Renovation of room system control – a step towards smart buildings

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A service platform for smart buildings is demonstrated in seven meeting rooms of an educational building. This concept is easy to utilize in retrofit of existing buildings. The main benefits of the system are: improved monitoring of the system performance, guaranteed indoor climate conditions and higher users' perception on the indoor climate.

Keywords: Service platform, smart buildings, IoT, field demonstration

Demand for improved smartness

Smart buildings refer to the capability of a building to sense, interpret, communicate and respond to changing conditions, which are introduced by requirements of occupants to indoor climate, operation of technical building systems and demands of intelligent energy systems. Possibility to adapt in response to the perception of the occupants and further empower end-users makes possible to enhance users' satisfaction to indoor climate.

Merged together with smart energy systems, building technical system should be able to adapt its operation to the needs of the occupant and the energy systems and to improve its energy efficiency and overall performance. Technical solutions are then able to optimize dynamic energy prices in the part of demand response control and thus enhance the flexibility of energy systems.

Readiness to facilitate maintenance and efficient operation of technical building systems guarantee optimal performance of systems. In smart buildings, this should happen in cost and environmentally efficient way by adapting in response to the smart energy grid. All this requires paradigm shift in commercial buildings where passive users are amended to be prosumers (Kosonen et al. 2018).

Recently, it has realized that the actual system performance is not as designed in many buildings. There are lot of technical faults in HVAC- systems like unbalanced air flow rates, wrong set points, stuck actuators, dirty measurement devices etc. Some of those faults can be avoided with proper monitoring of building management system. Still, it should be noted that some of faults are not possible to note easily with the standard building automation measurements. In those cases, continuous time retro-commissioning process should be implemented.

In the existing building stock, it is quite well-known fact that standard building systems are not able to give high users' satisfaction on indoor climate. It is quite typical that users' dissatisfaction on indoor air quality and thermal comfort is 30% in A- class commercial buildings. This indicates a need for both systematic facility management process and also the development of more sophisticated systems that make possible to control user's local micro-environment (Kosonen et al. 2019).

The current norm of having comfort conditioning systems that are designed for an average person, where the thermal comfort and indoor air quality conditions of individuals are deemed to be impossible to fulfil, are changing fast. The development of more advanced smart systems should be, and are being, introduced to improve indoor climate conditions for all the occupants of a space, not just the mythical average man.

Retrofit solution for room where occupancy vary

In meeting rooms of educational buildings, water radiator heating system with thermostats and variable air volume systems are commonly used in Nordic countries. **Figure 1** shows a typical heating and ventilation system in Nordic. Water radiators are equipped with thermostats that are able to prevent the premises from overheating. Still, the set point of the water radiator is not possible to control accurately with mechanical thermostats. In practice, this means that ventilation cooling and heating setpoints overlap each other in many cases. This can create indoor climate problem and lead to unnecessary high energy consumption.

In the demand-based ventilation system, the air flow rate control is typically based on occupancy sensor, room air temperature and CO_2-level that boost ventilation if the spaces are occupied. The control of ventilation system is centralized and users are not able to control their indoor air quality.

There is urgent need to develop the controllability of the aforementioned system. The performance of the whole system should be improved so that overlapping of heating and ventilation systems is not possible. Also, the users should be able to control their own micro-environment conditions.

In the part of the cutting-edge solution, the water radiators are equipped with IoT thermostats that makes possible to control room air temperature accurately. The set point of heating system could be adjusted based on user's perception and/or dynamic energy price. Typically, the performance of ventilation is controlled only by building management system. In a service platform, information of building management systems is merged together with separate IoT based controls and measurements into a cloud server. (**Figure 2**).

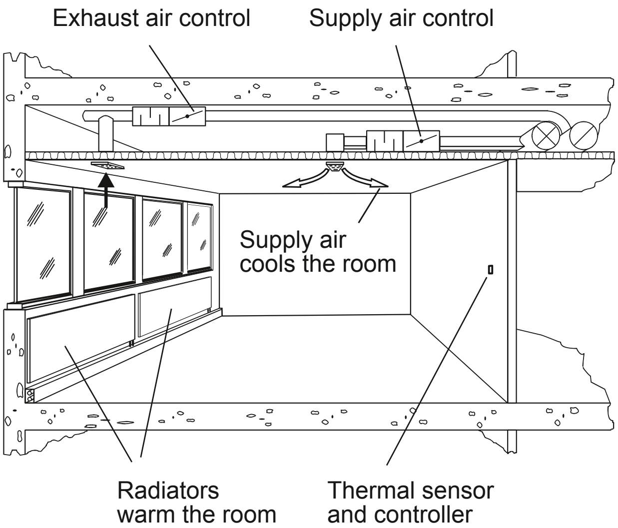

Figure 1. A typical heating and ventilation concept in Nordic.

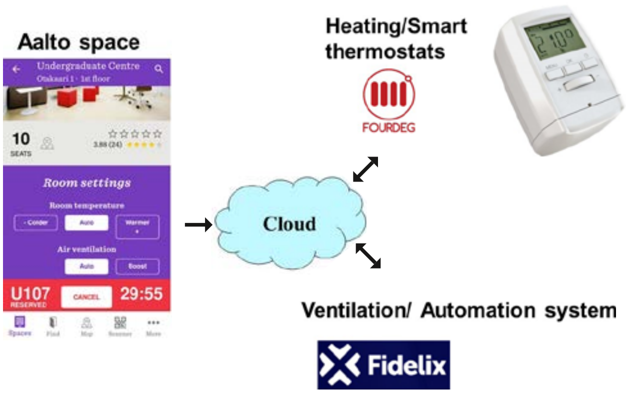

Figure 2. A retrofitting concept of heating and ventilation system where users are able to control indoor condition with apps.

The previous service platform was demonstrated in seven meeting rooms of an educational building at Aalto University campus. In this concept, users are able to control their own room air temperature and if they wish, boost ventilation with the Indoor Climate Service of the Aalto Space Campus Application. Based on their perception, the room air temperature is possible to change ±2°C with the app. It's possible to boost ventilation to the maximum air flow rate from the normal occupancy mode.

As a separate service, the performance of VAV could be monitored with separated IoT sensors by measuring pressure difference over building envelope that indicates the possible unbalance of supply and exhaust air flow rates.

The implemented service platform enables also the collection of the feedback of actual comfort perceived

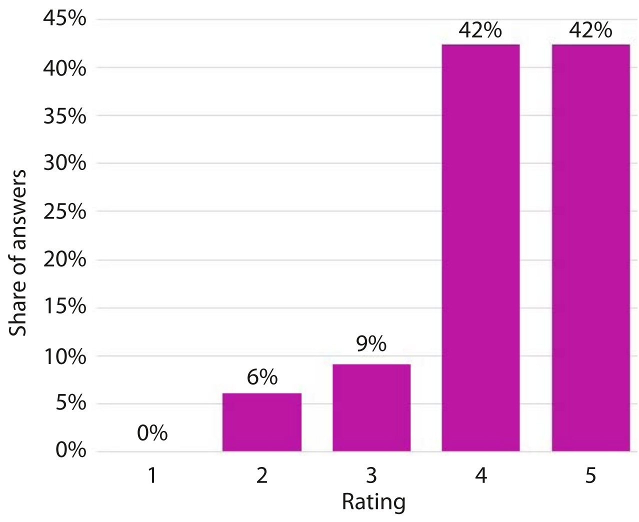

Figure 3. The feedback of users' satisfaction on indoor climate.

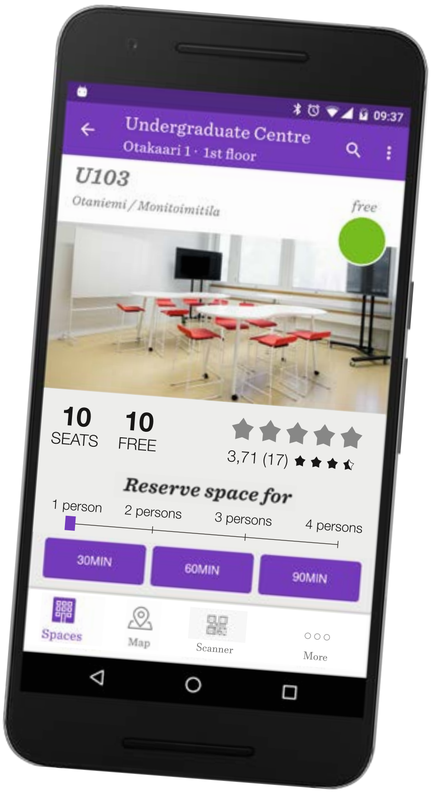

Figure 4. The interface of the Aalto Space Indoor Climate Service.

by the occupants on the indoor conditions together with physical parameters measured in spaces (**Figure 3**). Based on the conducted study, the general perception of users on indoor climate was quite good. More than 80% of the users ranged condition on the level of 4 or 5. This can be considered as a good result because it is quite difficult to reach over 80% satisfaction in a field study.

In the service platform, the core is the space reservation interface (**Figure 4**). It integrates smart campus IT infrastructure with the building automation services. It is important to note, that building services engineering is not a separate small islet, but it is integrated seamlessly together with the building real estate business platform. For the future smart buildings, it is not anymore enough to integrate just only building technical systems: building services should be integrated with a business platform.

Conclusions

Smart buildings refer to the capability of a building to sense, interpret, communicate and respond to changing conditions. Smart buildings should also give a platform to integrate building technical systems with real estate core processes. That makes possible to make buildings capable to sense, interpret, communicate and respond to changing conditions. The carried out demonstration study indicate that it is possible to enhance service level of old buildings by introducing a cloud integrated platform. When users are able to control their own set points for room air temperature and indoor air quality, the satisfaction on indoor climate conditions increased significantly. ■

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