Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Technik & Architektur
Institut für Gebäudetechnik
und Energie

Do-it-yourself, low-cost building monitoring system

Olivier Steiger, Reto Marek
Lucerne University of Applied Sciences and Arts, Technikumstrasse 21, CH-6048 Horw
Institute of Building Technology and Energy IGE

Summary

Monitoring systems are essential for the energy-efficient and comfortable operation of buildings. However, today's monitoring solutions are relatively expensive in terms of purchase, installation, and maintenance. At the same time, there is a need for low-cost monitoring systems, especially for smaller buildings.

To address this need, a novel do-it-yourself, low-cost building monitoring system based on open technologies has been developed. The system is intended to be assembled and put into operation by laymen in accordance with given instructions. Accordingly, all work stages must be simple and obvious.

System architecture

The architecture of the low-cost building monitoring system is depicted in Figure 1.

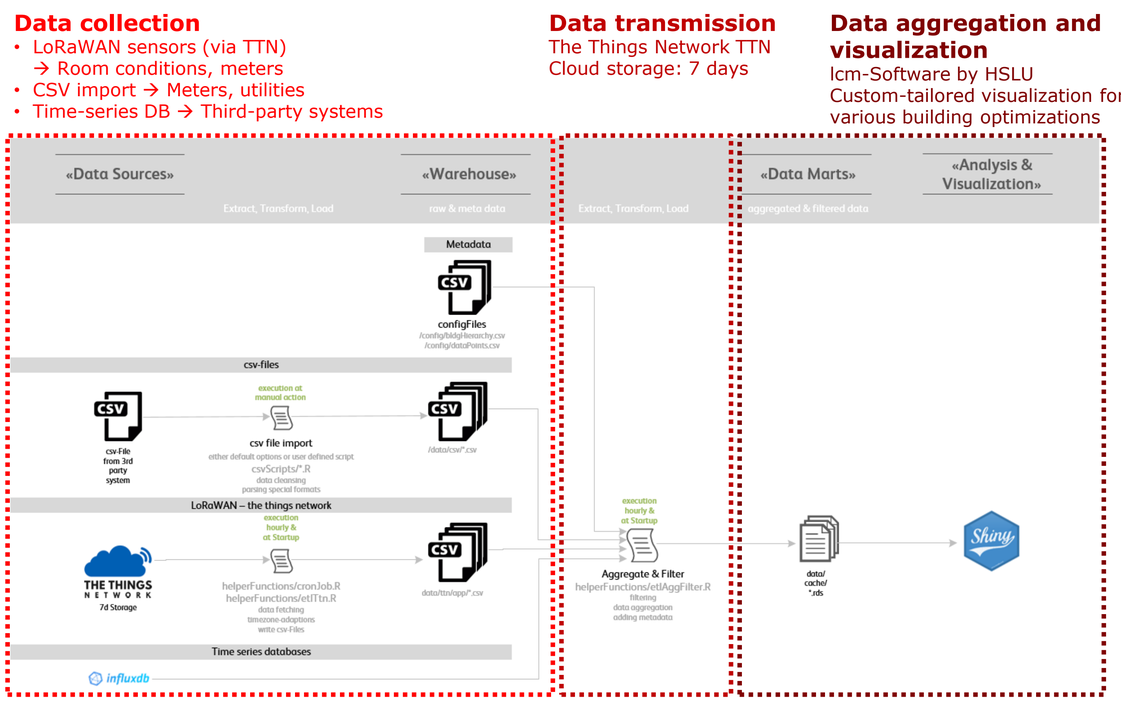

Figure 1. Architecture of the low-cost building monitoring system. The monitoring data stem from three different sources: (i) LoRaWAN sensors; (ii) CSV import; (iii) Time-series database. Data from LoRaWAN sensors are transmitted over The Things Network and stored on the TTN-cloud for max. 7 days. All data are aggregated and visualized using the custom-made "lcm"-software.

Measuring devices

In the present prototype implementation of the low-cost monitoring system, the following measuring devices are supported. These are used "as is", i.e., without any further calibration.

Avelon – Wisely Standard
→ Room temperature, humidity

Avelon – Wisely Carbonsense
→ Room temperature, humidity, air quality (CO_2-concentration)

Dragino – LHT65
→ Outdoor temperature, flow temperature of central heating system

nke WATTECO – Flash'O
→ Readout of legacy meters

Monitoring software

The custom-made monitoring software "lcm" consists of several data evaluation modules and configuration functions. Each module carries out a different evaluation of the monitoring data. I.e., each module is dedicated to different applications or optimization measures. An overview of all available modules is provided in Table 1.

Module	Purpose	Visualizations	Required measurements
Room > Temp vs. Hum	Comfort analysis regarding humidity and temperature (overheating, mold problems, dry air in winter)	-Humidity vs. room temperature -Mollier-h,x-Diagram	-Room temperature -Relative humidity
Room > Room vs. Outside Temp	Reduction of overheating hours	-Room- vs. outdoor temperature	-Room temperature -Outdoor temperature
Room > Air Quality	Comfort analysis regarding indoor air quality (often problematic in bedrooms)	-CO_2 vs. time -Lower and upper quantile	-Room air quality (CO_2)
Room > Temp Reduction	Reduction of heating energy by lowering the room temperature	-Room temperature vs. time -Mean value, setpoint, deviation	-Room temperature
Flat > Electricity	Analysis and reduction of electricity consumption Analysis and reduction of standby consumption	-Daily consumption vs. time -Standby consumption	-Electricity consumption flat
Flat > Heating	Analysis and optimization of heating energy consumption	-Heating energy per year/month	-Heating consumption flat
Flat > Hot Water	Analysis and optimization of hot water consumption	-Hot water consumption per year/month	-Hot water consumption flat
Central > Heating Signature	Analysis of the heating signature Determination of the actual heating limit	-Heating signature (actual)	-Energy consumption central heating -Outdoor temperature
Central > Heating Curve	Analysis and optimization of the heating curve	-Heating curve (actual)	-Flow temperature central heating -Energy consumption central heating -Outdoor temperature

Table 1. Overview of the data evaluation modules of the monitoring software "lcm".

Results

The low-cost monitoring system has been tested with anonymized data from an apartment house. The building is located in central Switzerland and comprises four flats. Each flat is inhabited by a family. The test data correspond to a measurement period of two years. An exemplary screenshot of the GUI is depicted in Figure 2.

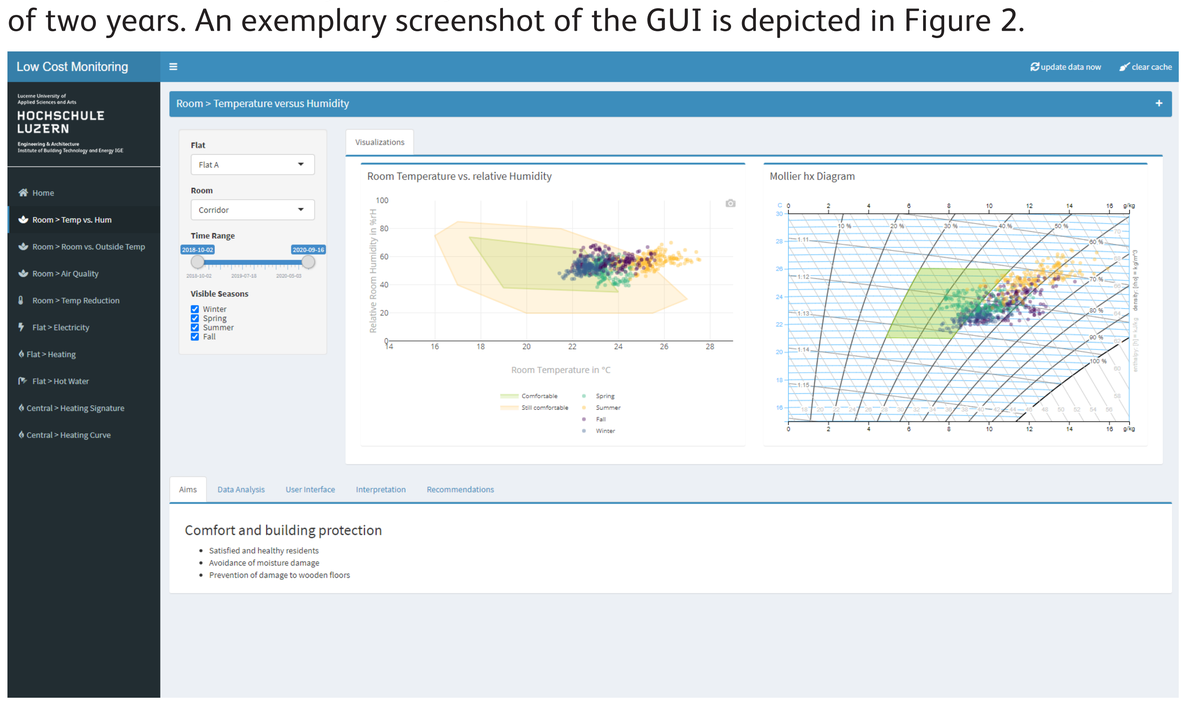

Figure 2. Screenshot of the monitoring software "lcm". The screenshot shows monitoring data from a single flat. These are visualized using the data evaluation module "Room > Temp vs. Hum". In the main display, data are represented in two diagrams: room temperature vs. relative humidity (left); Mollier-h,x-diagram (right). The comfort zone is depicted as green area.

Outlook

The following steps are planned next:
- Validation with a larger number of buildings
- Elimination of software bugs
- Improvement of documentation and support
- Implementation of additional data evaluation modules
- Generation of case-specific optimization recommendations

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LIVE DEMO

https://hslu-ige-laes.shinyapps.io/lowcostmonitoring/