


GREENit
Green Initiative Troupe
Intel Supply Chain

# Using Wireless Sensor Networks to Support the Greening of Intel

## Energy Monitoring and Management Demonstration System

**Intel GREENit Day**
**May 6, 2009**


# Background

- As part of Intel's Green Initiative, actions are being take to identify opportunities to conserve energy resources and reduce carbon footprint
- Monitoring and management of energy in the office environment has been identified as an integral part of that conservation.
- Information gathered about energy consumption in the office environment can empower:
  - Employees to voluntarily conserve energy resources once they are aware of energy consumption
  - Corporate building services to architect, design, and operate more efficient offices
- An automated method of collecting energy consumption information in the office environment to support this effort was desired.
- This document describes the Wireless Sensor Network (WSN) design that was implemented and demonstrated on GREENit Day for that purpose.

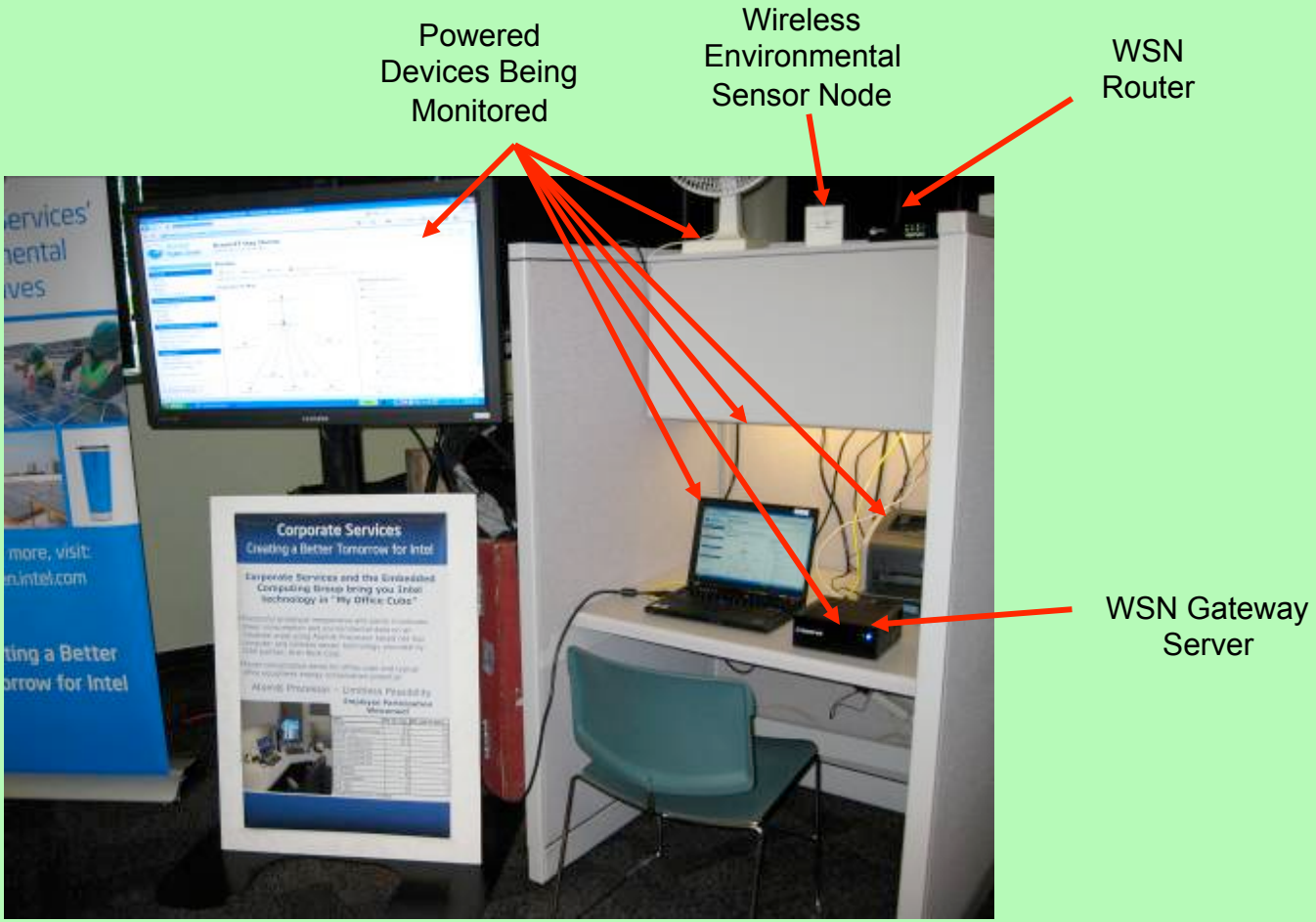

# Introduction

- The system described herein utilized commercially-available components featuring a low-power Intel Atom™ based server to efficiently monitor energy consumption in a mocked-up office cubicle.
- The demonstration system, while limited in scope and implemented for portability in a tradeshow-like setting, is designed to be easily scaled to larger, more permanent and more complete office environments.
- The system architecture employed is a three-tier architecture consisting of:
  - An *ad-hoc* wireless sensor mesh network consisting of multiple environmental and power sensor nodes that measure key environmental and energy consumption parameters
  - A mid-tier layer of *routers* which collate and convert sensor mesh network data traffic to intermediate Local Area Network format and communicate that data by various means to the next higher tier, and
  - A top-tier Intel Atom™ based server that:
    - Collects and stores pertinent information in a Postgres database for further analysis
    - Manages all three tiers of the WSN
    - Provides web-services-based reporting and graphing of key environmental and energy consumption parameters

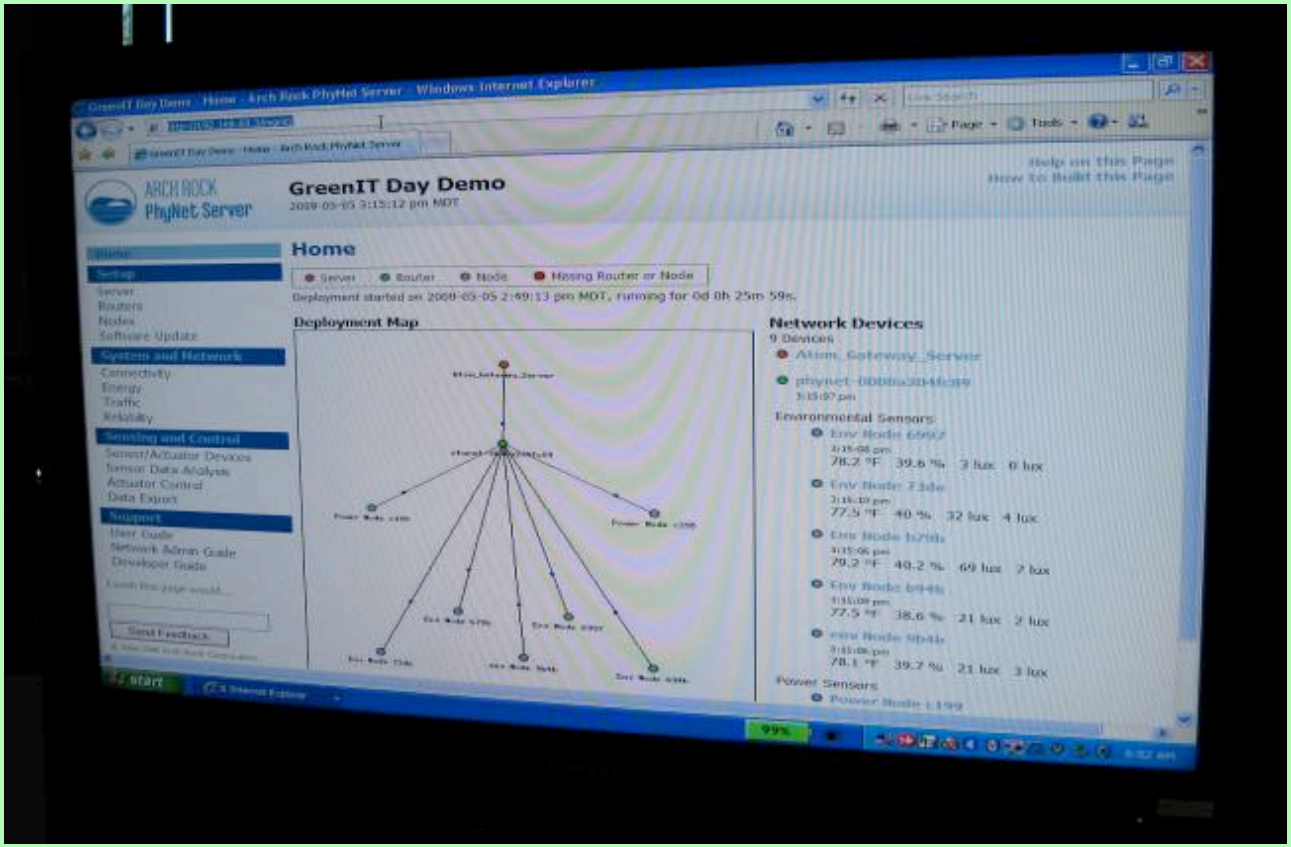

# Application Overview

- The objective of the demo system was to show how commercially-available Wireless Sensor Network (WSN) components could be applied to measure energy consumption in the office environment featuring an Intel Atom™ Gateway Server.
- A laptop PC was connected to the Gateway Server, and an internet browser was used to monitor and display environmental and energy consumption data from various powered devices in the desktop environment, including:
  - A large screen monitor that displayed the web-services interface
  - The laptop PC
  - A printer
  - A common office fan
  - Desktop lighting
  - The energy monitoring components themselves

# Monitoring Energy Use in Office Space



# WSN Deployment Overview




# GREENit Demo Architecture

Gateway Server Level


Featuring *Intel Atom*™ Based Gateway Server

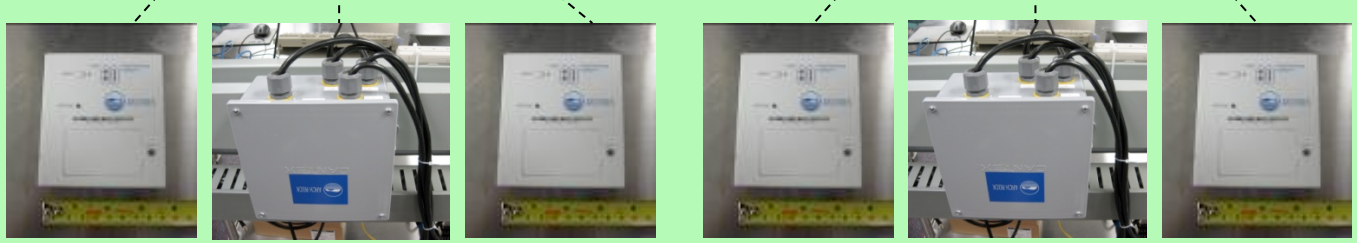
802.3

Ethernet Switch

Router Level

802.15.4

Sensor Level



Environmental Sensor

Power Sensor

# Components Overview


- The **Gateway Server** used was implemented on a Kontron model KTUS15/mITX commercially-available Atom™ platform box coupled with Arch Rock™ Gateway Server software.

- The **router** used was an Arch Rock™ PhyNet™ commercially-available router that connects 6LoWPAN mesh networks via Wi-Fi and Ethernet interfaces to tie the 802.15.4e wireless sensor mesh network to the gateway server.

# Wireless Sensor Mesh Network


**Environmental sensor nodes** employed were Arch Rock™ IPsensor™ wireless sensor nodes that measure ambient temperature, humidity, and (two forms of) light (with optional discrete and analog I/O capabilities),

**Power sensor nodes** employed were Arch Rock™ Rack IPpower™ nodes. These nodes measure complex current and voltage and report resultant power consumption as complex vectors for up to three single-phase circuits (or one three-phase circuit) per node.


# Results

This small-scale system implementation successfully validated and demonstrated:

- the viability of the low-power Intel Atom™ based gateway server to collect and store data and produce and provide web-services-based interfaces to the system

- the capabilities the overall system architecture to successfully perform automated energy monitoring in typical office environments in an extensible way that can be applied to large-scale installations both in office and more general environments (such as factories, data centers, etc.)