PRO 07 LEAP—Low Power Energy Aware Processing

PRO 07.1 Overview
A broad range of embedded networked sensor (ENS) systems for important environmental monitoring and other applications now require advanced capabilities to support highly capable, high power sensor devices. Many of these applications also require support for on-demand high performance computing and communication for complex information processing. This includes image processing, statistical computing, and optimization algorithms required for selection of proper sensor sampling. In order to support these applications efficiently we require an ENS platform designed with integrated energy monitoring and scheduling features.

PRO 07.2 Approach
In collaboration with Refraction Technology Inc., we have developed a state of the art seismic data acquisition system based upon the successful LEAP2 platform. The LEAP2 platform is a second generation low power, energy aware processing (LEAP) ENS system that was designed specifically to allow high accuracy, low overhead energy measurement of platform resources at granularity levels previously unachievable. Additionally, energy measurement domains may be added to or removed from the platform through an expandable energy monitoring bus integrated into the LEAP2 stacking connectors. We note that LEAP enables energy aware applications through scheduling and energy profiling of high energy efficiency components including multiple wireless network interfaces, storage elements, and sensing capabilities. As ENS applications continue to increase in scale and complexity, energy profiling with high temporal resolution is now required to permit per process and per subsystem energy accounting.

At the heart of the LEAP system is its Energy Management and Preprocessing (EMAP) capability. On LEAP2 this is integrated into a dedicated ASIC implemented in a micro-power antifuse based FPGA. The EMAP2 ASIC performs continuous, real-time energy monitoring functions as well as sophisticated power scheduling across the entire LEAP2 platform. This allows for a new design approach that focuses on minimizing energy required for each individual sensing, computing, and communication task. Through the EMAP2 ASIC, LEAP2 peripherals may be scheduled for use only when needed and detailed energy information is gathered during their operation. Energy usage information for individual platform subsystems including computational resources, such as the PXA270 microprocessor, memory subsystems, such as the SDRAM, NOR flash, NAND flash and SRAM, and peripheral subsystems, such as the Ethernet, 802.11, USB, Imaging, Compact Flash, and external sensors modules are all available at millisecond accuracies. In addition, the EMAP2 ASIC’s energy data and scheduling controls are available to the host processor through a high bandwidth memory bus interface, minimizing measurement overhead issues. This enables the host processor to obtain energy usage information across a wide range of devices at millisecond intervals and with a minimal overhead. These features provide LEAP2 with a unique platform monitoring and control capability that allows one to significantly reduce overall platform energy usage.

GeoNet
The Reftek RT-155, shown in Figure 1, incorporates LEAP2 technology to provide energy aware data acquisition enabling low average power dissipation. The LEAP technology is embedded in a new RT619 circuit board including a micropower FPGA. The FPGA contains logic from the EMAP2 ASIC as well as a new time synchronization module, proving sub microsecond time accuracy from both GPS and network timing sources. The FPGA dissipates less than 2mW while performing energy measurements from up to 24 energy domains as well as operating the power management scheduler and time synchronization algorithm. The RT619 module interfaces with the LEAP2 HPM...
(processor module) which runs a custom Linux kernel. The kernel integrates support for LEAP energy monitoring hardware and is able to accurately determine energy costs for most platform operations. The analog sampling engine may be configured and controlled via the Linux console through simple file system operations. This provides an easy to operate and robust platform for application development.

The RT-155 platform is a highly capable data acquisition system, capable of providing 6 channels of 24-bit data with sample rates up to 4 KHz. This is performed while maintaining average power dissipation less than 300mW. The platform is able to operate continuously in low power vigilant states while performing event detection. If events require, the platform can quickly transition to a fully vigilant mode where networking and additional platform resources can be enabled through the EMAP logic. The platform is able to continuously record data through these power mode transitions.

The LEAP enabled RT-155 is currently operating in field exercises with L-4 seismometers as well as acoustic microphones.