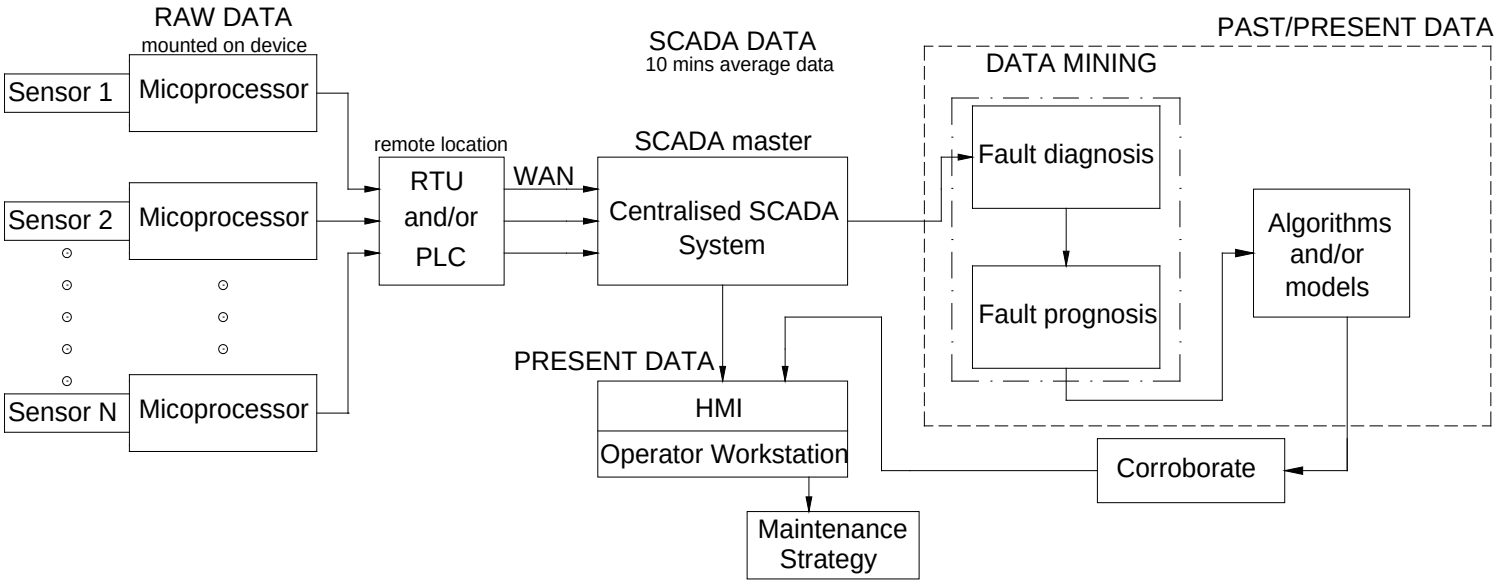


Third Generation SCADA System



Typical SCADA System

SCADA Data Based CMS for WT



Raw Data and SCADA Data (proposed frame work)

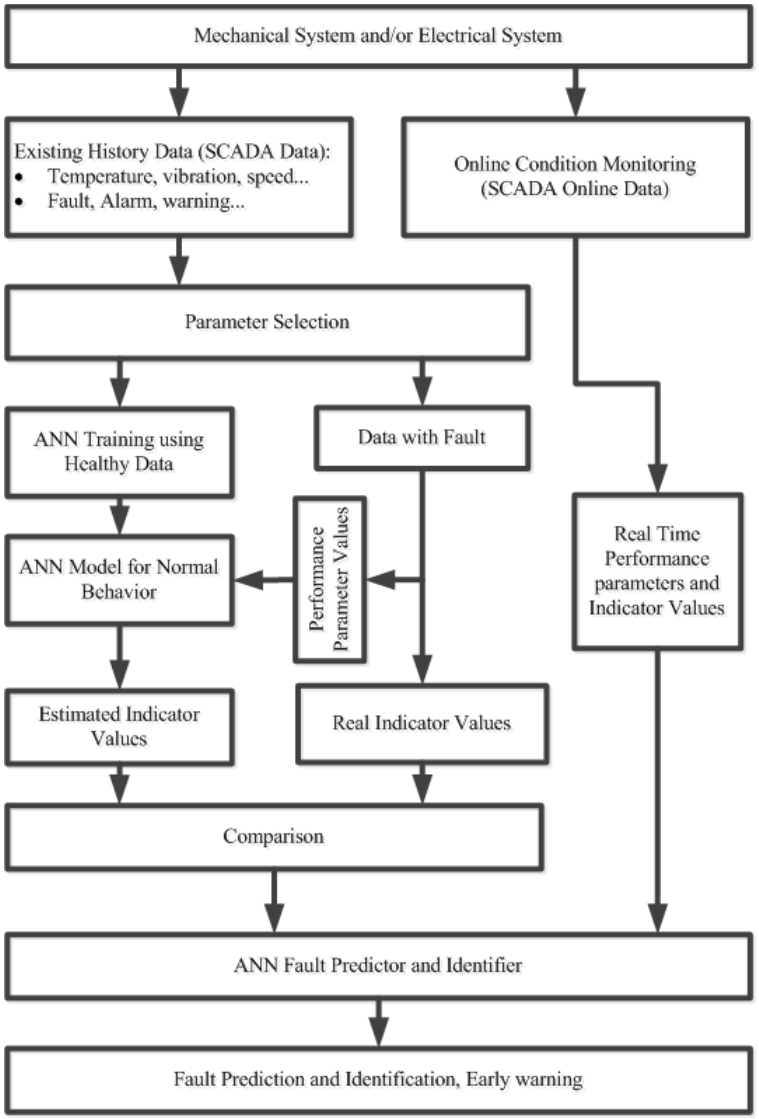
SCADA Dataset Description

- **Wind parameters**, such as wind speed and wind direction;
- **Performance parameters**, such as power output, rotor speed, and blade pitch angle;
- **Vibration parameters**, such as tower acceleration and drive train acceleration; and
- **Temperature parameters**, such as bearing temperature and gearbox temperature.

Examples

- Active power output (10 min max/min/average)
- Anemometer-measured wind speed (10 min max/min/average)
- Turbine speed (10 min max/min/average)
- Nacelle temperature (10 min max/min/average)
- Turbine rear bearing temperature (10 min max/min/average)
- Turbine rear bearing vibration (10 min RMS max/min/average)
- Turbine front bearing temperature (10 min max/min/average)
- Turbine front vibration (10 min RMS max/min/average)
- …

ANN-based Modeling of SCADA Parameter Normal Behavior

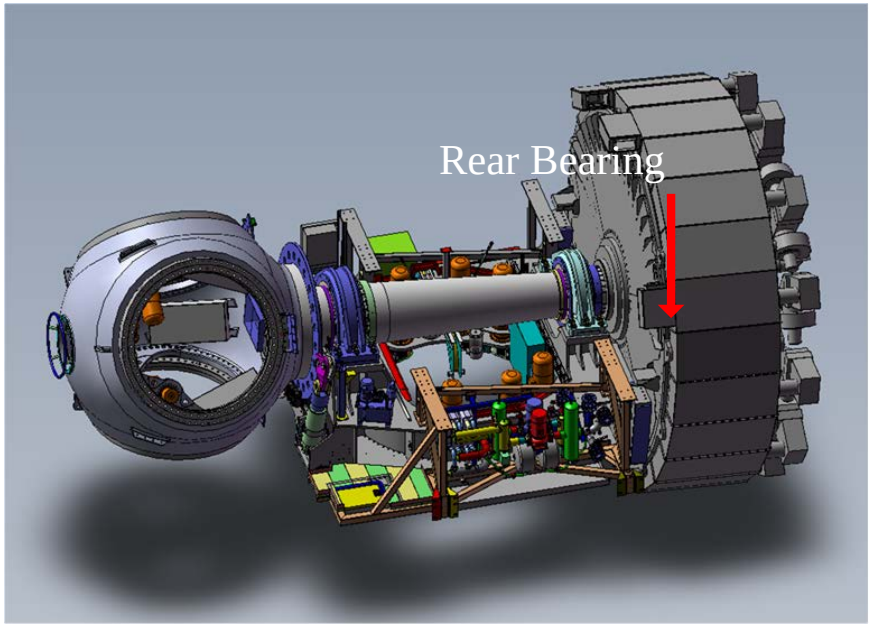


Procedure of Fault Detection based on SCADA Data

Case Study

Parameter Selection

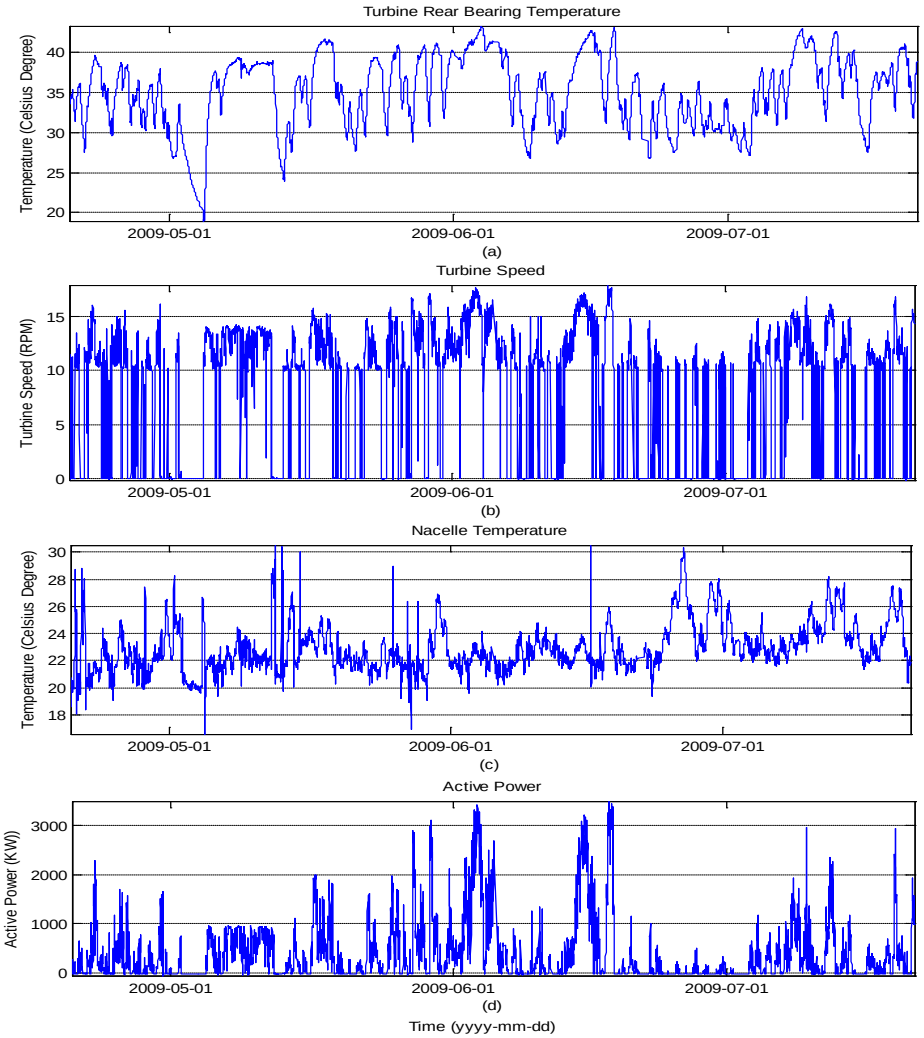
- Indicator: Temperature
- Possible parameters influence or relate to indicator:
  - Rear bearing temperature (t-1)
  - Active power output (t)
  - Nacelle temperature (t)
  - Turbine speed (t)
  - Cooling fan status



Input and Outputs of ANN Model

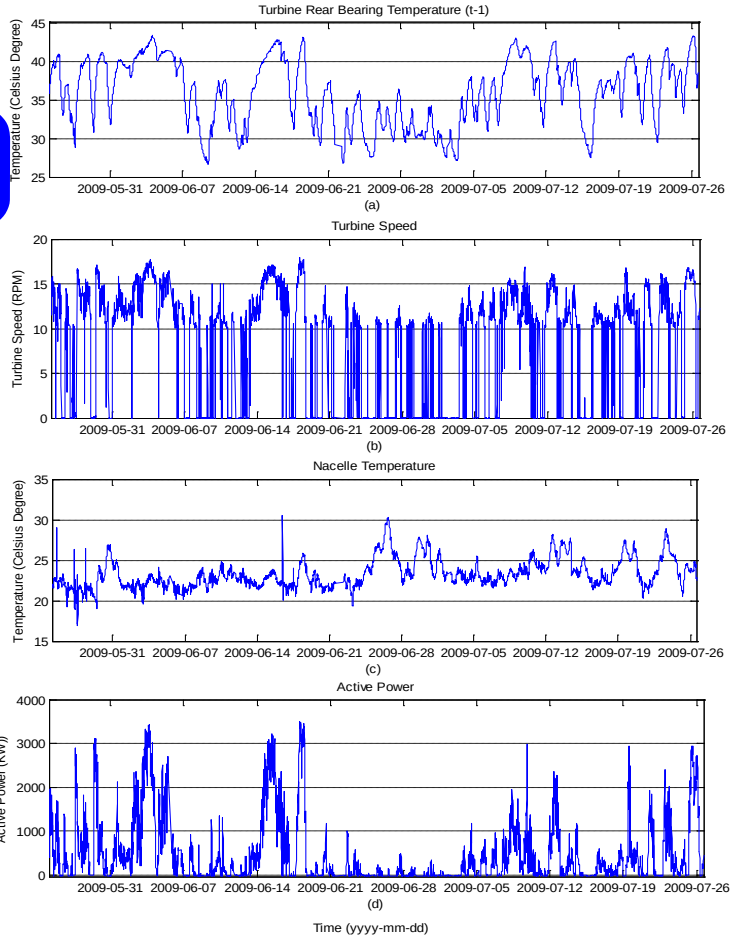
Model Output	Input
Rear Bearing Temperature	Rear bearing temperature (t-1) Active power output (t) Nacelle temperature (t) Turbine speed (t)

ANN Model Training



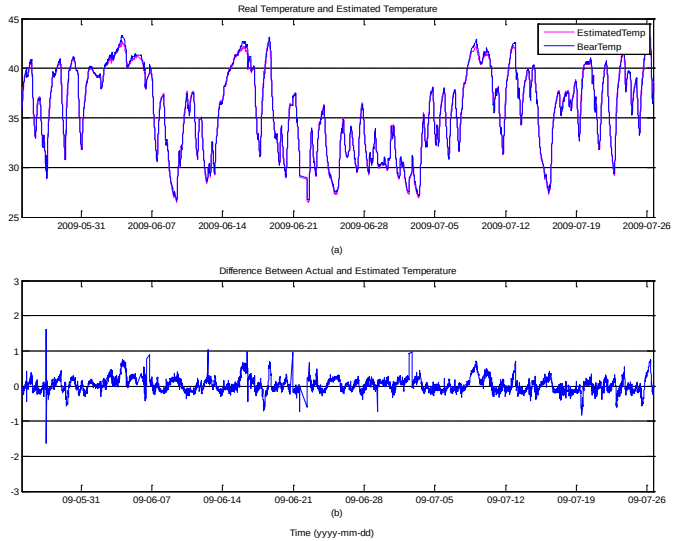
Rear Bearing Temperature Model Training Data

ANN Model Testing



Rear Bearing Model Testing Input Data

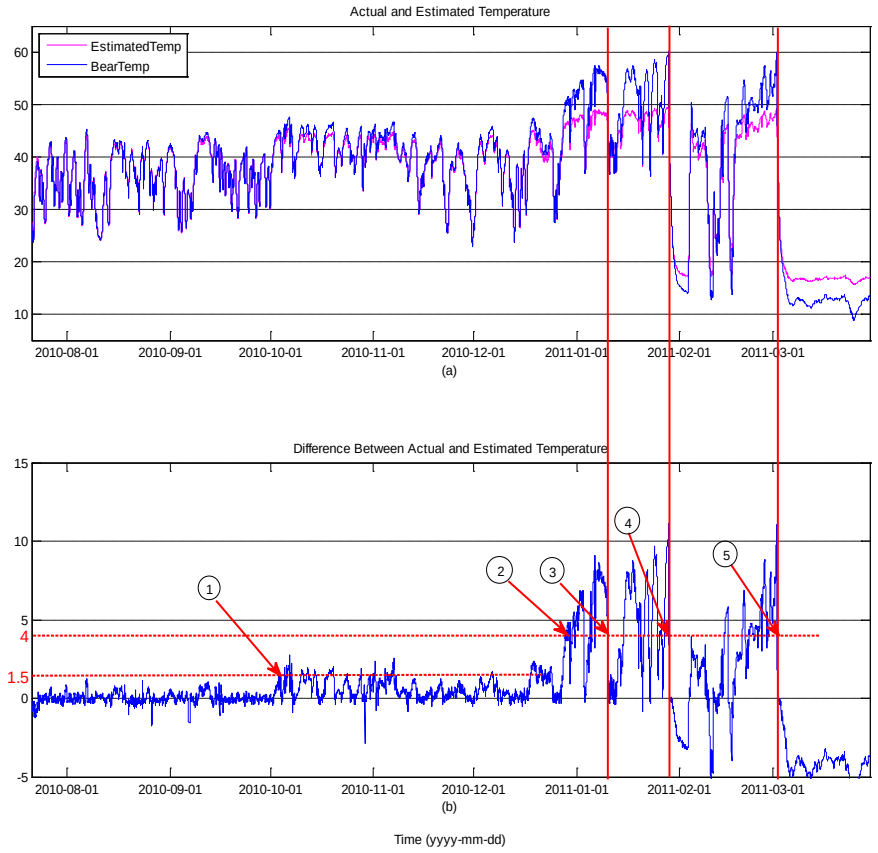
Test Data: 26.05.2009 to 26.07.2009



Rear Bearing Model Output in Normal Condition

Detection of Rear Bearing Fault

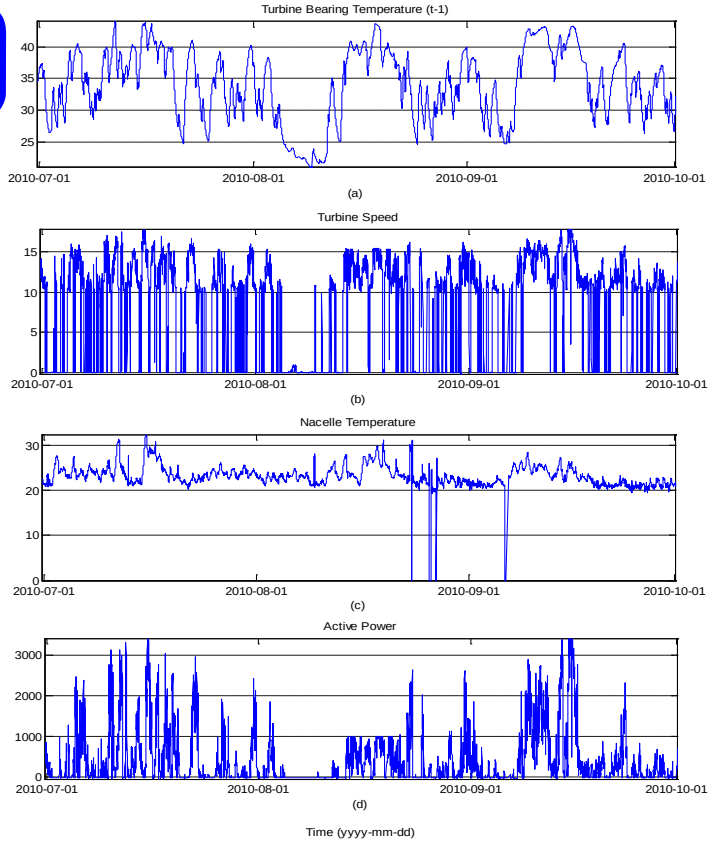
- ①: The first important deviation from the model estimates occurred from the start of October 2010.
- ③: the turbine was stopped because of overheating.
- The operator try to solve the problem two times in point ③ and ④ but not successful.
- ⑤: the turbine was completely stopped because of the overheating
- 3 months early warning
- 10 days close alarm



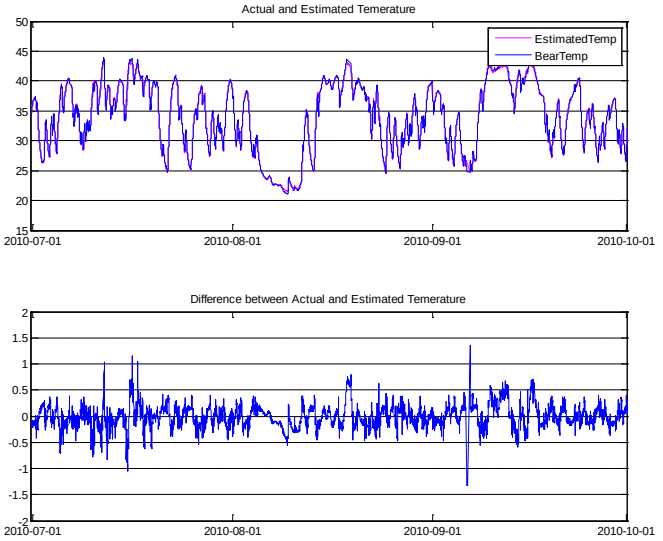
Fault Detection Results of Rear Bearing

Discussion

Whether the model established from the SCADA data of one turbine, can be applied in fault detection to another turbines?



Rear Bearing Model Testing Input Data of New Turbine



Yes, with the same type of turbines

Conclusions (1)

- The accuracy of the diagnosis model depends upon the input data. Thus a careful selection of variables and the quality of the data (free from noise) are the prime factors affecting accuracy. Hence adequate pre-processing models are desirable. Though the comparison results of various models is mentioned but no one clear cut perfect modeling technique could emerge. So this area needs further explorations. Hence a lot is to be done in this area, in order to obtain a generic model for CMS using SCADA data.
- The most of the research has been carried out using low frequency SCADA data (10 minutes average) and for a better prediction higher quality data is required (high frequency, noise free and long duration). This is another point which needs to be explored, i.e. what frequency SCADA data gives optimal results in case of WTs.
- It is proposed to diagnose and prognosticate with both conventional data and SCADA data and with the comparison of the two results. The suitable maintenance strategy could then be worked out.

Conclusions (2)

- Furthermore the relationships between faults have not been explored.
- It has been demonstrated that with combination of appropriate data mining algorithms and computational intelligence concepts the accuracy and robustness of model is enhanced.
- Most of the researchers have pinpointed that the data sharing by the wind engineering industry was major hindrance in this type of research. Hence there is a strong need for a pooling of common data base for researchers across the globe.
- Based upon the CMS of WT's using SCADA data appropriate maintenance strategy could be worked in order to achieve the goal of PdM.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Thanks for your Attention!