Anomaly Detection in Power Quality at Data Centers

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ABSTRACT
The goal during my internship at the National Center for Critical Information Processing and Storage (NCCIPS) is to implement an anomaly detection method through the StruxureWare SCADA Power Monitoring system. The benefit of the anomaly detection mechanism is to provide the capability to detect and anticipate equipment degradation by monitoring power quality prior to equipment failure. First, a study is conducted that examines the existing techniques of power quality management. Based on these findings, and the capabilities of the existing SCADA resources, recommendations are presented for implementing effective anomaly detection. Since voltage, current, and total harmonic distortion demonstrate Gaussian distributions, effective set-points are computed using this model, while maintaining a low false positive count.

OBJECTIVES
• Perform data analysis to check raw data for anomalous behavior.
• Investigate existing solutions for monitoring power quality with the ION meters and StruxureWare software.
• Calibrate the built-in StruxureWare SCADA Power Monitoring System to detect anomalous behavior in power quality.
• Detection of anomalies should give informative messages regarding what type of anomalies have occurred.
• Use and maintenance of anomaly detection implementations should be simple.

MATERIALS & METHODS
• Schneider-Electric StruxureWare Power Monitoring Software
• Schneider-Electric PowerLogic SCADA Power Monitoring System
• Gaussian distribution of voltage, current, and total harmonic distortion indicate that an estimation of Gaussian distribution can be formed for these features. The result will indicate the probability of the current value occurring. If the value is extremely unlikely to occur, it is an anomaly and should throw an error.
• Gaussian distribution is given by
  \[ p(x) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \]
• Choosing the smallest threshold of probability while maintaining low false positives can be chosen by selecting the threshold with the highest F1 score on a large set of test data.
• F1 score is given by
  \[ F1 = \frac{2 \cdot prec \cdot rec}{prec + rec} \]

RESULTS
• Anomalous instances of voltage found at the input and output of UPS A.
• To isolate the anomalies, data from the UPS’s source and panels at the UPS’s output was analyzed.
• Through the historical trend data, voltage anomalies are isolated to UPS A, transformer, and switch.
• Waveform capture is possible at UPS A using the StruxureWare Power Monitoring software and built-in circuit monitor meter.
• Proper configuration of the circuit monitoring meter on UPS A will log anomalous waveforms and allow the data center to study what is happening during an anomalous event at each individual waveform cycle.

Future Work
• Perform waveform capture on an anomalous event
• Examine the distributions and relationships between other measured features.
• Explore how “Learning” is done by advanced meters.
• Compare effectiveness of Gaussian anomaly detection against advanced techniques used in newer meters.

REFERENCES

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