COPILOT PC POWER INSIGHTS

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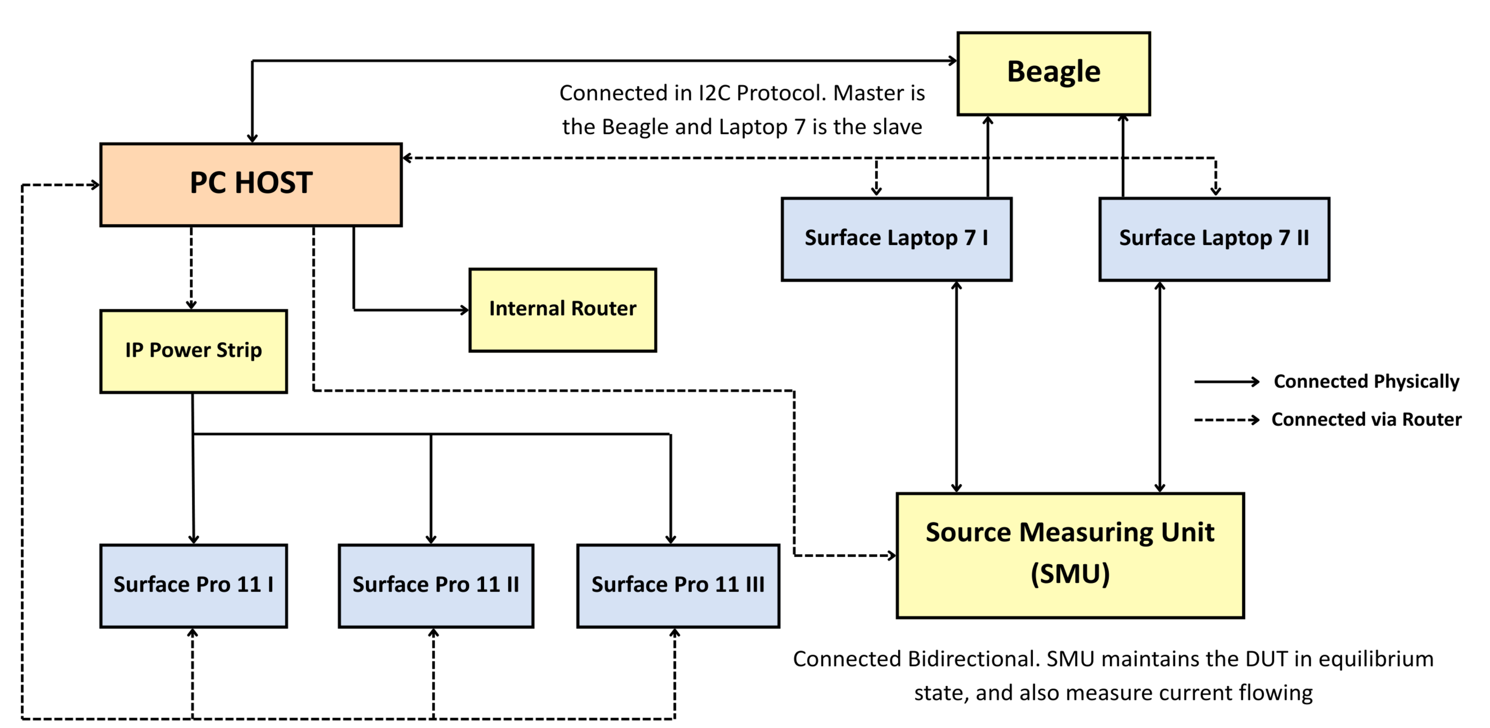
Problem Statement

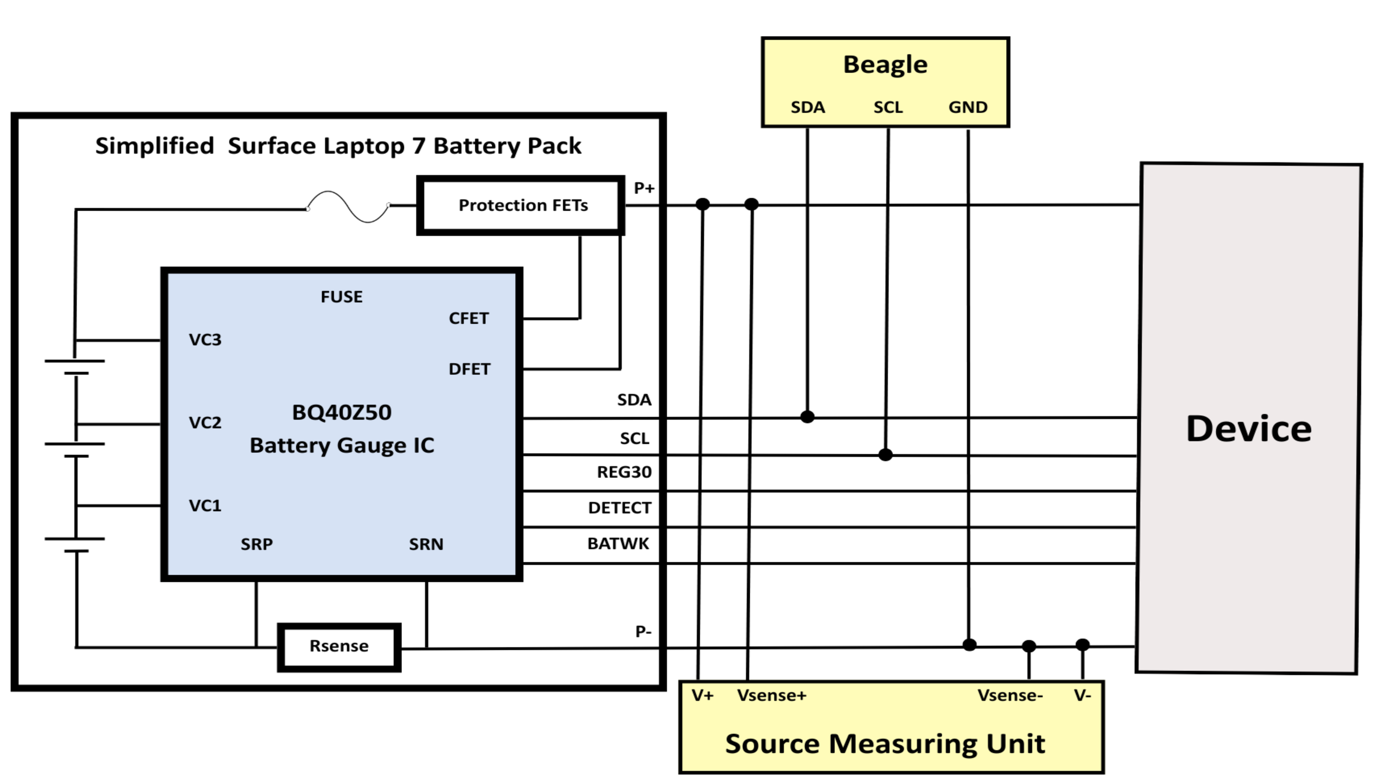
- **Project Focus:** Characterize power consumption across Microsoft Surface Copilot personal computers through various application use-cases to aid in enhancing Windows power awareness.
- **Motivation:** Develop a predictive statistical model for power consumption to enable carbon footprint reduction during the use phase of Copilot-enabled Windows PCs. This effort targets lowering the 29 kg CO_2 associated with product use, part of the 190 kg CO_2 total life cycle footprint of the Surface Laptop 7 13". Insights from power consumption data will not only improve energy efficiency but can also extend battery life.

Technical Requirements

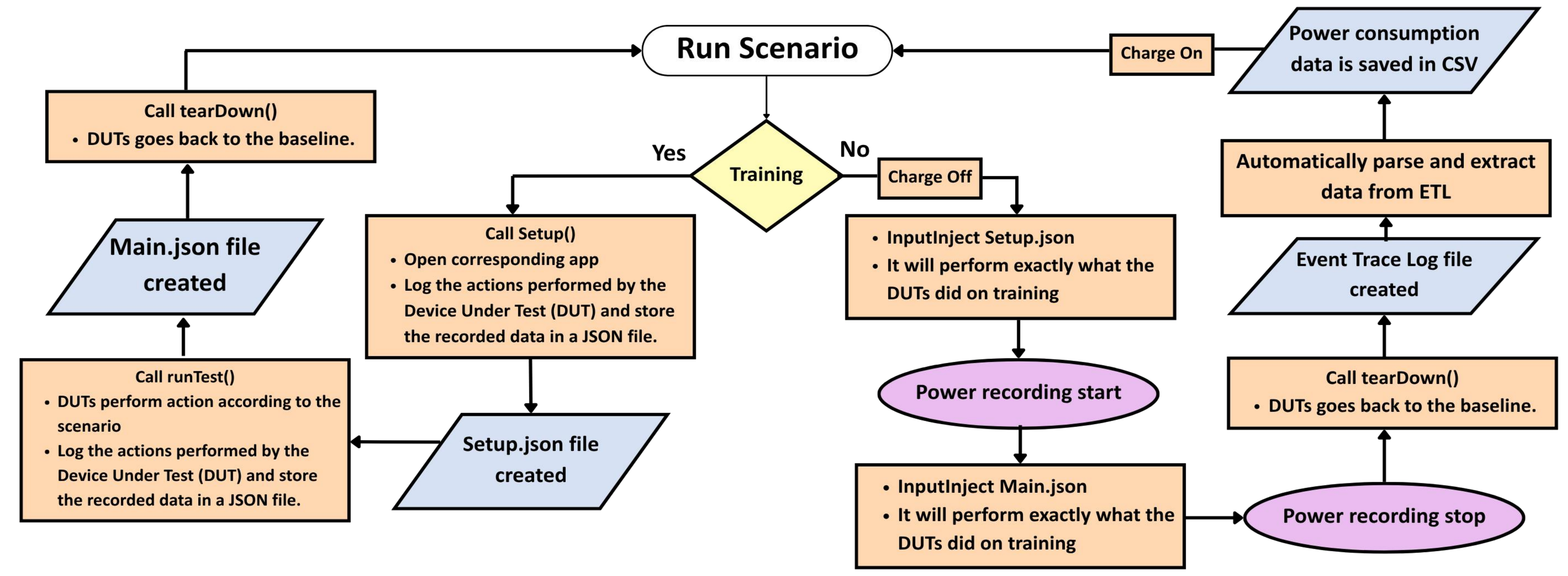
- Must capture and log real-time power consumption data from various subsystem components (SoC, Display, Wi-Fi, Storage, Memory) and system processes.
- Since we are testing five devices across numerous scenarios, it is essential to automate the scenario testing to efficiently gather a large volume of data points and reduce manual labor.
- All subsystem and process data must be extracted including actual time series data for each device and run.
- Utilize the huge amount of the data to create predictive statistical model that feeds into a stochastic digital twin model that predicts how power consumption components add to create a distribution of power over time.

Diagram Workflow

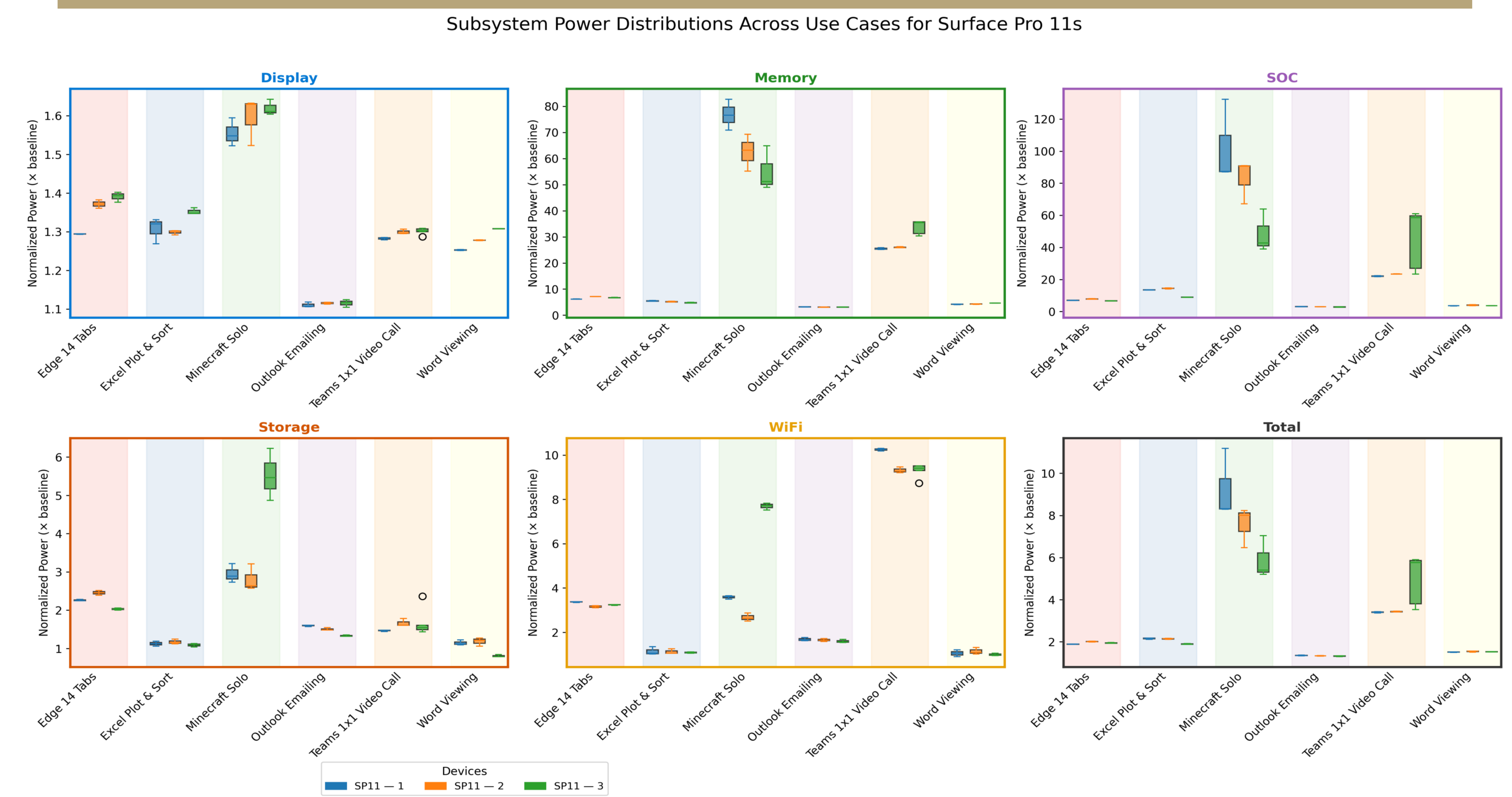


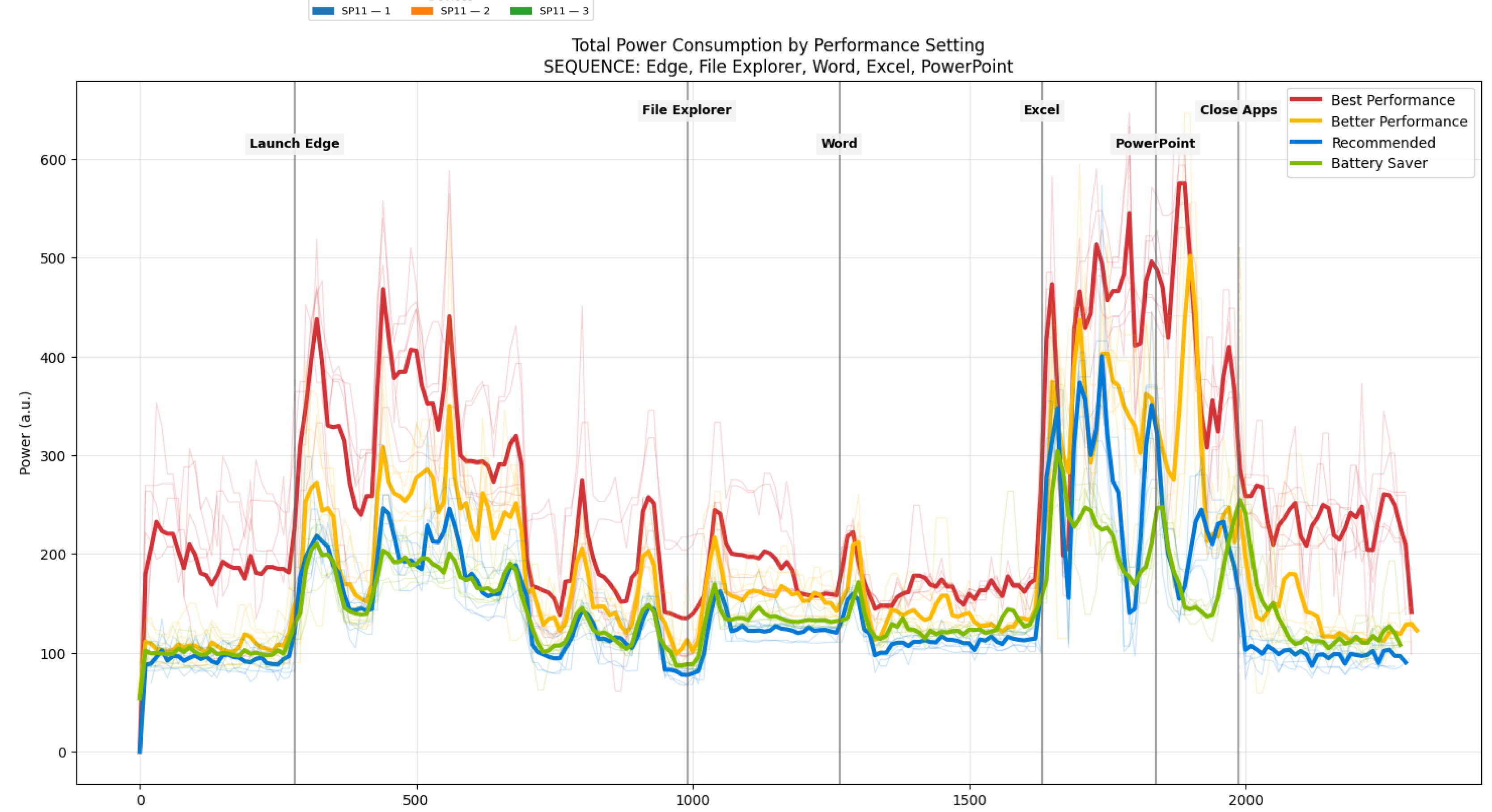


Automated Testing Procedure



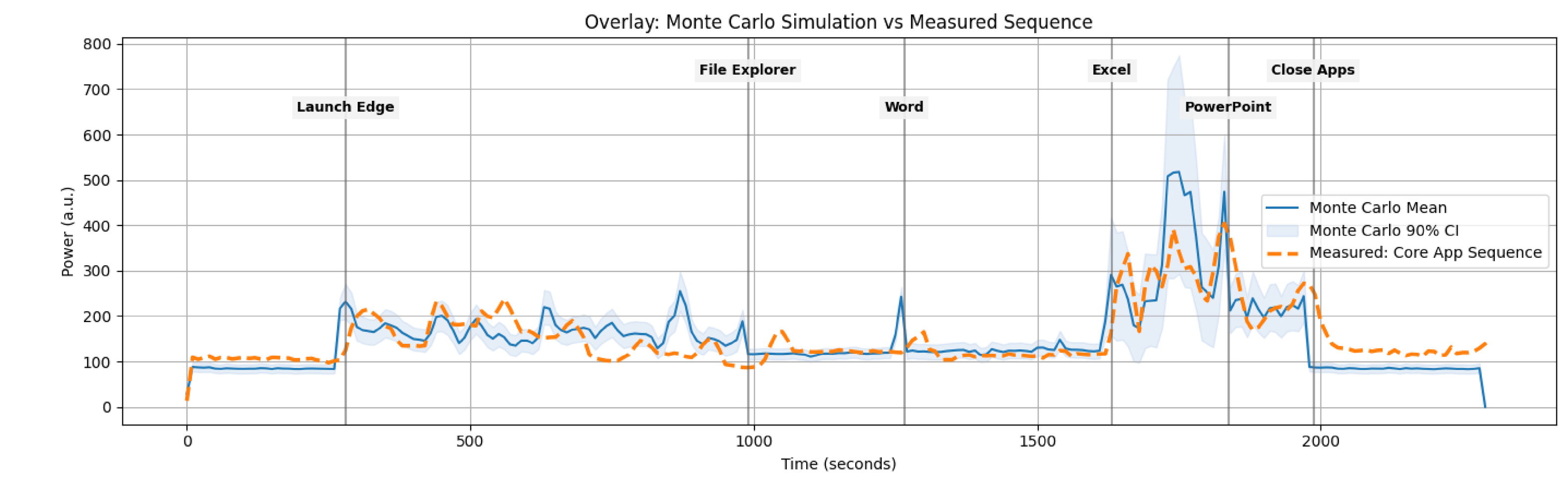
Results





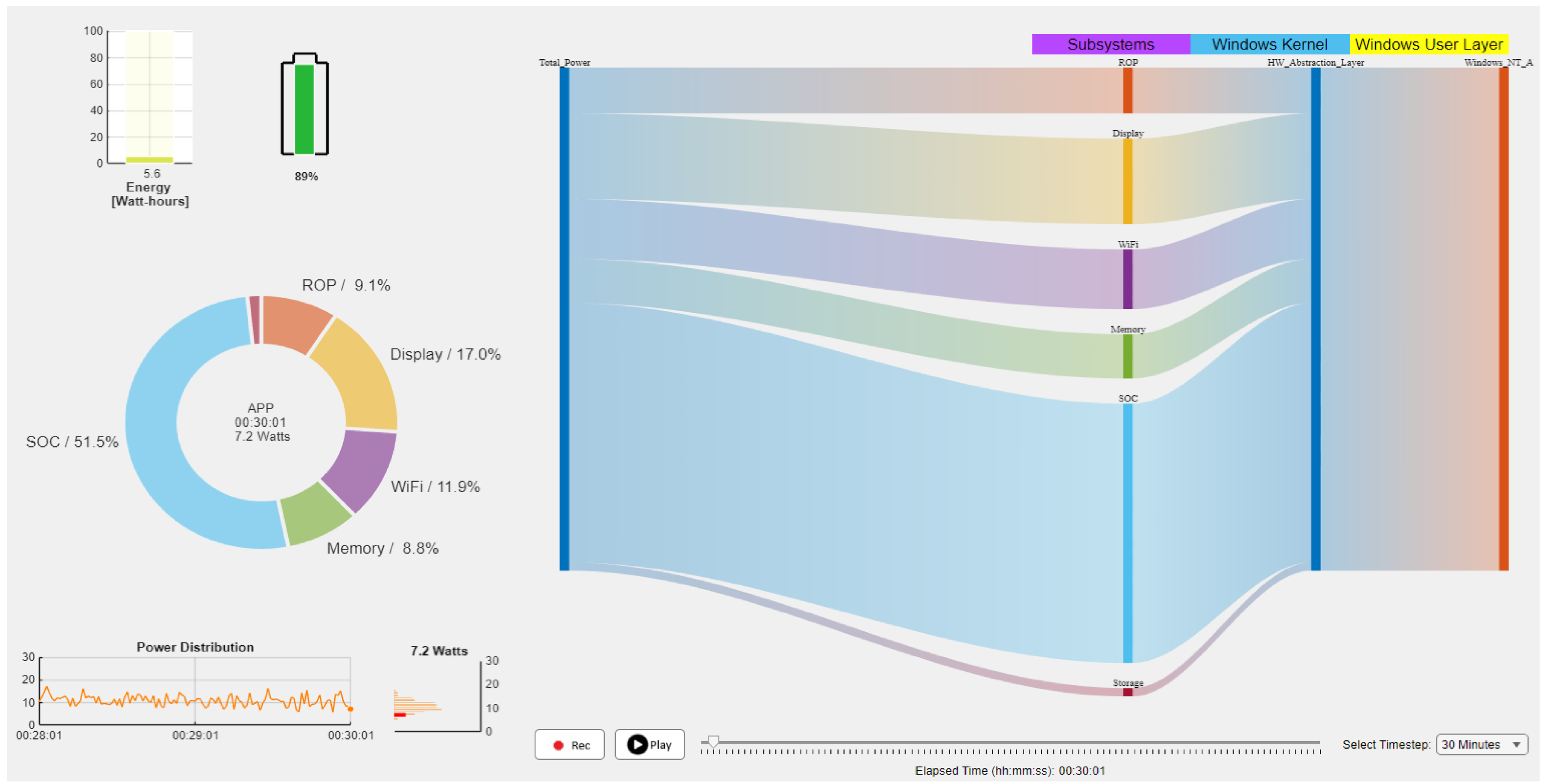
Predictive Statistical Model for Multiple App

- The single-app time series are scaled to match multi-app timelines, using Monte Carlo simulations to add realistic variation using actual subsystem statistics from collected data.
- Comparing the reconstructed to actual signals reveals modeling gaps and can be used as a parameter when training a regression model to predict the residual and enhance the overall prediction accuracy.



Digital Twin

- **Estimated Power Visualization:** The digital twin generates a simulated time series of power consumption by using statistical summaries from selected subsystems.
- **Simulation & Optimization:** Supports evaluation of different scenario tests and usage conditions. Helps identify inefficiencies across overall system performance, and guide design improvements.



Conclusion and Future Work

In this project, we successfully automated over 75 scenarios that simulate real-world usage, enabling us to collect more than 25,000 data points. This data was used to analyze the power consumption of various device subsystems, visualize the results through digital twin modeling, and develop a predictive statistical model with Monte Carlo to be utilized for single and multi-app comparisons. Our findings show that during heavy usage scenarios, the SoC is the primary power consumer. In contrast, during light usage activities, the display accounts for the highest power usage.

In the future, we expect to collect additional data points to explore previously untested areas such as different settings (Brightness, audio, dark-mode, and more). Furthermore, using a significantly larger dataset, we would like to develop machine learning models that are more accurate for more precise power consumption prediction. Additionally, fully integrate and automate the SMU within the testing framework across both device models. Finally, try to implement an algorithm to verify test validity by analyzing metadata, such as detecting whether the Device Under Test (DUT) was charging during execution.

Acknowledgement

We want to acknowledge HOBL (Hours of Battery Life): Microsoft's internal automated testing framework for retrieving power consumption, built with Selenium. Used under the MIT License. We would also like to thank Microsoft for supplying the base MATLAB code for digital twin modeling, which we built upon to visualize our data and develop our model.

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