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SUSTAINABILITY

Power Manager Telemetry

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Abstract: Reaching net-zero power usage has become critical in light of rising power consumption caused by the proliferation of 5G and edge computing devices. This project develops a method to track and measure computer system power consumption in order to address the sustainability challenge. The project entails gathering telemetry data from CPU, Memory, NIC, and Battery, documenting system characteristics that impact power consumption, and investigating open-source tools for power monitoring. The project measures and logs the power consumption of various system components like CPU, Memory, NIC, and Battery. In an era of increased computing demands, this research seeks to provide insights into optimising power use in computer systems, thereby reducing costs and enhancing energy efficiency.

Keywords: Power Management, Telemetry, Sustainability, Computer Systems, Energy Efficiency

1 Introduction

The widespread use of 5G networks and the emergence of edge computing have resulted in a notable surge in the dispersion of computing devices in diverse areas. This rise has consequently escalated power consumption, posing serious sustainability concerns. Efficient monitoring, measuring, and regulation of power utilization in computer systems as energy costs rise and environmental laws become more stringent. In this context, power management telemetry is crucial for collecting and analyzing power usage data across key system components such as the CPU, memory, Network Interface Card (NIC), and battery. We may uncover inefficiencies, acquire important insights into power usage trends, and put policies in place to optimise energy consumption by utilising sophisticated telemetry tools and procedures. The goal of this project is to create a complete power management telemetry solution that will enhance the current computer environments energy efficiency, economic effectiveness, and environmental sustainability.

2 Literature Survey

A comprehensive literature review was conducted to understand the concept of power management telemetry.
In the related research by Chawla et al. [1] explored software-based power side-channel attacks on Apple M1/M2 systems, using on-chip power metres via the System Management Controller to extract AES encryption keys from macOS. Mago et al. [2] In order to improve smart grid operations, this study proposed a methodology for integrating telemetry data into power system models using the IEC-61968/61970 standards. Teeluck et al. [3] reviewed various power management programmes, going over their features, advantages, and efficiency in terms of maximising energy usage and enhancing system performance. Zhao et al. [4] described a wireless circuit module for data telemetry and power management, designed for high-compliance voltage electrical stimulation applications in medical devices.

Table 1: Related works based on research papers on power management telemetry

Author(s)	Title	Description	Issue Date	Reference
Nikhil Chawla, Chen Liu, Abhishek Chakraborty, Igor Chervatyuk, Ke Sun, Thais Moreira Hamasaki, Henrique Kawakami	The Power of Telemetry: Uncovering Software-Based Side-Channel Attacks on Apple M1/M2 Systems	Investigates vulnerabilities in power management telemetry data to software-based side-channel attacks, emphasizing the need for enhanced security measures.	2023	[1]
Nitika V. Mago, John D. Moseley, Ndr Sarma	A Methodology for Modeling Telemetry in Power Systems Models using IEC-61968/61970	Proposes a methodology for integrating telemetry data using IEC-61968/61970 standards, enhancing data integration and reliability in power systems.	2013	[2]
Satyajit Teeluck, Sameerchand Pudaruth, Somveer Kishnah	A Review of Power Management Software	Reviews and evaluates various power management software tools, providing a comparative analysis of their features and performance.	2013	[3]
Jianming Zhao, Lei Yao, Rui-Feng Xue, Li Peng, Minkyu Je, Yong Ping Xu	A Wireless Power Management and Data Telemetry Circuit Module for High Compliance Voltage Electrical Stimulation Applications	Designs a wireless power management and data telemetry circuit for high voltage applications, offering efficiency and reliability.	2013	[4]

3 Libraries Used

In the project for various tasks, following packages are used.

```
pandas
matplotlib
psutil
seaborn
time
threading
subprocess
csv
os
```

4 Methodology

A systematic approach was used to create a complete power management telemetry solution, involving various stages to ensure accurate data collection, analysis, and execution of power optimization strategies. Various stages of implementation are as follows:

Research and Tool Selection: Conduct a comprehensive literature review and online search. Select the most appropriate tools for measuring power consumption in different system components.

Setup and Initialization: Install necessary open-source tools for power measurement and data collection (e.g.powercfg, psutil). Install Python libraries for data handling and plotting (e.g., pandas, matplotlib).

Script Execution: Write a Python script that collects real-time telemetry data (CPU, memory, NIC utilization, and battery). Measures power consumption using identified tools. Aggregates and processes the collected data.

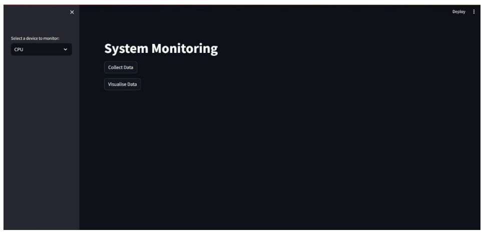
Collect Data: Use psutil or similar libraries to gather system metrics. Use powercfg or other power measurement tools to capture power consumption data.

Plot Data: Read the CSV file using pandas. Plot the data using matplotlib to visualize power consumption against system utilization.

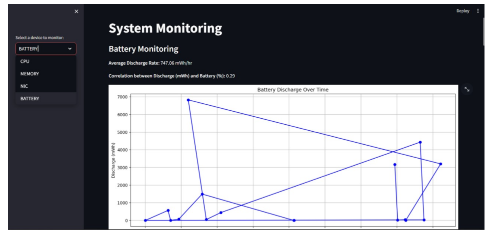
5 Results & Discussion

The analysis of system performance over time reveals significant variations in CPU utilization across all four cores, with notable peaks and periods of low activity. Memory management patterns show detailed usage statistics and trends over the monitoring period. The analysis was conducted using a development environment running on an 11th gen Intel Core i7-1165G7, an HP laptop with a 12th gen Intel Core i5 processor and 16GB of RAM, as well as on an Intel Core i3-1215U.

The results, which encompass user interface visuals and detailed graphs illustrating the management and utilization of CPU, memory, NIC, and battery, are as follows:



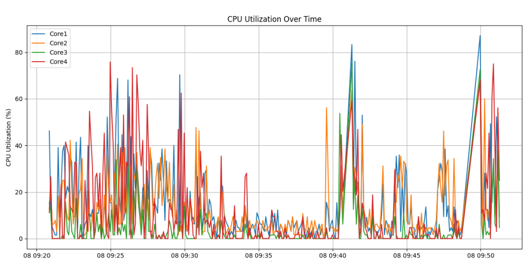
(a) User Interface



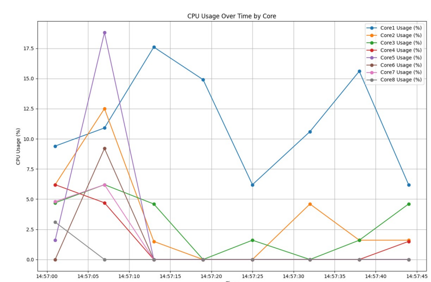
(b) UI showing Battery Monitoring Rates

Figure 1: User Interface(UI) of Power Manager Telemetry

The image shows a battery monitoring system. It displays a graph of battery discharge over time, currently at 7000 mWh. The content demonstrates a frail positive relationship between release and battery rate, meaning they both go down together but not in a very strong relationship.



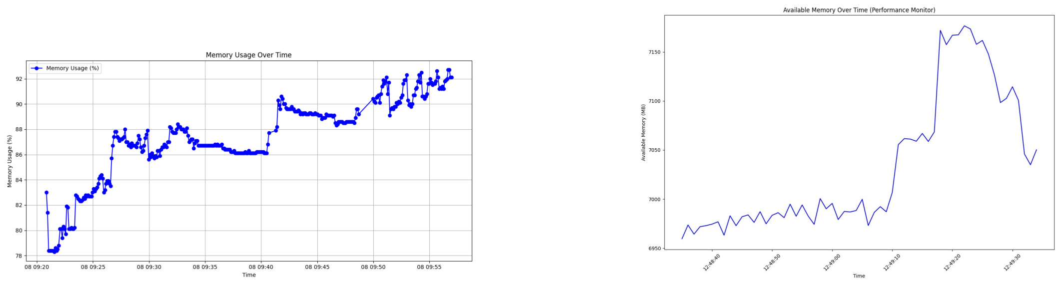
(a) CPU Utilization Over Time by 4 Core



(b) CPU Usage Over Time by 8 Core

Figure 2: Graphs showing battery usage

The CPU utilization changes significantly over time for all four cores. Peaks near 80 percent or higher are visible around 08:25 and between 08:40 and 08:50. Utilization frequently drops to near 0 percent, indicating low activity periods.



(a) Memory Usage Over Time (b) Available Memory Over Time

Figure 3: Graphs showing memory usage

The graphs present a line plot appearing memory utilization rates over particular interim. Beginning around 79 percent, it varies with discernible spikes, cresting over 92 percent. These varieties demonstrate periods of increased memory movement, with a by and large slant of progressive increment, reflecting developing request on the system's memory assets.

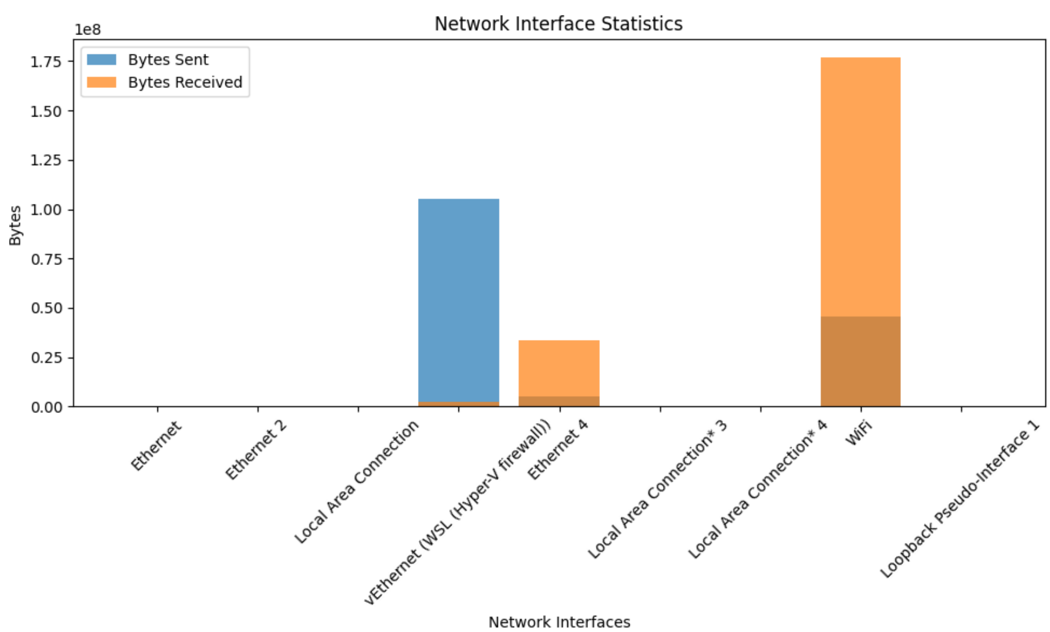
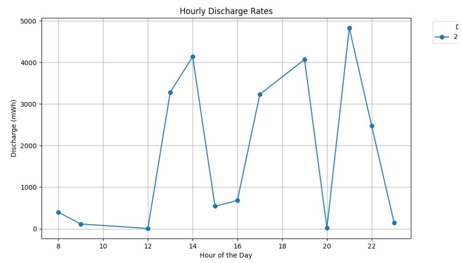
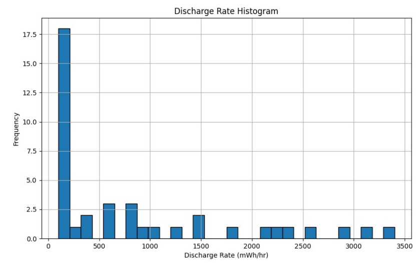


Figure 4: Network Interface Statistics

The WiFi interface shows the highest activity with significant bytes received and fewer bytes sent. vEthernet (WSL) and Local Area Connection have notable bytes sent but fewer received. Other interfaces show minimal to no activity.



(a) Hourly Discharge Rate



(b) Dicharge Rate Histogram

Figure 5: Graphs Showing Battery Usage

The graph titled "Hourly Discharge Rates of Battery" shows varieties in control release measured in milliwatt-hours (mWh) all through the day. Crests in release, strikingly around 14:00, 18:00, and 22:00 hours, show periods of higher control utilization, whereas other hours appear negligible or no release, uncovering particular cycles of vitality utilization over time.

6 Limitations and Future Works

The current procedure focuses on collecting telemetry from the CPU, memory, NIC, and battery, selected for their compatibility and precision. However, limitations and biases in these instruments, along with unaccounted-for environmental factors such as temperature and humidity, may affect the accuracy of the data.The Thermal Design Power(TDP) was not addressed, and measuring power utilization was challenging due to device restrictions. This strategy has only been implemented on our portable workstations and is designed specifically for Windows operating systems and utilizes Windows-specific functionalities, ensuring compatibility and optimized performance within the Windows environment. Development and testing of this analysis was conducted using a development environment running on an 11th gen Intel core i7-1165G7.

Validating the approach in real-world 5G and edge computing scenarios will ensure its robustness. Implementing real-time dynamic techniques will optimize energy usage, while supporting multiple platforms will enhance flexibility. Analyzing environmental impacts will lead to more sustainable practices. Future efforts will explore advanced machine learning for predictive control, integrate additional system components, and validate the approach in diverse real-world settings to develop a more efficient, adaptable, and sustainable power management system.

7 Conclusions

In conclusion, the implemented power management telemetry solution has yielded comprehensive insights into CPU, memory, NIC, and battery usage patterns, facilitating targeted strategies to optimize energy distribution. Significant outcomes include dynamic workload adjustments to efficiently handle peak loads and pinpointing areas for enhancing efficiency in network interfaces and battery utilization. As computational demands escalate, these findings underscore the critical role of data-driven approaches in achieving sustainable energy practices. Future directions involve refining predictive methodologies, broadening coverage across system components, and ensuring adaptability to evolving computing requirements. This project represents a notable stride towards achieving sustainable and efficient power management within contemporary computing infrastructures.

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[2] MAGO, N. V., MOSELEY, J. D., AND SARMA, N. A methodology for modeling telemetry in power systems models using iec-61968/61970. In *2013 IEEE Innovative Smart Grid Technologies-Asia (ISGT Asia)* (2013), IEEE, pp. 1–6.

[3] TEELUCK, S., PUDARUTH, S., AND KISHNAH, S. A review of power management software. *IMLCS 2013 proceedings Kuala Lumpur* (2013), 1–4.

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