High Confidence Building Operating System

Principal Investigators:
Prof Alberto Sangiovanni-Vincentelli (UCB)
Prof King-Jet Tseng (NTU)
Prof Sanjib Panda (NUS)
Prof Boon Hee Soong (NTU)
Prof Peter Chong (NTU)
Prof Yung C Liang (NUS)

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Mission

Develop the Foundations, Methodology and Tools to design and demonstrate a multi-scale embedded, intelligent distributed system consisting of wireless and wired networked sensors, actuators and controllers that executes a hierarchical control plan in real-time and in cooperation with building energy distribution grids and interactions with external utility grid, while adapting to system evolutions and local variations, controlling and optimizing resources, so as to achieve energy efficiency and sustainability in buildings.

Objectives

To apply new foundations and methodologies to design and demonstrate building operating systems that

- Enable a fundamental change from oblivious consumption and isolated production to aware, agile, optimized and adaptive consumption and generation of energy in the building, particularly in the form of electrical power;
- Provide high degree of cooperation between the building and the future extended smart power grid which incorporates intelligence into various points of consumption and generation within the building;
- Provides critical functionality at all times, despite damages caused by accidental faults, errors, and degradations or malicious intrusions.

Methodology

Utilize and integrate **pervasive instrumentation**, **broadly embedded intelligence, control and communication, modeling, forecasting** and **planning** to actively manage the load buildings present to an intelligent energy distribution grid within and external to the building while also providing a comfortable and productive environment to occupants.

Work Packages

WP3.1: Development of Building Automation and Control System

a. Modeling and Controller Design

Modeling thermal dynamics of buildings; Calibrating with historical data; Validating with a different set of data; Design control architecture for whole system; Optimal control which maintains temperature within desired bounds using minimum possible amount of energy

b. Complete Design Flow

Extend design flow to co-design building control algorithms & electronic platform.
Extend design space exploration to include more physical aspects such as occupation.
Apply the methodology to co-design multiple sub-systems such as HVAC and lighting.

c. Wireless Sensor Network Design and Deployment

WP3.2: Intelligent Energy Distribution and Storage in Buildings

a. Intelligent Power Switches (IPS) and their Control

An IPS combines communications with a power electronic interface to manage the link between any energy source, storage or load and the energy distribution grid. The IPS is responsible for controlling power flows to ensure reliable operation of energy distribution.

b. Hybrid DC/AC Building Power Distribution

Most building loads will be inherently DC, e.g LED lighting and variable speed chillers. Individual AC-to-DC converters in building loads generates heat losses. Consolidating all the power conversion into one central large AC-to-DC converter and using DC distribution can cut down on heat loss, simplify cooling and increases efficiency.

WP3.3: Information Networks for Intelligent Buildings

a. Efficient Information Network for Intelligent Building Optimization

The selection of an optimal network is driven by several metrics such as cost, network lifetime, throughput, and also resiliency to sudden failures in network architecture

b. Information Network for Intelligent Building Applications

By utilizing pervasive sensing of embedded devices with sensors and communication technologies to provide information on user's real time preferences according to price, metrics, external environment, etc.

Concept Diagrams