Building Environmental Systems
Lecture 1. Smart Building

ARE 346N
Spring 2019

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Many of these slides are derived from Prof. Zoltan Nagy's class (Fall 2017)
The plan for today

• About me
• Teaching plan
• Smart building concept
• Smart building examples
• Cyber physical system
• Lessons and questions
About me

• June Young Park, Ph.D. candidate in Civil Engineering major
• Dissertation title: Occupant Centered Building Control for Balancing Occupant Comfort and Energy Efficiency

• MS, Carnegie Mellon University, 2016
• BS, Illinois Institute of Technology, 2014
• BS, Hanyang University, 2014
Teaching Plan

- (3/26, Tuesday): Smart building
  - smart building & example, Cyber physical system

- (3/28, Thursday): Circuits (1)
  - current, voltage, sources, power, Kirchhoff’s law

- (4/2, Tuesday): Circuits (2)
  - circuit elements & configuration, Gadget demo
What is a smart building?
What is a smart building?

• Please answer this question during today’s lecture (in-class activity)

• Describe your answer by keywords

• You can participate either by your phone or laptop
Industry is technology focused

“A smart building is an intelligent space that will transform efficiency, comfort, and safety for people and assets.”
“A smart building is an intelligent space that will transform efficiency, comfort, and safety for people and assets.”

Source: Frost & Sullivan

CABA’s North American Intelligent Buildings Roadmap 2011
What is a Smart Building?

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Abstract

Purpose – Within the building sector a lack of clarity in terminology does not help designers, clients or researchers. Non-domestic buildings have shown rapid increases in the use of advanced technology and control systems with varying drivers, many of which are labelled as intelligent. The term smart has been used interchangeably with intelligent without any clear distinction between the two. If the term Smart Buildings represented a separate, more advanced grouping, it would provide an opportunity to focus the future progress of non-domestic building development. The paper aims to discuss these issues.

Design/methodology/approach – Drawing upon academic and industrial literature and experience, this paper reviews the scope of Intelligent Buildings and the current available definitions of Smart Buildings to form a clear definition of both smart and Intelligent Buildings.

Findings – These definitions define the border between the intelligent and the (more advanced) Smart Building. The upper bound of the Smart Building is defined by (the future development of) the predictive building.

Originality/value – This work provides a clear focus which will allow the progression of the non-domestic building sector by providing guidance and aspiration, as well as providing a platform upon which a large amount of technical work can be based.

Smart = intelligence

“ [...] the term intelligence loses both meaning and focus ”

“ [...] balance between allowing users to have control, and [...] allow the building systems to manage the energy consumption efficiency “
Regarding Building Environmental System course

Air conditioning

Heater

Lighting
Two objectives in BES

Air conditioning

Heater

Lighting

Provide occupant comfort

Main energy consumers
Smart building’s main objective

Balancing **occupant comfort** and **energy consumption**;
Example 1: building energy management (BEM)
Example 1: building energy management (BEM)

- Monitoring HVAC equipment status
- Controlling HVAC actuators, e.g., damper, coil, ...
Example 2: learning thermostats

Image credits: nest lab, ecobee, honeywell
Example 2: learning thermostats

- Learning occupant’s schedule
- Detecting occupant presence
- Trying to save utility bill
- Monitoring equipment status

Image credits: nest lab, ecobee, honeywell
Example 3: smart home hub

Amazon Echo Tech Specs

Image credits: Amazon, Google
Example 3: smart home hub

- Connecting other smart appliances with human using natural language processing
- Controlling connected devices
- Monitoring connected devices
- Internet of Things

Image credits: Amazon, Google
Example 3: smart home hub
Example 4: Mozer’s adaptive house

- First example of “smart home” in 1990s
- Computerized home
- Program itself by observing the lifestyle and desires of the inhabitants
- Learning to anticipate and accommodate their needs

Example 5: LightLearn

- Learning occupant’s preference by reinforcement learning
- Controlling light switch
- Adaptive to occupant behavior and room configuration
- Balancing between occupant visual comfort and energy saving

Example 6: thermography of human face

- Using human face skin temperature as proxy
- Understand occupant’s thermal comfort

Smart building application?
Cyber physical system (CPS)
Electric circuits for smart building applications

- Sensors to acquire 1) occupant related information, 2) environmental condition, and 3) building system operation
- Actuators to control building systems
- Communications between IoT enabled devices
Figure 1.2  The headlight circuit. (a) The actual physical layout of the circuit. (b) The circuit diagram.
Figure 1.3 An electrical circuit consists of circuit elements, such as voltage sources, resistances, inductances, and capacitances, connected in closed paths by conductors.
What is a smart building?

• Please answer this question during today’s lecture (5 minutes)

• Describe your answer by keywords

  Example answer: occupant comfort, energy saving, artificial intelligence, HVAC, lighting ...

• You can participate either by your phone or laptop

  Respond at PollEv.com/junepark731

  Text JUNEPARK731 to 37607 once to join, then text your message
Design CPS for thermal control of this classroom

• Sensors:
• Actuators:
• Communication:
• Data stream interval:
• Objective:
• ...

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Lessons today

• Smart building is popular for both industry and research
• Industry focuses on technological development of smart building
• Research focuses intelligence of smart building
• Building environmental systems are direct applications of smart building
• Cyber physical system for smart building
• Electric circuit is the fundamental basis for smart building applications