Lucerne University of Applied Sciences and Arts

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

energieschweiz

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 lowcost 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.

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	-Humidity vs. room temperature	-Room temperature

System architecture

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

ta collectio DRaWAN sensor PRoom conditio SV import → Me ime-series DB →	n rs (via TTN) ons, meters eters, utilities → Third-party systems		Data transmise The Things Network Cloud storage: 7 da	sion Da TTN vis ys Icm Cus var	ta aggregation and sualization -Software by HSLU stom-tailored visualization ious building optimization
«Data Sources»		«Warehouse»		«Data Marts»	«Analysis & Visualization»
			Extract, Transform, Load	aggregated & filtered dat	
	csv-files	configFiles /config/bldgHierarchy.csv /config/dataPoints.csv			
csv-File from 3rd party system	execution at manual action	/data/csv/*,csv			
	LoRaWAN – the things network		execution hourly &		
THE THINGS	execution hourly & at Startup > helperFunctions/cronJob.R helperFunctions/etITtn.R	data/ttn/app/*.csv	Aggregate & Filter helperFunctions/etlAggFilter.R	data/ cache/ *.rds	Shiny

	(overheating, mold problems, dry air in winter)	-Mollier-h,x-Diagram	-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	-CO ₂ vs. time	-Room air quality (CO_2)
	(often problematic in bedrooms)	-Lower and upper quantile	
Room > Temp Reduction	Reduction of heating energy by lowering the room	-Room temperature vs. time	-Room temperature
	temperature	-Mean value, setpoint, deviation	
Flat > Electricity	Analysis and reduction of electricity consumption	-Daily consumption vs. time	-Electricity consumption flat
	Analysis and reduction of standby consumption	-Standby consumption	
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	-Heating signature (actual)	-Energy consumption central heating
	Determination of the actual heating limit		-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.

Low Cost Monitoring	=		🔂 update data now 🛛 💉 clear cache
Lucerne University of Applied Sciences and Arts HOCHSCHULE	Room > Temperature versus Humidit	y	+
LUZERN Engineering & Architecture Institute of Building Technology and Energy IGE	Flat	Visualizations	
🛠 Home	Flat A Room	Room Temperature vs. relative Humidity	Mollier hx Diagram
🕹 Room > Temp vs. Hum	Corridor	T. 80	C 0 2 4 6 8 10 12 14 16 g/kg 30 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
🕹 Room > Room vs. Outside Temp	Time Range 2018-10-02 2020-09-16	Ai Aibi e 60	
🕹 Room > Air Quality	2018-10-02 2019-07-18 2020-05-03	Р Н 40	26 1:12 70 % 60 Figure 1
Room > Temp Reduction	Visible Seasons	20 gg	24 1:13 80 % 64
Flat > Electricity	✓ Sping ✓ Summer ✓ Fall		22 - 90 % 82 - [4]
♦ Flat > Heating		Room Temperature in °C	20 1.14 100 % e0
🎓 Flat > Hot Water		Comfortable • Spring	18 1:15 58
Central > Heating Signature		Still comfortable Summer Fall Winter	16 18 20 22 24 28 30 32 34 38 38 40 42 44 48 48 50 52 54 58 0 2 4 6 8 10 12 14 18 g/kg
	Aims Data Analysis User Interface	Interpretation Recommendations	
	Comfort and building prot Satisfied and healthy residents Avoidance of moisture damage Prevention of damage to wooden floor 	s	



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.



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



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

Avelon – Wisely Standard \rightarrow Room temperature, humidity

Avelon – Wisely Carbonsense \rightarrow Room temperature, humidity, air quality (CO₂-concentration)



nke WATTECO – Flash 'O \rightarrow Readout of legacy meters

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/

