Panel #2
Digital Applications

Moderator:

Jin Wen
(Drexel University)

ANNEX 81

EBC Energy in Building and Communities Programme

BRAINS 4 BUILDINGS

Panellist:
Zheng O'Neill
(Texas A&M)

Digital Applications

B4B/IEA Annex 81 online symposium on Data-Driven Smart Buildings (DDSBs)

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J. Mike Walker '66 Department of Mechanical Engineering

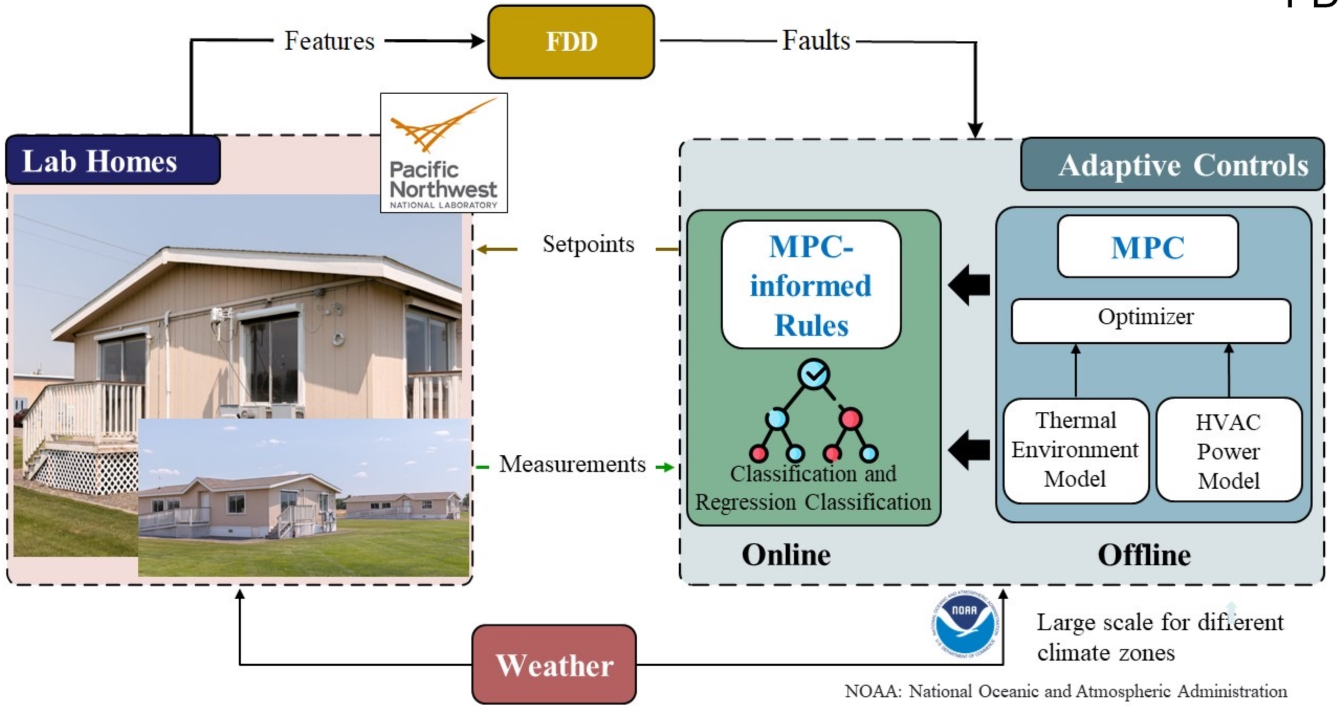
Texas A&M University

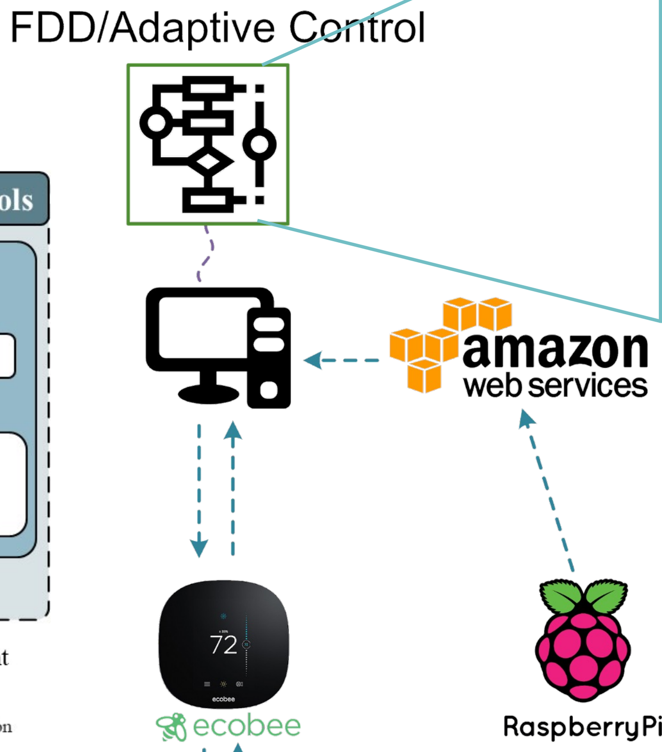
February 28th, 2024

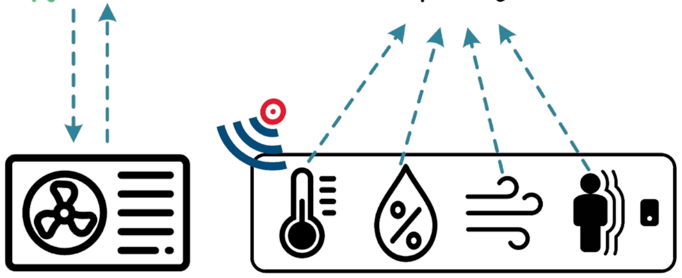
Smart and Connected Homes

DOE project: IoT Based Comfort Control and Fault Diagnostics System for Energy Efficient Homes

FDD: Fault Detection and Diagnosis







- Data hub to collect data from **low-cost sensor network**
- **Learning-based** analytics with **computationally efficient FDD**
- **Adaptive comfort control** considering building and HVAC health status

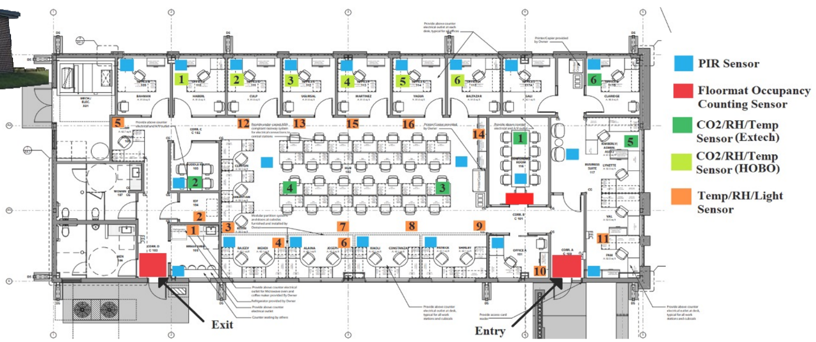
1) Heat Pump FDD:
- Detection Accuracy: **96.4%**
- Diagnosis Accuracy: **90.18%**

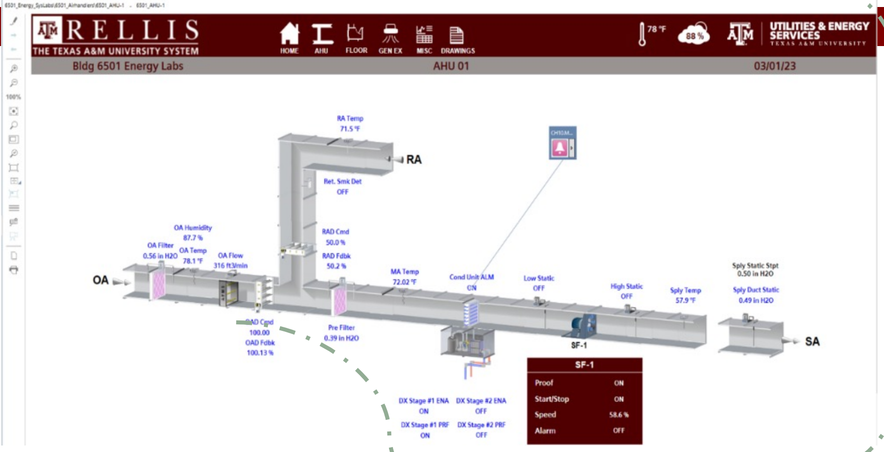
2) Adaptive controls for maximizing occupants' comfort under HVAC faults (Sep. 6th – 21st, 2022): **Around 2 F-hr** unmet hour mitigation

3) Adaptive to the occupancy (Aug. 31st-Sep. 2nd): **more than 14% HVAC** energy savings

Wireless low-cost unit:
- Temperature sensor
- Air flow sensor
- Humidity sensor
- Occupancy sensor

Occupant Centric Controls in Office Building





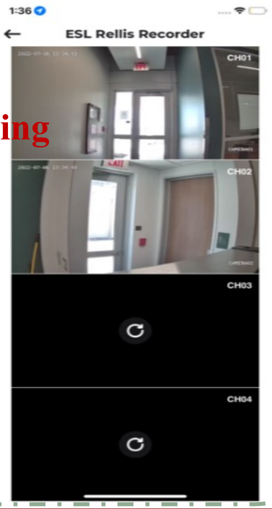
Sensor Hub/Cloud

Ethernet

Floor Mat Sensors → (**Wireless LoRa**) → Sensor Gateway → (**Ethernet**) → Linksys Router

Linksys Router → (**Ethernet(MQTT)**) → Rasp-Pi Controller → (**Static IP Ethernet Connection**) → Ethernet Switch

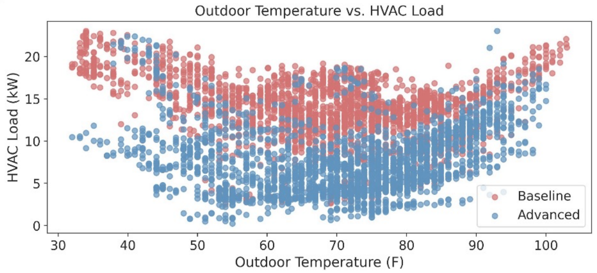
BACnet Device ↔ (**Ethernet**) ↔ Ethernet Switch → (**Ethernet**) → BACnet Network



LoRa: Long Range Radio Connection

Data-driven Predictive Controls – Dynamically Reset:

- Zone temperature setpoint
- Zone minimum supply airflow
- System minimum outdoor airflow rate



One-year Field Testing:

- **About 49% HVAC savings.**

Key Takeaways

Scalability and Practicability

Low-cost and robust sensor network: wireless vs. wired; interoperability; plug and play

Cloud-based architecture: secured integration with currently installed building energy systems

Computationally efficient FDD and demand side controls (optimization-informed): easily-implemented in Home/Building Energy Management Systems on market

ANNEX 81

EBC Energy in Building and Communities Programme

BRAINS 4 BUILDINGS

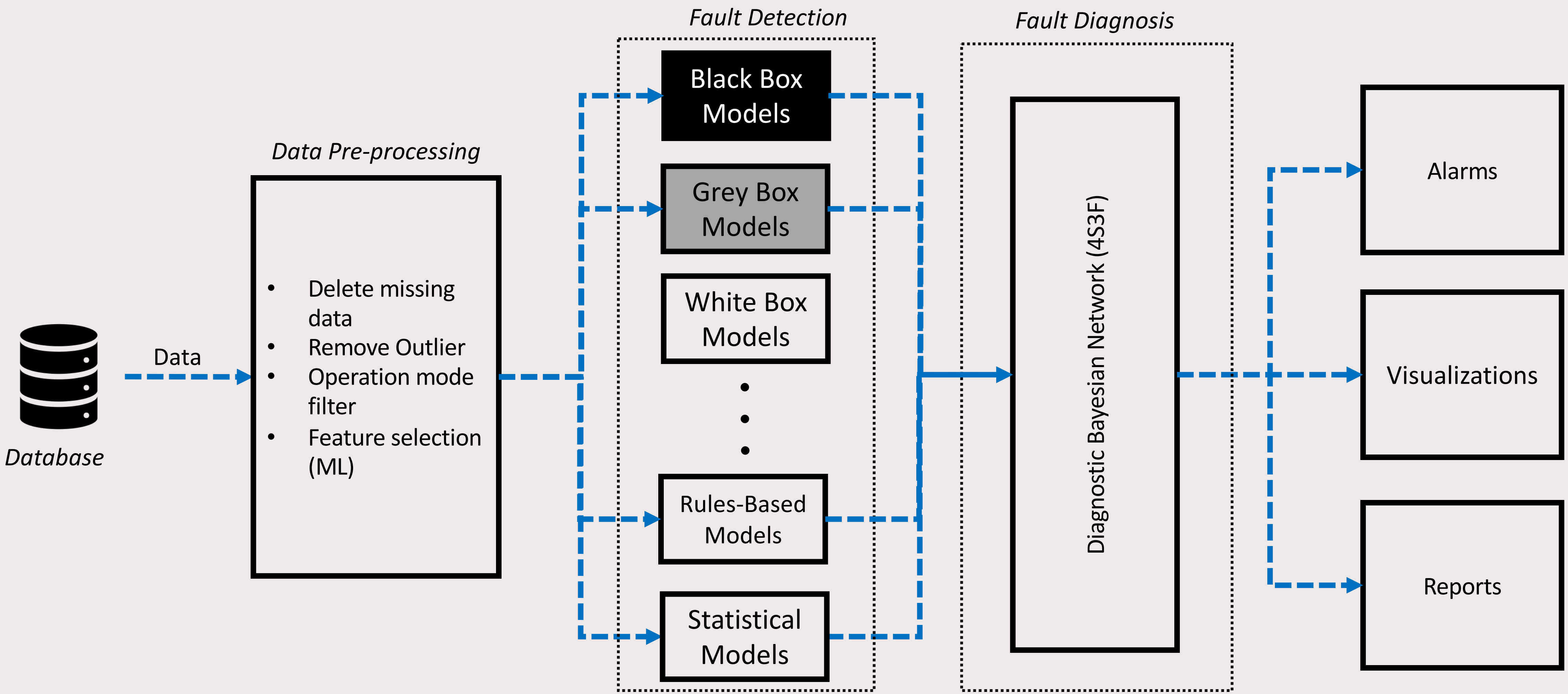
Panellist:
Rick Kramer
(Eindhoven University of Technology)

Brains4Buildings – IEA EBC Annex 81: Digital Applications

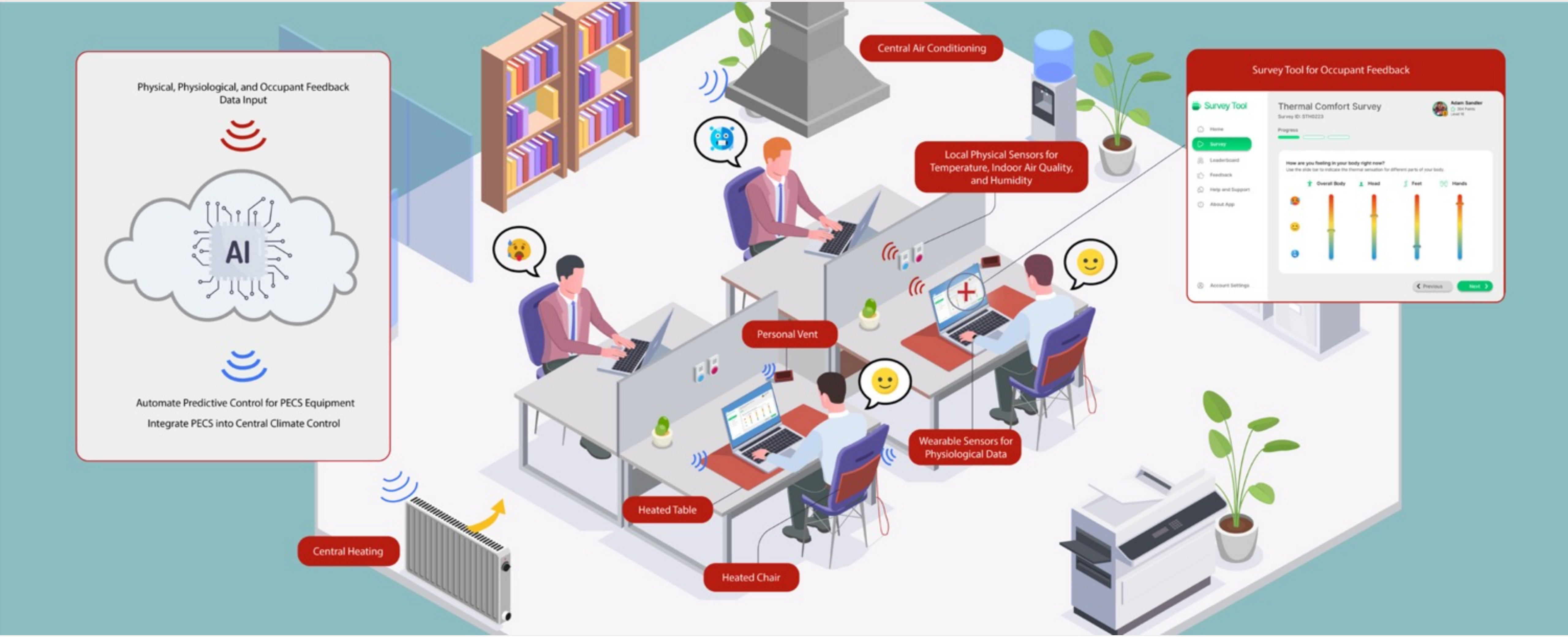
28 FEBRUARY 2024

Rick Kramer, assist. prof. Building Services

FAULT DETECTION & DIAGNOSIS METHOD



Central and decentral control: Occupant feedback



Proposition

Achieving individual occupants' *comfort* and *long-term health* requires an overarching intelligence orchestrating *central* and *decentral* HVAC control taking into account a data flow of subjective feedback.

For data *efficiency* and *scalability*, the underlying *data-driven* models need to be augmented with *knowledge-based* features.

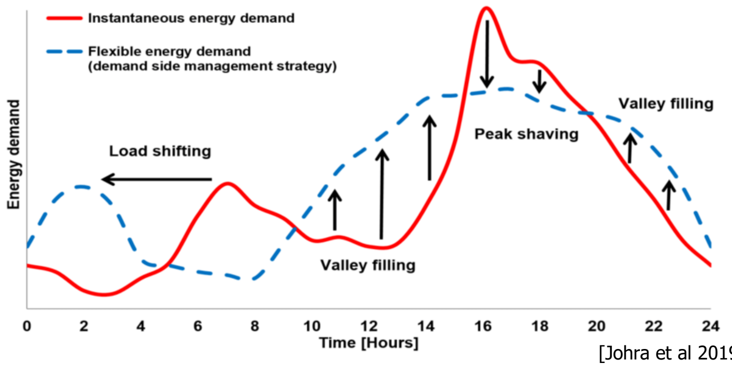
ANNEX 81

EBC Energy in Building and Communities Programme

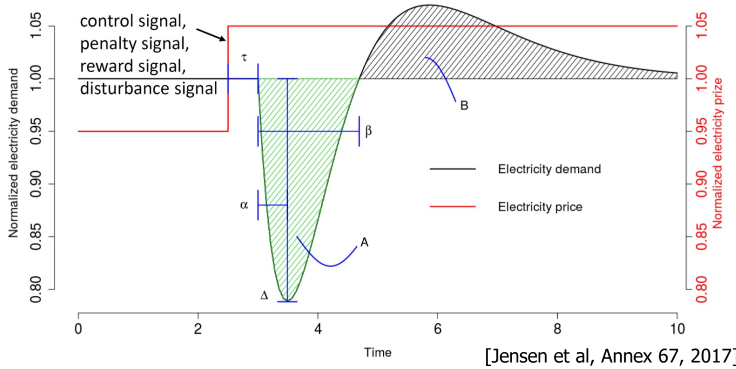
BRAINS 4 BUILDINGS

Panellist:
Tamas Keviczky
(Delft University of Technology)

Digital Applications
Panel discussion



[Johra et al 2019]



[Jensen et al, Annex 67, 2017]

Tamás Keviczky

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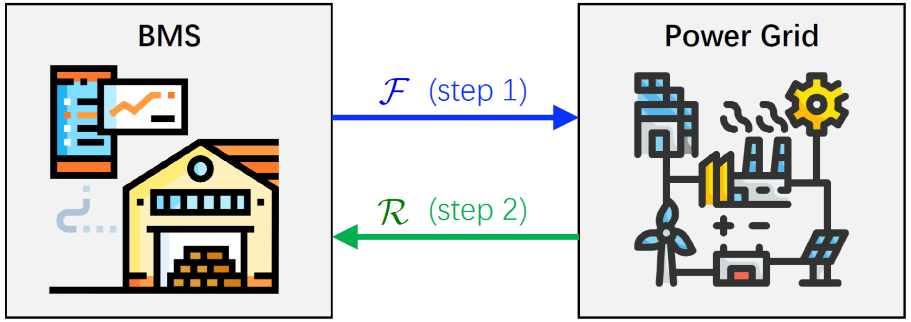
BRAINS 4 BUILDINGS

TU Delft
Delft University of Technology

Predictive Control for Energy Flexibility

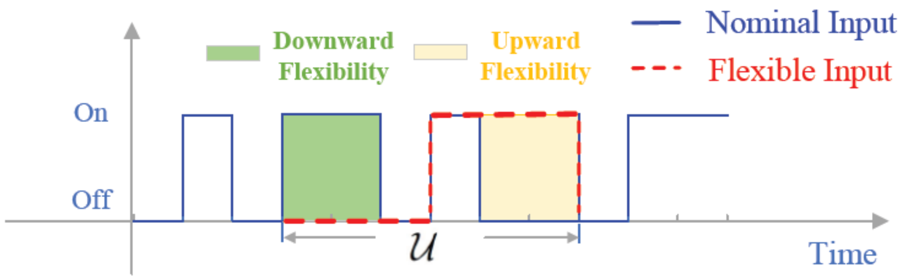
(Yun Li, Neil Yorke-Smith)

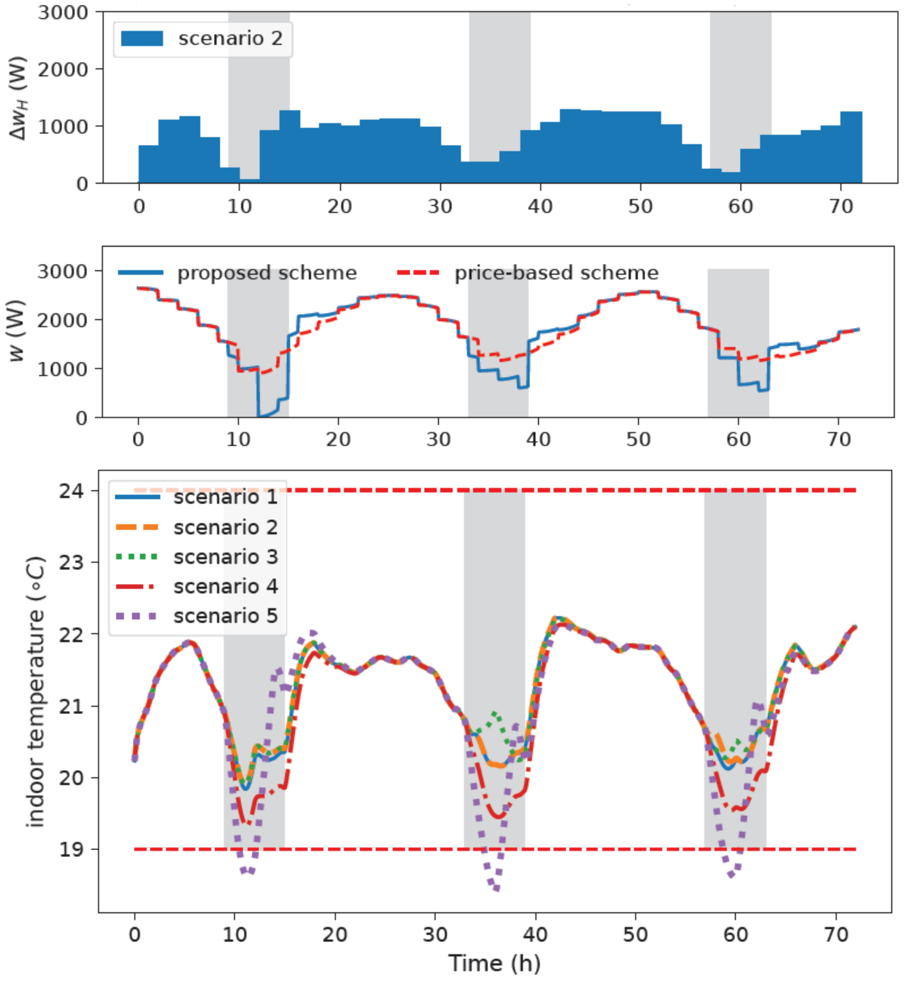
Shift energy usage in response to DR requests based on quantitative robust flexibility assessment and predictive control while ensuring comfort constraints.



Two-stage approach:

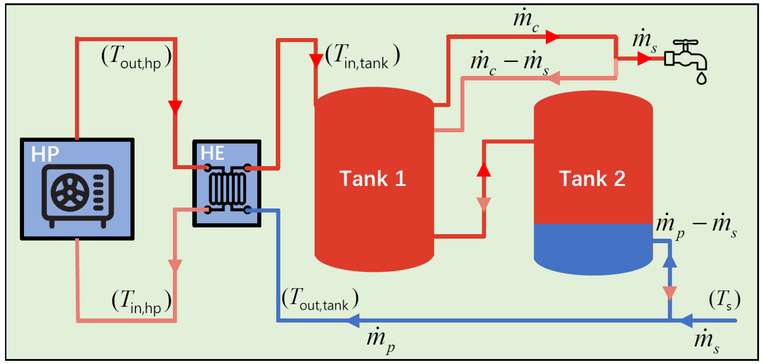
- Calculate available energy-use flexibility based on forecasts, uncertainty representations.
- Realize corresponding building control in response to real-time demand-response request.





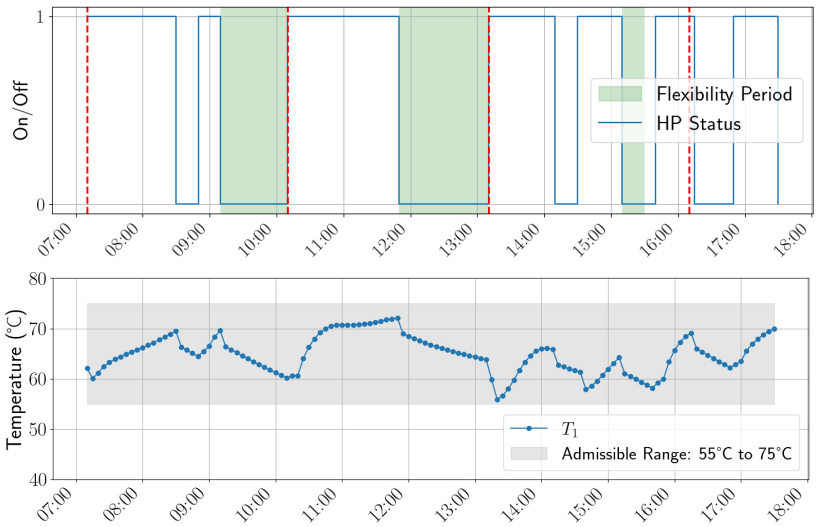
Experimental demonstration
(Weihong Tang, Yun Li, Shalika Walker)

MPC for flexible and cost-efficient domestic hot water supply (HP + thermal storage)



- Control-oriented modeling of HP and thermal storage tanks
- Hot water demand prediction model (SARIMA)
- Mixed-Integer MPC solution to minimize energy costs and fulfill supply temperature and HP constraints
- Provide energy use flexibility in response to DR requests

Experimental demonstration of shifting energy usage based on demand-response request.



	Energy savings	
	Consumption	Cost
Simulation	~9%	~12%
Experiment	~6%	~10%

Other experimental proof of concepts planned in buildings near TU Delft campus.

Key takeaways

1) The developed algorithms offer **new mechanisms for building-grid interaction** (e.g., instead of price- or best effort-based reactive buildings, we can robustly guarantee flexibility, opening up new types of contract based grid services).

2) Automated flexibility assessment tools can lead to **new building energy flexibility labels** based on quantitative metrics.

Challenges/propositions

1) What prevents **wide-scale adoption of new technologies** developed by researchers? How to turn them into a **business case**, who will be setting up / tuning / managing these systems?

2) Bridging gap between academic/research results in pilots and actual **scalable adoption** (whose role is this, companies, municipalities, etc)?

3) Opportunities and challenges for **cloud-based operation** of buildings (hiding the methods/algorithms from building operators, allowing rollout of updates)?

4) **Human capital challenges** for next generation of building management systems (manual labor vs IT/software engineering).