Energy Modeling for KioskNet

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ABSTRACT

We highlight the potential for accurate software-level energy modeling and prediction on commodity embedded computers for DTN deployments, such as KioskNet [3]. Our experiments confirm that accurate prediction of energy consumption, without relying on any hardware power measurement tool, is feasible. We performed controlled micro-benchmarks on the three major components of an embedded computing device: the processor, the storage, and the communication sub-systems. Energy consumption in all three follows simple models.

1. MOTIVATION

KioskNet[3] uses low-cost commodity embedded computers as delay tolerant networking (DTN) [1] nodes to provide low-cost Internet connectivity for rural areas in developing regions. Electrical power is a major constraint in KioskNet target areas; therefore, computing in rural kiosks should be power-aware. Towards this goal we are interested in the answer of the following questions:

1. What is the energy consumption model in a typical kiosk computer?
2. How can the energy consumption during an opportunistic connection be minimized?
3. How can the energy consumption in kiosk computers be minimized during idle times?

2. EXPERIMENTS

We performed controlled micro-benchmarks on the three major components of the embedded computers used in KioskNet: the processor, the storage, and the communication sub-systems. The early results suggest that energy consumption in such computers follows a simple model. Further evaluation of this model would help us understand power and performance [2] trade-offs of the DTN reference implementation, which is currently used in KioskNet.

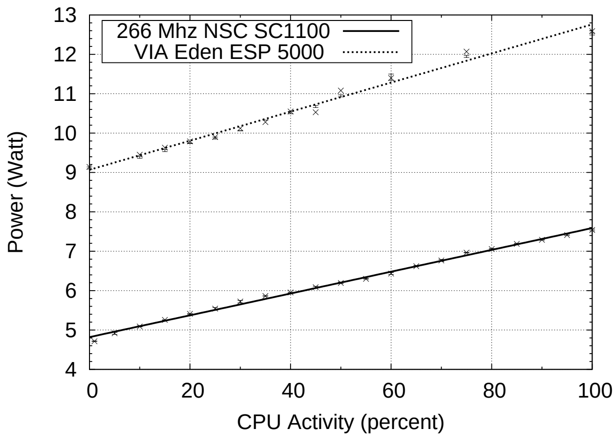

Figure 1: Measured power vs. CPU activity for two different CPU types: 266 Mhz NSC SC1100 and VIA Eden ESP 5000.

Figure 1 illustrates system power consumption vs. CPU activity. We used two different CPU types (266 Mhz NSC SC1100 and VIA Eden ESP 5000) for this experiment. Energy consumption on both of them follows a linear relation with CPU activity.

$$P_{CPU} = k_{cpu} \times x + P_{base}$$

Where P_{base} includes the power consumption of all hardware components in the idle mode.

Figure 2 presents the measured power consumption of the Atheros 802.11abg Wi-Fi card for different 802.11a data rates vs. network throughput. Surprisingly, power consumption of different 802.11a data rates are essentially identical and increase linearly with the network throughput. We intend to repeat this experiment for different wireless interfaces and different modes and data rates.

$$P_{nic} = k_{mode} \times throughput + P_0$$

P_0 corresponds to the power consumption of the wireless interface when no data is being transmitted. This model for the wireless interface, although coarse grained, is sufficient for on-line software power prediction.

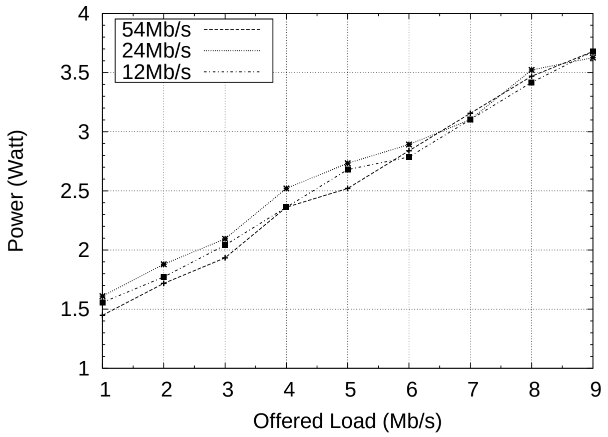

Figure 2: Measured Wi-Fi power consumption vs. throughput for different 802.11a data rates.

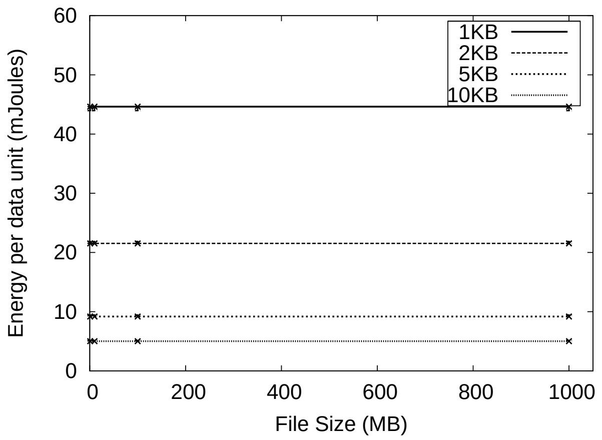

Figure 3: Energy consumed per data unit vs. amount of data written on disk for different write system call sizes.

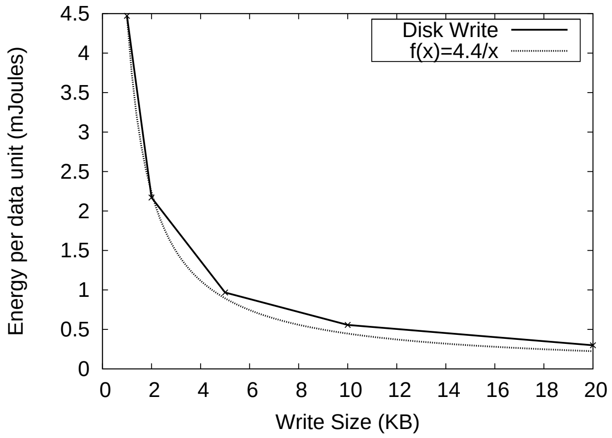

Figure 4: Energy consumed per data unit vs. write call size.

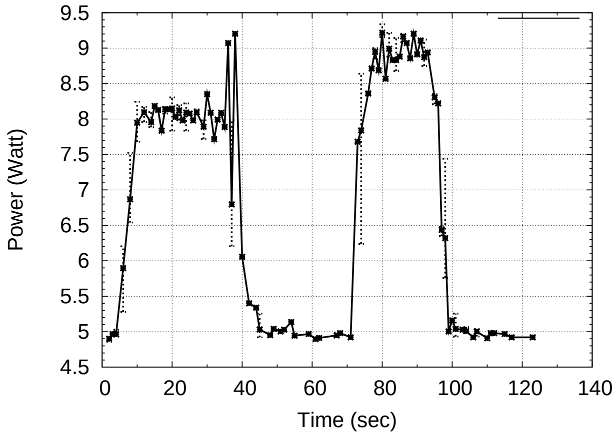

Figure 5: Energy consumption in a KioskNet node before, during, and after an opportunistic connection

Our measurements on disk energy consumption presented in Figure 3 and Figure 4 are compatible with previous research results on disk power consumption modeling [4]. The energy consumed by the disk for writing each data unit is inversely proportional with the write system call size.

We performed power measurements on a test bed with the same network configuration as our previous work [2]. Figure 5 illustrates variations in system energy consumption of a KioskNet node during an opportunistic connection. The first peak corresponds to data enqueuing phase and the second peak corresponds to a 20 second opportunistic connection window.

We are working to precisely identify the energy consumed by each of the three major components. Our next step will be predicting power consumption based on the information that the OS provides and evaluating our prediction.

$$P_{system} = P_{disk} + P_{nic} + P_{cpu}$$

3. REFERENCES

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