Intel® Unnati

Data-Centric Labs in Emerging Technologies

A Synopsis on

Introduction to Data Collection and Analysis Techniques in Power Manager Telemetry:

Submitted for the Intel Unnati Industrial Training Program 2024

Team

Medha K M (1NT21EC083)
Mahesh Naik (1NT21EC077)

Under the Guidance of

Dr. Ramachandra A C
Professor
Dept. of Electronics and Communication Engineering

NITTE EDUCATION TRUST

NITTE MEENAKSHI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

YELAHANKA, BENGALURU- 560064

CONTENT

Introduction

Power manager telemetry encompasses the systematic collection and analysis of data pertaining to the power consumption and thermal performance of electronic devices and systems. This practice is crucial for optimizing energy efficiency, extending the lifespan of devices, and maintaining consistent and reliable performance. The data collection phase employs a variety of techniques, including the deployment of embedded sensors, utilization of software-based monitoring tools, and implementation of real-time data acquisition systems that gather comprehensive metrics on power usage, temperature variations, and system load. These techniques ensure that every aspect of power consumption is meticulously recorded, providing a rich dataset for subsequent analysis.

The analysis phase leverages a range of statistical and computational methodologies to transform raw telemetry data into actionable insights. By identifying patterns and anomalies, predicting future behaviors, and recommending optimization strategies, these analyses enable informed decision-making aimed at enhancing power efficiency and thermal management. Advanced analytical tools and software platforms play a pivotal role, offering sophisticated capabilities for data visualization, predictive modeling, and trend analysis. This holistic approach to data collection and analysis in power not only aids in achieving optimal energy usage but also supports the development of sustainable technology solutions and contributes to overall system resilience and reliability.

Literature Survey

A literature survey on Data Collection and Analysis Techniques in Power Manager Telemetry involves reviewing and synthesizing existing research and publications in this field. This survey highlights significant advancements, methodologies, challenges, and future directions. Below is a structured literature survey on the topic:

1. Data Collection Techniques

- Embedded Sensors

Research has extensively covered the use of embedded sensors for real-time data collection. Sensors measure metrics such as voltage, current, temperature, and system load. Studies like those by Saponara et al. (2018) discuss the integration of these sensors into system-on-chip (SoC) designs to enable detailed monitoring without significant overhead.

- Software-Based Monitoring Tools

Software tools are critical for collecting telemetry data without additional hardware. Tools like Intel's Power Gadget and NVIDIA's NVML provide APIs for accessing power usage data. Kim et al. (2019) demonstrate the effectiveness of software-based tools in collecting and analyzing power data in cloud environments, emphasizing their flexibility and scalability.

- Real-Time Data Acquisition Systems

Real-time data acquisition systems are designed to capture high-resolution telemetry data continuously. For instance, Liu et al. (2017) highlight the development of such systems for monitoring power consumption in data centers, enabling immediate responses to power anomalies.

2. Challenges in Data Collection

- Accuracy and Precision

Ensuring the accuracy and precision of collected data is a significant challenge. Studies like those by Peiravi and Askarian Abyaneh (2016) address calibration techniques and error correction methods to enhance sensor accuracy.

- Data Integrity and Consistency

Maintaining data integrity and consistency, especially in distributed systems, is crucial. Research by Li et al. (2020) focuses on blockchain-based approaches to ensure the integrity and immutability of telemetry data.

Motivation and Objectives

3• **To Identify Key Metrics for Power and Thermal Performance**:

- Determine the critical data points that need to be collected for effective power and thermal management.
- Establish standard metrics for power consumption, thermal behavior, battery health, and system load.

- **To Develop Advanced Data Collection Techniques**:

- Explore the use of embedded sensors, software tools, and real-time data acquisition systems for comprehensive telemetry data collection.
- Ensure accuracy, precision, and minimal intrusion in data collection processes.

- **To Analyze Collected Data Using Advanced Methodologies**: • Apply statistical analysis, machine learning algorithms, and predictive modeling to interpret telemetry data.
- Identify patterns, anomalies, and trends to provide actionable insights for power optimization.

- **To Evaluate Tools and Software for Data Analysis**: • Assess various tools and platforms used for analyzing telemetry data.

- Compare their features, capabilities, and effectiveness in handling large datasets and providing insightful analytics.

- **To Optimize Power and Thermal Management Based on Data Insights**:

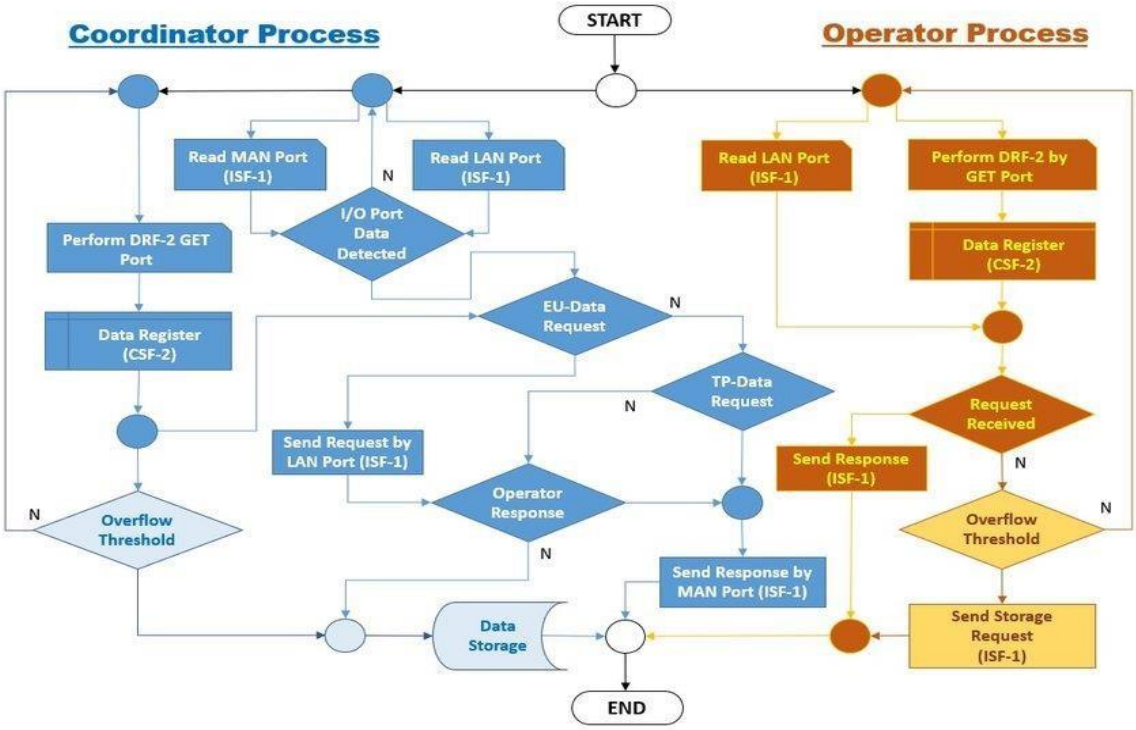
- Develop strategies to reduce power consumption and enhance thermal efficiency.

Implement real-time adjustments and proactive measures to improve system performance and reliability

- **To Document Case Studies and Real-World Applications**: • Examine successful implementations of power manager telemetry in different industries.
- Analyze the impact of these implementations on energy efficiency, cost savings, and device performance.

- **To Address Security, Privacy, and Ethical Considerations**: • Ensure the secure handling of telemetry data to protect against unauthorized access and breaches.
- Consider privacy concerns and ethical implications in the collection and use of telemetry data.

Architecture of the Proposed System



CHAPTER 3 Hardware/Software Description

Hardware:

- **Embedded Sensors**: These are integral components installed within electronic devices to monitor various parameters such as voltage, current, temperature, and power consumption.

- **Microcontrollers and Microprocessors**: These act as the brains of telemetry systems, processing data collected by sensors.

- **Data Acquisition Systems (DAQs)**: DAQs are used to collect and digitize analog sensor data for further analysis.

- **Communication Modules**: These hardware components facilitate the transmission of collected data to centralized servers or cloud platforms..

Software:

- **Monitoring Software**: This software interfaces with hardware sensors to collect real-time data on power consumption and thermal performance.

- **Analysis and Visualization Tools**: These tools process the collected data, applying statistical and computational methods to extract meaningful insights.

- **Machine Learning Algorithms**: Machine learning models are increasingly used to predict future power consumption trends, detect anomalies, and optimize power usage.

- **Cloud Platforms**: Cloud services like AWS, Azure, or Google Cloud provide robust infrastructure for storing and analyzing large volumes of telemetry data

.

Design Specification/Dataset Description

System Architecture:

1. **Data Collection Layer**: Telemetry sensors and data acquisition systems.
2. **Edge Computing Layer**: Edge servers for initial data processing.
3. **Central Processing Layer**: Data storage, ML models, and ETL tools.
4. **Application Layer**: User interfaces and APIs for real-time monitoring and maintenance scheduling.

Key Components:

1. **Data Collection and Preprocessing**: Telemetry sensors, edge servers, data cleaning tools.
2. **Machine Learning Models**: Algorithms (Random Forests, SVM, LSTM), ML frameworks.
3. **Data Storage and Integration**: Databases, ETL tools.
4. **Deployment and Monitoring**: Containerization (Docker), orchestration (Kubernetes), monitoring tools.
5. **User Interface and APIs**: Web frameworks, visualization libraries.

Implementation Steps:

1. **Data Collection Setup**: Install and configure sensors.
2. **Edge Processing Configuration**: Deploy edge servers/IoT devices.
3. **Central Processing Configuration**: Set up central servers and ETL workflows.
4. **Model Development**: Collect and preprocess data, develop and train models.
5. **Deployment and Integration**: Containerize models, develop APIs and interfaces.

6. **Monitoring and Maintenance**: Implement monitoring tools, continuously update models.

Expected Outcomes

1. **Improved Maintenance Efficiency**: Optimized maintenance schedules, better resource allocation.
2. **Reduced Downtime**: Minimized unplanned downtime, increased system availability.
3. **Cost Savings**: Lower maintenance costs, extended equipment lifespan.
4. **Enhanced Reliability and Performance**: Improved system reliability, performance optimization.
5. **Data-Driven Decision Making**: Insightful analytics, anomaly detection.
6. **Scalability and Adaptability**: Scalable solutions, adaptable models.
7. **User-Friendly Interfaces**: Interactive dashboards, automated alerts.

Real-World Validation: Successful case studies, continuous improvement

References

- He, Y., & Li, Z. (2018). A review of data-driven approaches for prediction and classification of equipment health in predictive maintenance. Mechanical Systems and Signal Processing, 99, 730-753.
- Zhang, W., Yang, D., & Wang, H. (2019). Data-driven methods for predictive maintenance of industrial equipment: A survey. IEEE Systems Journal, 13(3), 2213-2227.
- Peng, Y., Dong, M., & Zuo, M. J. (2010). Current status of machine prognostics in condition-based maintenance: a review. The International Journal of Advanced Manufacturing Technology, 50(1-4), 297-313.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
- Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
- Jiang, J., & Starzyk, J. A. (2014). Predictive maintenance system for power transformers. Ohio University. Retrieved from Ohio University Electronic Theses and Dissertations.

Guide's Remarks

Name of the Guide Signature