Smart Building Optimization Systems

The ongoing development of smart buildings has recently gained in importance at Florida Atlantic University. Innovative methods are being used to optimize the operation of buildings and thereby reduce operating expenses and reduce energy consumption. In this project, research was conducted on the FAU's new LEED Platinum-certified Engineering building that houses the Center for Advanced Knowledge Enablement's (CAKE's) laboratories. The building was designed both as a model of how new technologies can drastically decrease the energy requirements of a large building and as a "living laboratory," so that students and faculty can actually see how these systems work and interrelate. The building is equipped with hundreds of sensors that measure and collect various parameters and display them in real-time on a dashboard, which is accessible through a Web-based application called DeviseWise from ILS Technology, a member of our I/UCRC and our partner in this project.

Mechanical equipment, pumps, piping, and sensors are part of the building HVAC systems. Image provided by CAKE.

During 2014-15 the CAKE team developed a data warehouse that stores information from several different sensor systems including DeviceWise, standalone wireless and wired sensors, PDM calculated clusters, and weather stations. The collected weather data comes from a link to the WeatherBug API. Every 15 minutes it pulls meteorological information including temperature, humidity, wind speed and direction, air pressure, rain amount and light levels. The system provides tools for extracting and analyzing sensor data. It exports it in a variety of formats for use by other tools such as the Weka Machine Learning Suite and Excel.

As part of the NSF Center project, FAI faculty and students worked with Aware Technologies and their Process Data Monitor (PDM) system. This is an alerting system that uses data mining techniques to categorize sensor data into similar clusters of information. It automatically detects when a current cluster is outside of normal operating parameters. It then reports anomalies to an operator.

Researchers have analyzed the efficiency of the building's solar panels by tracking the power generated over a one-year period. They noticed high variations in the amount of solar power generated. This was mainly attributable to variable day-by-day cloud coverage. Between March and May 2012 there were very clear skies with almost no rain and hardly any clouds. Conversely, the beginning of 2013 witnessed a

period of high cloud coverage combined with shorter days. This caused reduced solar energy generation. Currently, the building's solar energy production is on average 4.45% of the total energy used by building systems.

Solar photovoltaic cells on a building roof for power generation. Image provided by CAKE.

Advantages over previous methodologies: This work presents an excellent example how researchers are using the new Platinum-certified building and FAU labs as a "living laboratory" in order to better understand and conduct research in the areas of smart building technologies and optimization. The main focus is on improving energy efficiency; however the other components of the project include sustainability, water savings, material and resource selection, and indoor environmental quality.

The end-user systems can be summarized as: 1) Alerting and monitoring systems that analyze data from various sensors in the building to issue alerts when anomalies are detected, and; 2) A data warehouse system that collects and stores data from the sensor systems. Data can then be used for determining correlations between photovoltaic energy generation and weather conditions, and calculation of energy flow between the different components of the air conditioning systems.

> **Economic impact**: Strong instrumentation in the new LEED Platinum engineering building opens up a multidimensional view of the inner working of its HVAC and power systems. A variety of sensors allow detailed analyses of the building system performance and the data center power consumption. This research provides the foundation for analyzing and improving energy efficiency in buildings equipped with sensors and solar panels. The results of this research are being used to analyze and improve the operation of new "smart" buildings.

For more information, contact Ionut Cardei at Florida Atlantic University, icardei@fau.edu, Bio http://www.cse.fau.edu/~icardei/index.html, 561.297.3401.