SoftUPS: Eliminating the Need and Cost of Battery Backups in the Developing World

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ABSTRACT

We propose to demonstrate a smart-home solution coupled with a smart-grid that can eliminate the cost of battery backups used in the developing world. We are developing a smart-home application, SoftUPS, that instruments a home and enforces lower levels of power consumption, providing a way for a grid to reduce demand and prevent whole-scale blackouts. We have built hardware to enable such control and will demonstrate this control using a Lab-of-Things application.

Categories and Subject Descriptors

C.3 [**Special-Purpose and Application-Based Systems**]: Real-time and Embedded Systems; B.m [**Hardware**]: Miscellaneous

Keywords

Demand Response, Demand Side Management, ICTD

1. INTRODUCTION

Many developing countries suffer from an electrical power deficit because of a mismatch between electricity generation potential and its demand. The power regulatory authorities in these countries then have to resort to whole-scale cutoff in the power supply to segments of their consumers. To maintain a semblance of normality during these blackouts, consumers now resort to running a few important devices from a limited amount of energy stored in batteries that are charged through UPS/inverters during normal power supply.

This solution, we argue, is inefficient, costly, and inflexible, and fails to provide any backup under blackouts of long duration. Seetharam et al. identify that these battery backups are not only **inefficient** (with ≈ 50% efficiency), but also have a positive feedback that increases the supply-demand gap [5]. They are **costly** both in terms of installation (around $250) as well as recurring expense in battery replacement every 8-12 months (another $100). The current backups require hard-wiring user-selected essential devices at installation time, and thus are **inflexible** in terms of a user's ability to dynamically reassign power to a different set of appliances. Finally, under long and regular blackouts (like 18hrs/day [3]), the limited backup capacity fails to keep even a small subset of low power and essential devices running.

We propose SoftUPS, an ICT based solution, that provides for consumers the same service as the current UPS + battery backup, i.e. powering a few important devices during enforced load-shedding intervals. SoftUPS essentially provides a way to automatically migrate homes in the developing world to a low-energy state whenever a utility cannot match the current demand. We expect that utilities, with such a capability, can transmit a request for "load-shedding" to our application that enforces such demand reduction, instead of an enforced blackout. As a software-based solution, we will allow the consumer to identify (and dynamically modify) devices they need available during the load-shedding event. Our system will ensure that the power budget of the identified devices is below a particular threshold, and if so, allow *only* these selected appliances to work directly *from the grid* whenever the grid demands a load-shedding event. Thus, by not requiring a battery backup our solution has no losses, no recurring cost, and unlimited flexibility in device operation (within a power-budget), while still providing utilities with the intended effect of load reduction.

We believe our solution's novelty lies in its clear incentive for usage in the developing world where consumers are already *paying* for installation of battery backups that enforce a very low-power consumption profile during blackouts. We see that existing automatic demand response solutions, with their focus on the developed world, do not realize this niche.

2. CHALLENGES IN BUILDING SoftUPS

Our solution requires a mechanism to instrument a home such that the power consumption of individual appliances can be controlled and overall consumption monitored. This objective raises several challenges (beyond the ability to control and monitor), of cost, architecture, misuse, and usability.

Our prototype here addresses the issues of misuse and usability; we demonstrate a controllable switching element, deployable at room level, that allows selecting individual sockets and appliances for low-power operation. We have developed a HomeOS/LoT [4] driver for our device, along with an application that is available (using LoT redirection service) as an HTML5 application on any connected device. We

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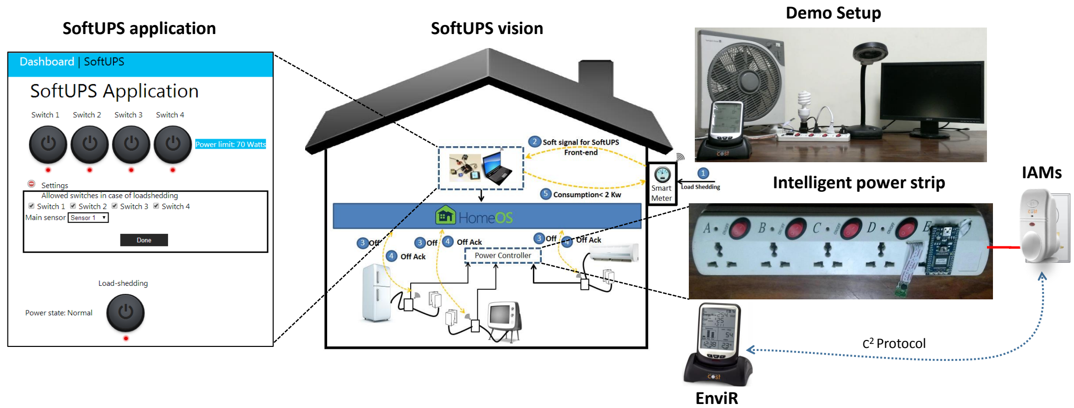

Figure 1: The SoftUPS vision and its prototype implementation as a HomeOS application.

address any potential misuse of our system through a power measurement device that helps enforce our power budget.

We are currently investigating the correct deployment architecture that provides the right tradeoff of cost and observation granularity. Instrumenting every device is a naive and costly option, but the granularity control impacts our the usability and flexibility of our solution.

3. DEMONSTRATING THE SoftUPS IDEA

Overview: Our system comprises the following two components: a) An intelligent Power Strip (iPS) with power monitoring capabilities, and b) A SoftUPS Application over HomeOS (demo video here [2]).

The iPS can demonstrates our ability to control appliances in a single room. Our research shows that room-level switch boards control all power sockets and additional appliances (fans/lighting) from a single location. We use the basic wiring scheme of conventional switch boards, and build our iPS to demonstrate socket level control of plugged in appliances. We augment our iPS with a power monitoring sensor to help enforce limits.

Our SoftUPS application provides a UI to setup policies to view the consumption of the iPS and selection of sockets to shut-off when utilities require load-shedding. This application allows setting a power-budget in theory, informed by power utilities. If this budget is exceeded (by mistake or otherwise) by plugging a higher power device, we enforce the power disconnection to all sockets; essentially the current model of a full blackout.

Implementation Details: Our iPS retrofits a four slot power supply with a RF transceiver (CC2500) controlled by a mbed microcontroller (Figure 1). Furthermore, the on/off state of each socket on the iPS is controlled by mbed using relays. This setup thus provides us with a wireless communication channel to control individual sockets. For power monitoring we use two devices developed by Current Cost [1]; an IAM device for monitoring power consumption of the iPS, and a base station EnivR energy monitor to which the IAM reports its measurements.

Our SoftUPS application is built using custom-developed HomeOS driver for the iPS, and utilizing drivers for their EnviR bases station. Thus our application has both the control (through iPS) and measurement data (through IAM) available to implement our prototype. The SoftUPS application display the available sockets on its UI, with settings option to select which sockets to shut down when utilities want to demand reduction (load-shedding). The UI also shows that the total consumption of the power strip with selected devices turned off, thus allowing the selection to remain below the utility specified threshold, which is also tunable. We emulate the load-shedding event through a button on the UI, which when pressed signals the iPS to block power supply to the selected socket. During this phase, our application continuously monitors the power consumption of the iPS. Thus, when we (for demo purposes) replace the device in a socket with a higher consumption one, such that the allotted consumption threshold is crossed, our application will communicate with the iPS to disconnect all devices. This state is only reset once utilities indicate the end of their load-shedding period.

Conclusion: We thus demonstrate our ability to automatically reduce power consumption of a home, while providing a level of flexibility for the user to select devices that remain available within a threshold. Several aspect of this idea need work, from socket level device disaggregation and security — we aim to target them as part of future work.

4. ACKNOWLEDGMENTS

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