NudgeFlow

The next generation of residential ventilation - tweaking the natural air flow with distributed components

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1

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2

Context

- Residential ventilation
  - COVID19 -> questionable state existing ventilation system in residential buildings
  - Contradictory expectations: good IAQ <> low energy use
  - Market shifting rapidly:
    - pushed towards reliable systems
    - performance-based services
  - Traditional systems: not smart & lack robustness

Context

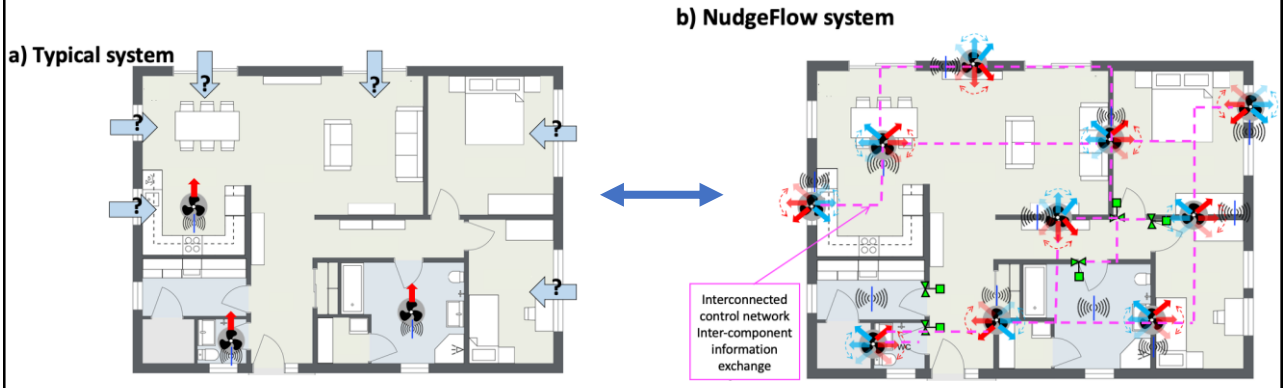
- Need for renovation solutions
  - Reduced spatial impact duct network
  - Lower & better phasing investment costs
  - Room-based decentralized ventilation -> do no cover whole building

Context

- **Next generation** smart residential ventilation system "**NudgeFlow**"
  - Truly smart ventilation system
  - Requires minimal intervention
  - User-and-context-aware
  - Guarentees good IAQ & thermal comfort & low energy use

https://nudgeflowproject.weebly.com

Typical ventilation system <> NudgeFlow system

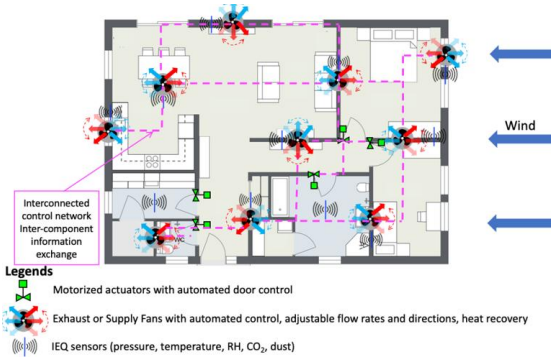


Fixed flow path
& uncontrolled natural supply

Adjustable flow rate and directions

NudgeFlow system: definition

- Definition
  - Dynamically nudges & tweaks natural flow through spaces of dwelling
  - Minimal mechanical work & energy
  - Adapt selection & operation components to climate conditions



NudgeFlow system: components

- Components
  - Interconnected low pressure drop ventilation components
  - IEQ sensors tracking ventilation demand, climate conditions and flow patterns
  - Distributed controller





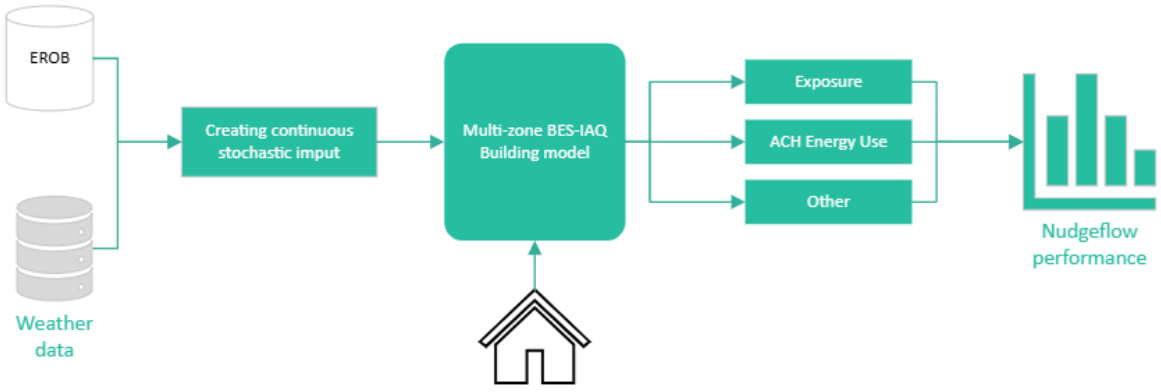
NudgeFlow system: challenges

- Challenges
  - Understand how & where to nudge **airflow pattern** in dwelling
  - Measure & benchmark **performances**
  - Determine performance-based **design** strategy
  - Create **control**
  - **Integrate** in technology concept

Research aim

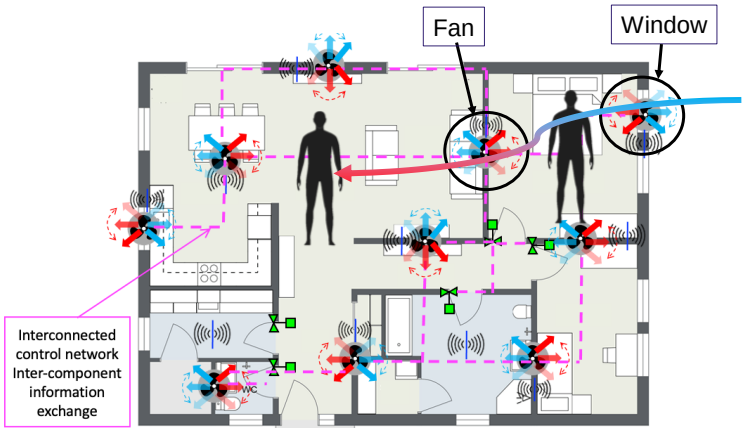
- Overall aim = to define **technology concept** of NudgeFlow system
- Specific goals
  - Enhance **understanding** effect of infiltration on indoor flows
  - Establish **CFD modeling approach** in & around NudgeFlow building
  - Propose **stochastic method** to assess IAQ & energy performance
  - Define **acoustical performance criteria** & evaluation method for NudgeFlow components
  - Formulate **performance-based design process**
  - Determine **distributed model-based controller** for NudgeFlow system
  - **Demonstrate** feasibility of **virtual** **NudgeFlow system**

Stochastic simulation approach



NudgeFlow control: challenges

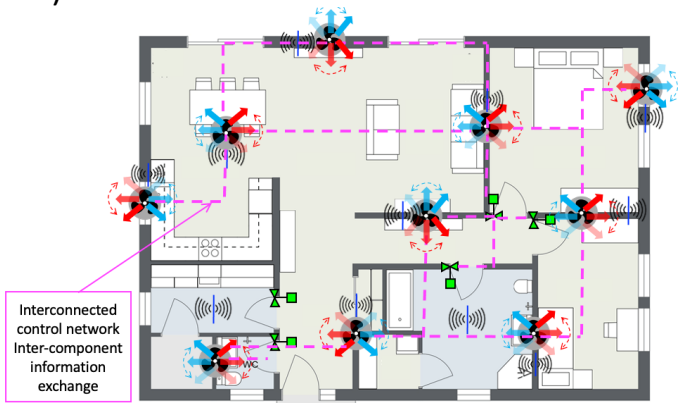
- Multiple distributed components causing contradictory decisions

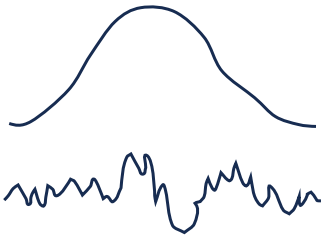


Window opens to ventilate bedroom
Fan operates to drive the flow to living room
IAQ in occupied living room decreases

NudgeFlow control: challenges

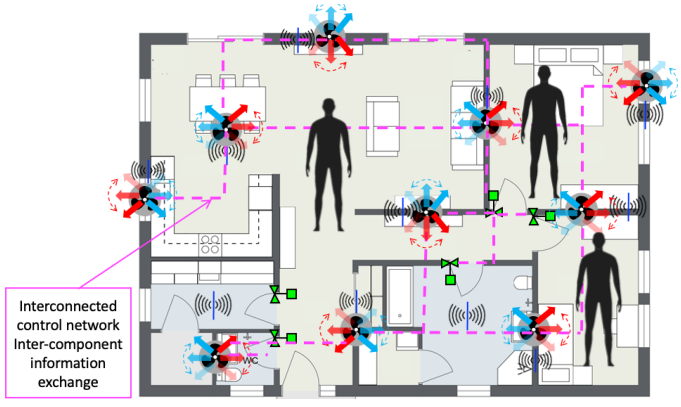
- Boundary conditions: Combined fast and slow dynamics (Wind vs. Temperature)





NudgeFlow control: challenges

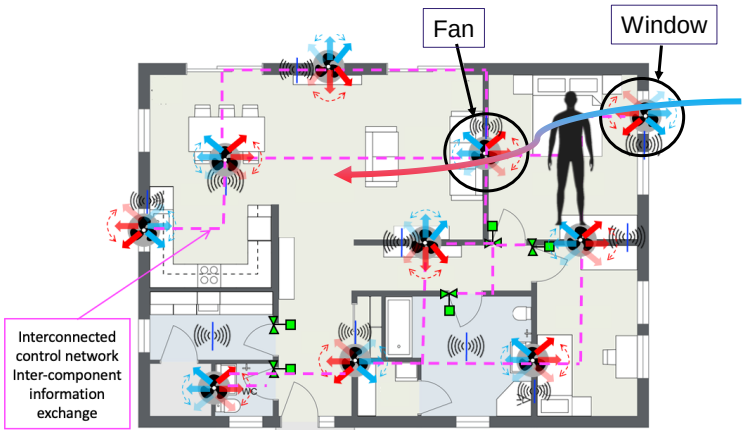
- Internal disturbances influencing the airflow patterns



Person moving around the house and opening doors, leaving them open

NudgeFlow control: challenges

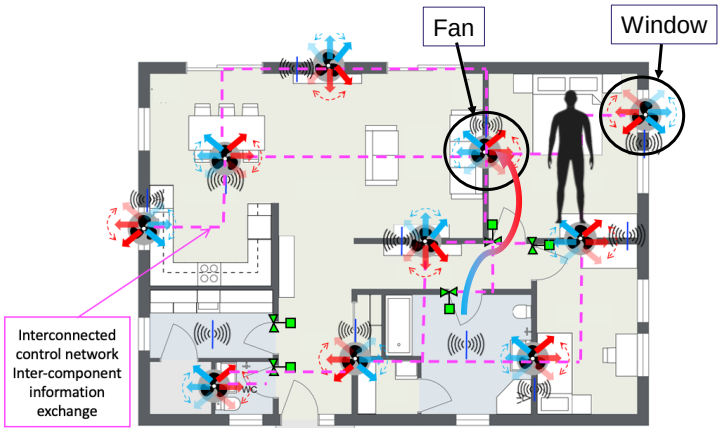
- Internal disturbances influencing the airflow patterns



Controller decides to open window and operate fan

NudgeFlow control: challenges

- Internal disturbances influencing the airflow patterns



Disturbance: Occupant decides to close the window and open the door

If fan is ON, risk of extraction of humid air from bathroom to bedroom.

Summarized

- Context
  - Residential ventilation market pushed to reliable systems
  - Need for renovation solution
- NudgeFlow system
  - Next generation in residential ventilation
  - Interesting for renovation
  - Dynamically nudges & tweaks natural flow through spaces of dwelling
- Aim = define technology concept via virtual testbed
- Research + follow-up valorisation

Discussion

- After presentation of NudgeFlow concept: do you see **additional research gaps** (in system design, control, performance assessment)?
- What are challenges and opportunities for **implementation** the NudgeFlow system in dwellings?