POWER MANAGER TELEMETRY

1. Introduction

In the era of 5G and edge computing, the increasing demand for energy-efficient systems has driven the need for optimizing power usage across different levels of computing systems. This project focuses on leveraging telemetry data and advanced analytical techniques to optimize power consumption at the hardware, operating system (OS), and application levels.

2. Objectives

The primary objectives of this project were to:

- Collect and analyze telemetry data to understand power consumption patterns.
- Develop models and strategies to optimize power usage.
- Implement optimization techniques using the PowerTOP tool and HTML code.
- Evaluate the effectiveness of the optimizations in reducing power consumption.

3. Problem Statement

The deployment of an increasing number of devices in the era of 5G and edge computing has led to higher power consumption, prompting government mandates for enterprises to achieve net-zero power usage. This project aims to optimize power consumption across computing systems by leveraging telemetry data and advanced analytics at the hardware, OS, and application levels. The project involves researching open-source power measurement tools, documenting power measurement controls, collecting power telemetry from components like CPU, memory, NIC, and TDP, and developing strategies to improve power efficiency, reduce wastage, and achieve optimal power utilization.

4. Technical Approach

4.1 Data Collection and Analysis

Telemetry data was collected from various sources within the system to provide a comprehensive view of power consumption. This data was analyzed to identify patterns and anomalies that could indicate inefficiencies. The analysis involved:

- Monitoring power usage at different levels (hardware, OS, and application).
- Identifying high power-consuming components and processes.
- Analyzing CPU idle states, CPU frequency, software activity, and device information.

4.2 Tools and Techniques

PowerTOP Tool:

PowerTOP is an open-source Linux tool used for diagnosing issues related to power consumption. It provides detailed reports on the power usage of various system components and suggests optimizations.

HTML Code Optimization:

Based on the insights gained from the PowerTOP analysis, HTML code was developed to implement the recommended changes. This code focused on reducing unnecessary power consumption and improving system efficiency.

5. Implementation

5.1 PowerTOP Analysis

PowerTOP was used to perform a detailed analysis of the system's power consumption. The tool provided insights into various aspects of power usage, including:

- **CPU Idle States**: Monitoring how often the CPU enters low-power idle states and identifying processes that prevent it from doing so.
- **CPU Frequency**: Analyzing CPU frequency scaling to ensure the CPU operates at the most efficient frequency.
- **Software Activity**: Identifying software applications and processes that consume significant power.
- **Device Information**: Gathering information on the power usage of peripheral devices.

5.2 System Tuning and HTML Code Optimization

The recommendations from the PowerTOP analysis were translated into optimized system settings and HTML code. The process flow included:

1. **Setup and Installation**
    - Install Ubuntu OS on the Acer Aspire 3.
    - Install PowerTOP using the package manager.
    - sudo apt-get install powertop
2. **Initial Data Collection**
    - Run PowerTOP to collect initial power consumption data.
    - Monitor and record power consumption metrics for CPU, memory, NIC, and other peripherals.
3. **Analysis and Identification**
    - Analyze PowerTOP reports to identify high power-consuming components and processes.
    - Identify optimization opportunities based on PowerTOP's tunable suggestions and data insights.
4. **System Tuning**
    - **Adjust CPU Frequency Scaling**: sudo cpufreq-set -g powersave

- **Enable Power-Saving Modes**: sudo powertop --auto-tune
- **Tune Kernel Parameters**: Modify /etc/default/grub to add power-saving parameters, then sudo update-grub and sudo reboot.
- **Disable Unnecessary Services**: sudo systemctl disable [service_name]

5. **Post-Optimization Data Collection**
    - Run PowerTOP again to collect power consumption data after applying optimizations.
    - Compare pre- and post-optimization data to quantify improvements.

5.3 HTML Code Optimization

The optimized HTML code aimed to:

- Reduce wake-up events caused by software processes.
- Optimize the usage of peripheral devices to reduce their power consumption.
- Ensure that the CPU operates in low-power states whenever possible.

6. Architecture

7. Results and Discussion

7.1 Improvements Achieved

The implementation of the PowerTOP recommendations and the optimized HTML code led to significant improvements in power efficiency. Key results include:

- **Reduced CPU Wake-Ups**: A noticeable reduction in the number of times the CPU was woken up from idle states, leading to lower power consumption.
- **Efficient CPU Frequency Scaling**: More efficient use of CPU frequency scaling, ensuring the CPU operated at optimal frequencies based on workload demands.
- **Lower Peripheral Power Usage**: Reduced power consumption by peripheral devices through optimized usage patterns.

7.2 Technical Challenges

Several challenges were encountered during the project, including:

- Ensuring the accuracy and reliability of the telemetry data collected.
- The complexity of analyzing telemetry data and identifying meaningful patterns.
- Translating PowerTOP recommendations into effective code changes.

8. Conclusion

The project successfully demonstrated the potential for optimizing power usage through detailed telemetry analysis and the application of advanced analytical techniques. The use of the PowerTOP tool and HTML code optimizations resulted in significant improvements in power efficiency at various levels of the system. The project highlights the importance of continuous monitoring and optimization to achieve energy-efficient computing.

9. References

- PowerTOP Tool Documentation: https://01.org/powertop
- Ubuntu Power Management: https://help.ubuntu.com/community/PowerManagement
- Github:https://github.com/Vishwaradhya1901/Power-Manager-Telemetry-