A sensor network for monitoring and adjusting building ventilation

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Introduction

- Building ventilation is designed to provide air at comfortable temperature and humidity levels and to keep the concentration of air pollutants low

- The ventilation process includes bringing in outdoor "fresh" air and exhausting roughly equal amount of indoor air from the building
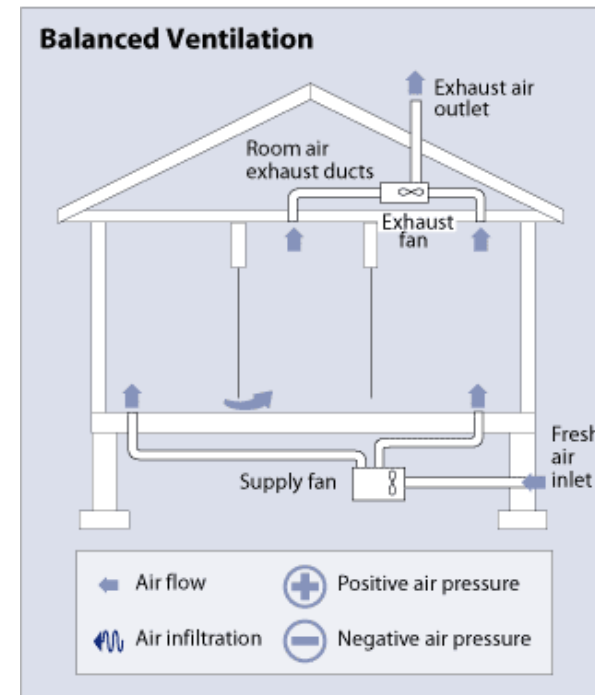
Air flow is lazy

- Air flows through a channel that provides least resistance to the air flow

- Ducts and other ventilation channels are meant to provide the easiest route for the air flow

Balanced air flow

- Unbalanced air flow will lead to increase in air flowing in/out of the building through other channels than ventilation ducts

- Airflow through the shell of a building may bring pollutants to the indoor air or increase humidity in the structure of the building which may lead to damage to the building

Balanced ventilation

- When inlet and exhaust air flows are balanced the airflow through the shell of the building is minimized
- There still we be local pressure differences which maintain the airflow between rooms and other spaces

Balanced Ventilation

Exhaust air outlet

Room air exhaust ducts

Exhaust fan

Fresh air inlet

Supply fan

- Air flow
- Air infiltration
- ⊕ Positive air pressure
- ⊖ Negative air pressure

Balancing is not universal

- Balancing is performed by adjusting inlet/exhaust fan speeds, dampers, vents and diffusers
  - Due to non-linearity of the ducts the balance is maintained only in the condition where the balancing was performed
  - If the conditions change the airflows are no longer balanced

Why do we make changes?

- To conserve energy the ventilation is usually reduced outside office hours of the building
- Automatic exhaust vents that react to humidity, CO_2 level, temperature etc. change the vent opening to increase/decrease air flow
  - A prototype of automatic vent that harvests it's energy from the airflow is under development in Metropolia

The solution

- The pressure difference between inside and outside of the building building tells if the ventilation is balanced
    - A large office is typically divided into several zones which requires multiple measurements
- A large number of measurements gives more accurate data for example of conditions over a whole week

The sensor network

- Zigbee based sensor network where each node is capable of measuring differential pressure
  - Pressure measurement can be also used to measure air flow in the vents if vent parameters are known
- Measurements can be used on the spot or stored on a server for later analysis
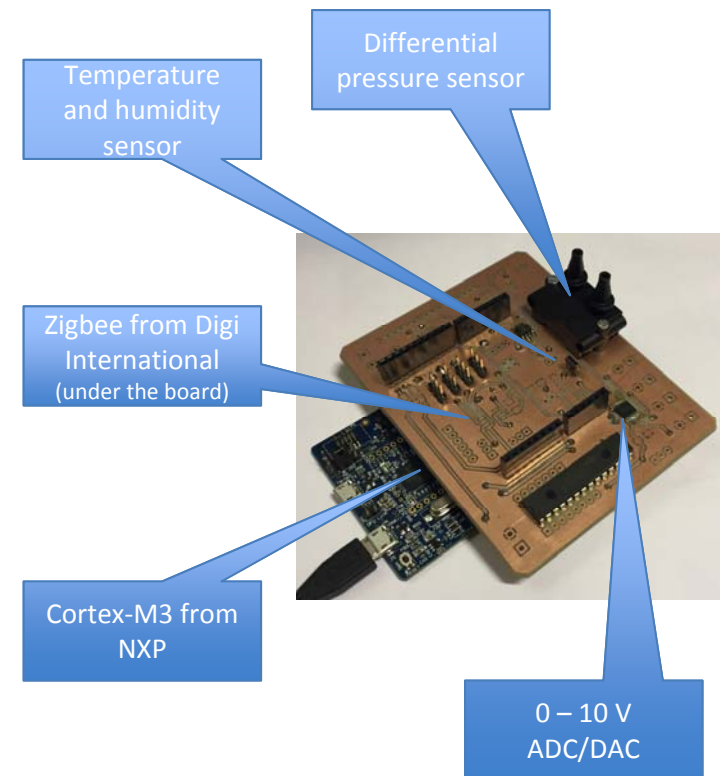
The sensor network

- Sensors can easily be deployed
    - Measurement tubes need to installed to measurement spots
- Most of the sensors can be battery powered
    - Measuring interval can be relatively long (minutes) so the devices will spend most of their time in a sleep mode
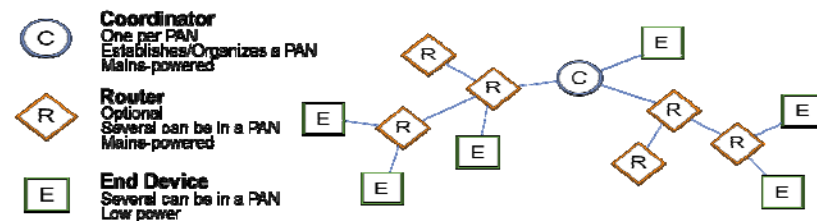
Prototype of the sensor

- Pressure measurement and other ambient conditions
- Can also be used to control the ventilation fans or any device with (0-10V control)
- Can intercept 0-10V control signals and do fine tuning of control signal on the fly

Temperature and humidity sensor

Differential pressure sensor

Zigbee from Digi International (under the board)

Cortex-M3 from NXP

0 – 10 V ADC/DAC

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The future

- First prototypes to be installed into a ventilation/heat recovery unit in Metropolia HVAC laboratory in Leppävaara on the week after AMIES-2016
- Software bugs are very likely to be found
- Hopefully no major HW/PCB issues

THANK YOU!

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