# Smart Home goes Public

## Applied research on the Usage of openHAB in a University Building

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FORSCHUNG AN FACHHOCHSCHULEN

HFT Stuttgart
i_city

VDI Technologiezentrum

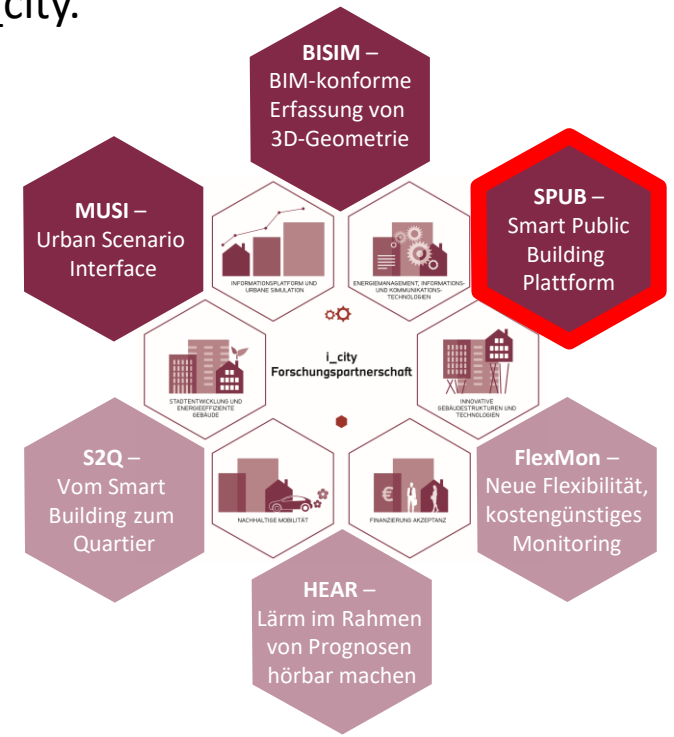
# Research joint venture „i_city“ at the HFT

## Innovative concepts for the Stuttgart metropolitan region

**Six cross-linked fields of action:** urban planning, architecture, IT, energy, mobility and finance.

**Aim:** Developing blueprints (methods, services, and products) for a sustainable urban development for both, districts and buildings, and transferring them into praxis.

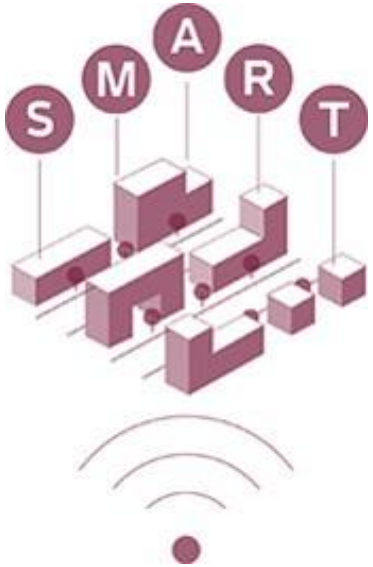
**Smart Public Building** is one of three explorative projects of i_city.

# Overview Smart Public Building

Background, motivation – and what about the „explorative“?

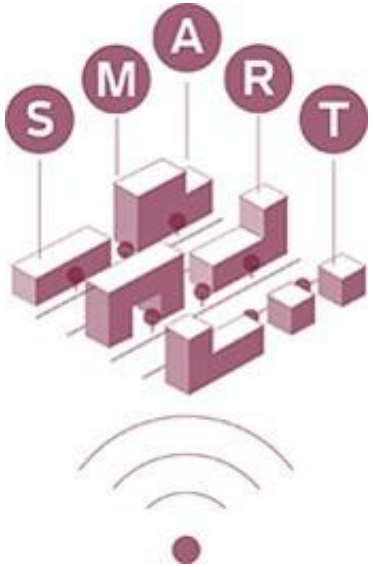
- **Why?**
  - Sustainable and energy-efficient use of public buildings
  - Improve room utilization and comfort
  - Better public services
- **How?**
  - Apply devices and technologies from the Smart Home
  - Develop use cases based on Open Source (openHAB)
- **Explorative project SPB:**
  - Prototypical implementation at the university campus
  - Focal point: users and occupants, not vendors
  - Participation of user groups, e.g. students, technical staff etc.



# Overview Smart Public Building

## Research questions

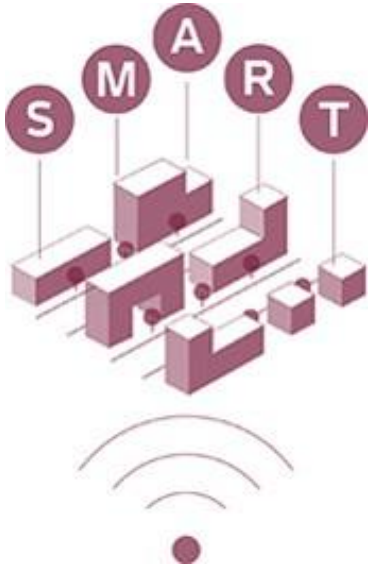
1. What are the **requirements** of smart public buildings regarding smart systems and technologies?
2. Which **technologies** in the field of smart homes are suitable for smart public buildings?
3. What **opportunities** do public buildings provide for the application of smart technologies?
4. How to deal with **data privacy** in the public sector?



# Overview Smart Public Building

Current state of the project

- **Requirements analysis** and classification of public buildings
- Survey of public institutions in the Stuttgart region
- **Basic installation** of server, clients and further infrastructure
- **Proof of Concepts, e.g.:**
  - Location Based Services (LBS)
  - Integration of social sensors
  - **Smart Lecture Rooms**
  - **Smart Metering (water, electricity, heating)**
  - Web based 2D/3D visualization of sensors
  - **Management of distributed openHAB systems**



# Requirements analysis

## Differences between private homes and public buildings

In general, a **public building** is understood to be open to the public. The term *public* also implies that it is financed by taxes, and that its purpose is to serve the public in some way. (cf. Van Baren, 2017)

According to **DIN 18040-1** (2010) the following types of buildings can be grouped as public buildings:

*„Cultural and educational institutions, sports and recreational facilities, health care facilities, office, administrative and courthouse buildings, shops and restaurants, parking lots, garages and toilets“*

| | Private homes | Public buildings |
|---|---|---|
| **Accessibility** | private | public |
| **Assembly** | few (residents) | numerous people |
| **Usage** | living | leisure, education, culture, sports, administration ... |
| **Visitors/users** | same | changing |
| **Control** | no / less | video monitoring |
| **Usage rules** | no / house rules | public policies and regulations |
| **Area in sqm** | 96,1 [1] | app. 900 [2] |
| **Number of users** | 2,1 per household [1] | app. 300 per day [1] |

[1] Average in Baden-Wuerttemberg (Statista, 2015)
[2] Average in Stuttgart (survey among public institutions, cf. N. Fiedler, 2017)

Table: Nicola Fiedler

# Requirements analysis

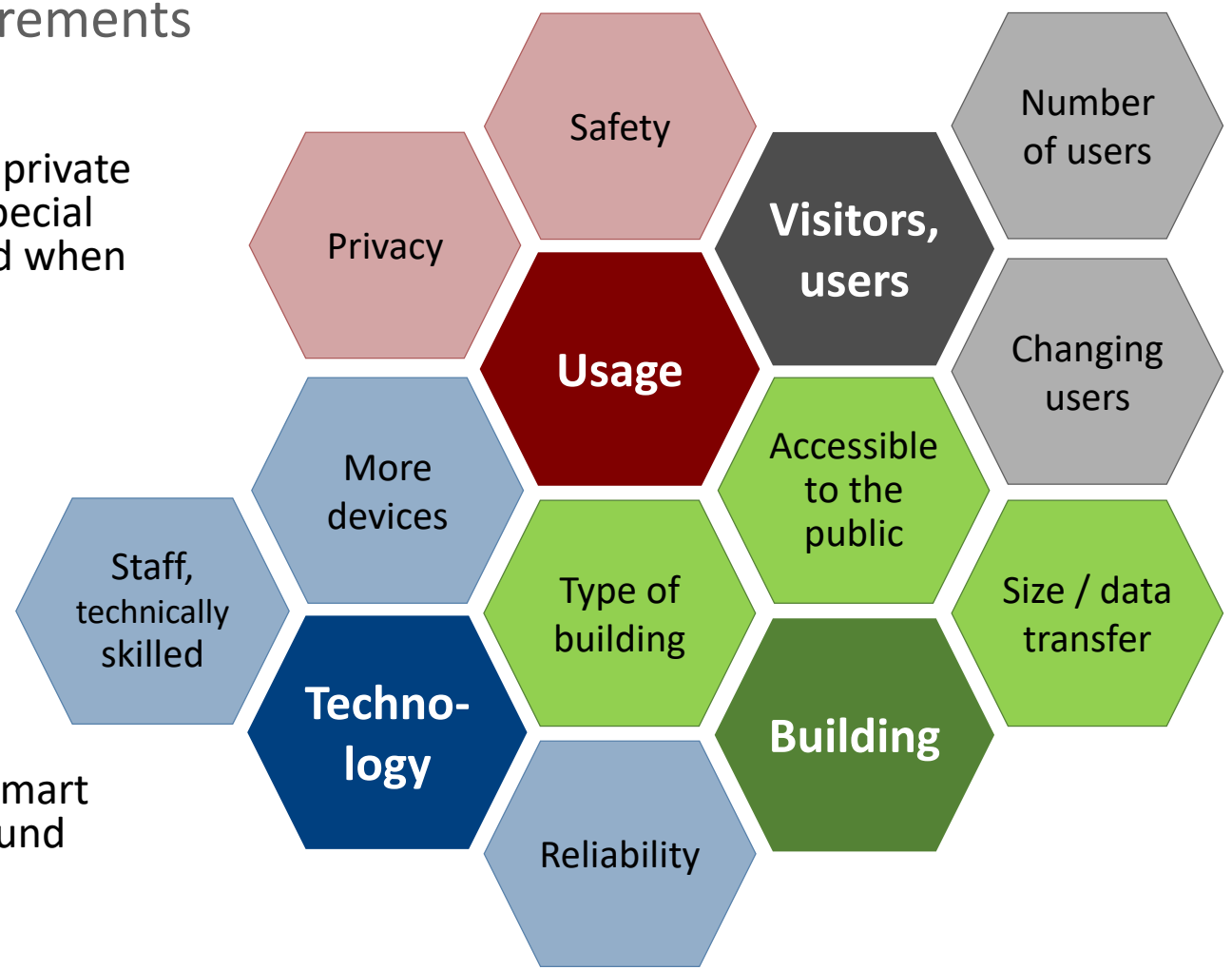
## Public buildings and their requirements

Resulting from the differences between private homes and public buildings, there are special requirements, that have to be addressed when using smart home applications in public institutions.

They are related to the following areas:

- **Building**
- **Usage**
- **Visitors, users**
- **Technology**

➢ Short report on public buildings and smart applications – „Öffentliche Gebäude und smarte Anwendungen“ – in GitLab: https://t1p.de/wbix




Requirements of public buildings regarding smart systems (Nicola Fiedler)

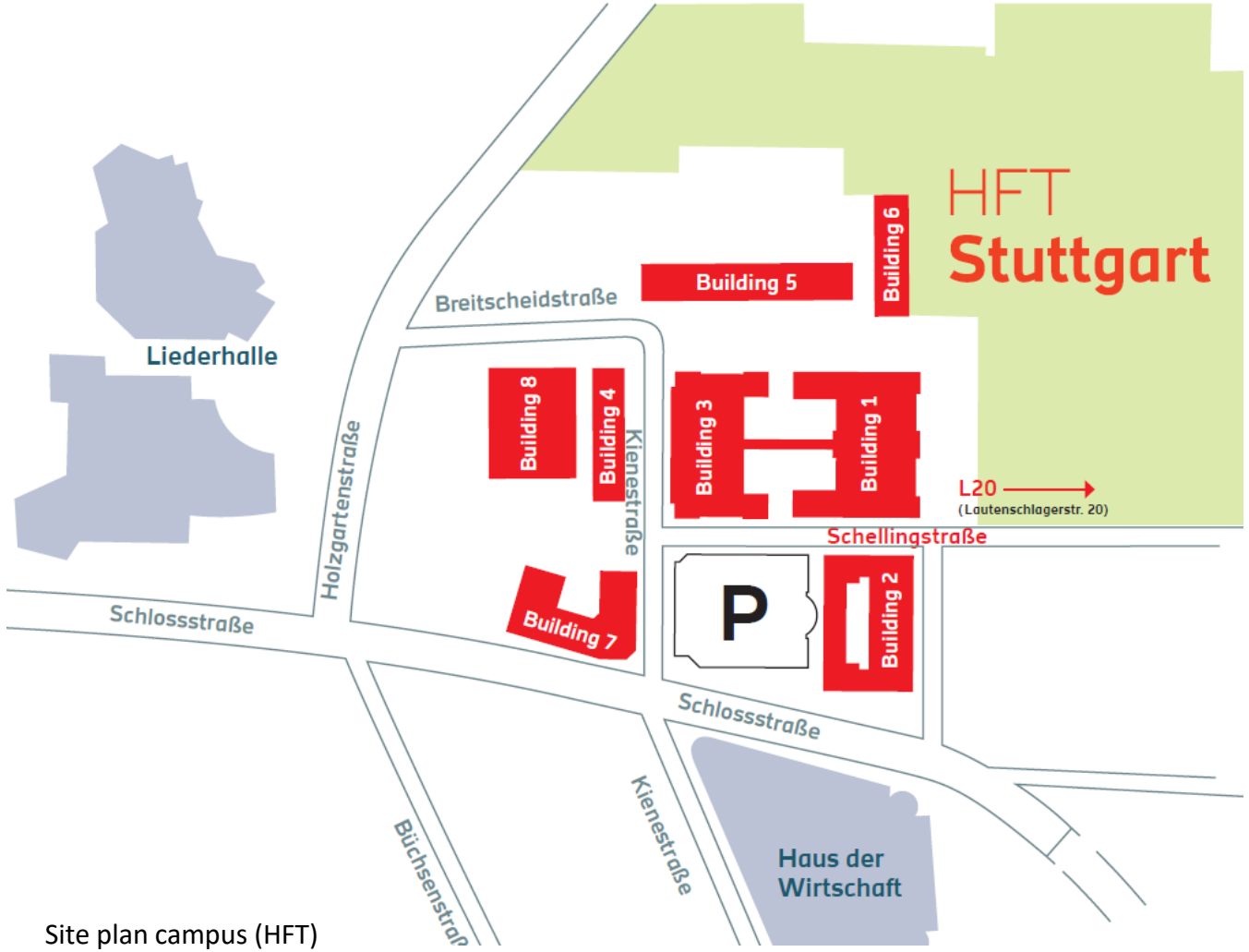
# The HFT as a Smart Public Building

## Buildings, usage and users

**Campus (city):**
- 8 buildings from different years of construction, shared buildings
- courtyard, parking lots, pavilion

**Usage:**
- assembly rooms, lecture rooms, offices, library, workshops, laboratories, cafeteria …

**Users:**
- students, staff (teaching, administrative, technical etc.), professors, researchers, guests, visitors …




Site plan campus (HFT)

# Why openHAB?

Using a smart home software for a Smart Public Building

**Why smart home?**

- **Availability** of systems and devices
- Affordable **retrofitting** of existing buildings (wireless)

**Why openHAB?**

- **Free and open source** software
- **Integration and management** of systems, devices, and services independently from vendors, technologies and protocols
- **Persistence** (MySQL, MongoDB, InfluxDB …)
- **Stability** (few major releases)
- **Modularity** through the development of bindings
- Active **community** (users as well as developers)
- **User interfaces, M2M interfaces** (RestAPI, MQTT)
- **Platform independent** (beginner-friendly)

# Basic installation: Overview

Current and future installations at the Campus

**At present:**

- **1 building** (rooms on **2 levels**)
- **1 openHAB server**, 2 test systems
- app. **60 sensors and actuators**
- **2 LoRa gateways** (TTN)
- **2 meters** (water, electricity)

**Future:**

- **1 building** (rooms on **4 levels**)
- **2 further buildings**
- **3 openHAB servers**
- app. **120 sensors and actuators**
- **4 LoRa gateways** (TTN)
- **3 meters** (at least)

University of Applied Sciences Stuttgart, building 2 (current installation)

# Basic installation: Overview

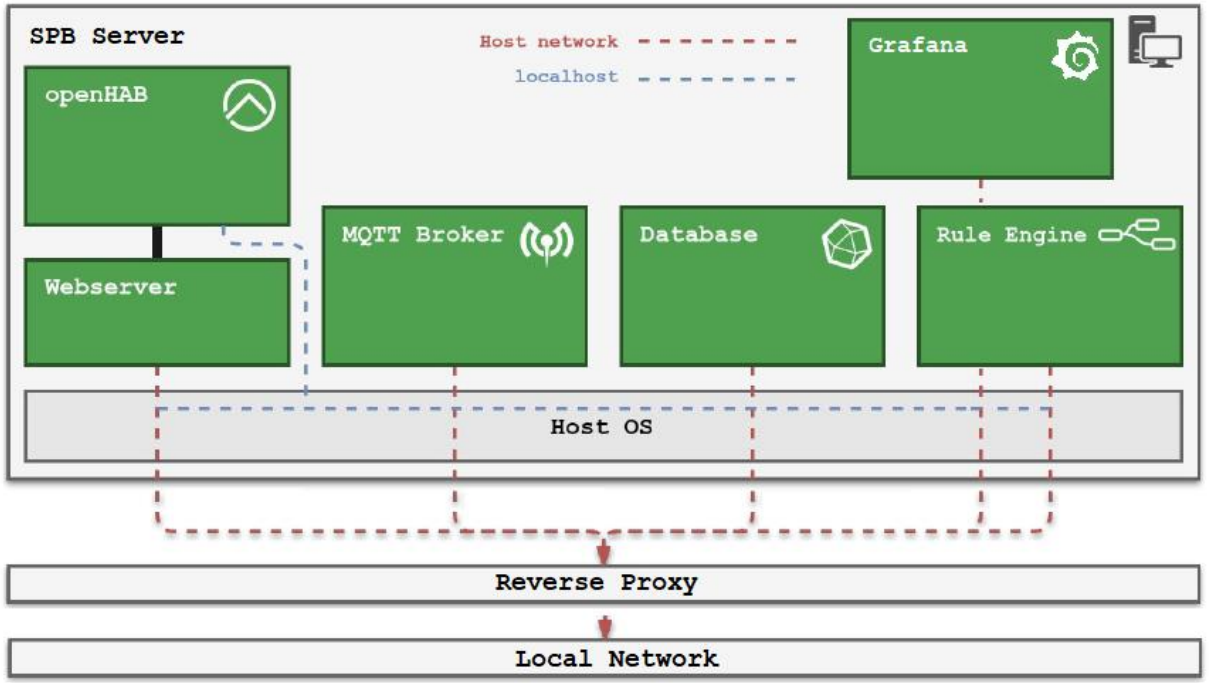
openHAB stack and services

**Automation:**
openHAB 2.4

**Databases:**
MySQL, MapDB

**Further services:**
Mosquitto, Grafana, NodeRED

**Reverse Proxy:**
Nginx




Smart Public Building, current server installation (based on A.Dobler)

# Proof of Concepts

## Seminars and theses (BA/MA) at HFT

### Bachelor (Information Logistics)

- Smart Public Building: requirements and potentials (Nicola Fiedler)
- Smart Lecture Room (Nikolai Noller)
- Location Based Services with Bluetooth beacons (Marius Böhm)
- Monitoring safety-relevant devices in public buildings (Jens Hilgert)
- Context and location aware visualization of sensor data (Andreas Jäkel)
- An intelligent charging station for e-bike sharing at HFT (Claudia Kieckeben)
- Reporting and managing damages in a building via smart phone (Markus Kulas)
- Social Sensors: collaborative votings on comfort (Benjamin Wohlfahrt)
- Automatic presence detection in lecture rooms (Kai Philipp Müller)
- Smart Metering at the HFT (Marius Scherff)

### Master (Photogrammetry, Software Technology)

- Adaption of openHAB for usage in public institutions with multiple buildings (Alexander Dobler)
- Evaluation and implementation of a web-based 2D/3D visualization (Marc Philipp Jensen)

### Current work (Information Logistics)

- Data security and privacy in Smart Public Buildings
- Reporting occupancy of parking lots in realtime

# Proof of Concept: Smart Lecture Room

## Improving energy efficiency, usability and room utilization

Part of the **basic installation:** sensors and actuators to monitor and adjust room conditions and devices in **lecture rooms** -> temperature, humidity, presence, lights, window status, power consumption.

**Extension:** $CO_2$ sensors (air quality), people metering (room utilization), wireless light switches …

- Rule based **automation**
- **Information** on room conditions
- Easy **control** of functions per room
- **Measurements** of energy savings

Basic installation: smart switches, thermostats, and multi-sensors in lecture rooms at HFT

# Proof of Concept: Smart Lecture Room

## Providing access to data and controls … but how?

Information and control via HABpanel in the browser or with the mobile app.

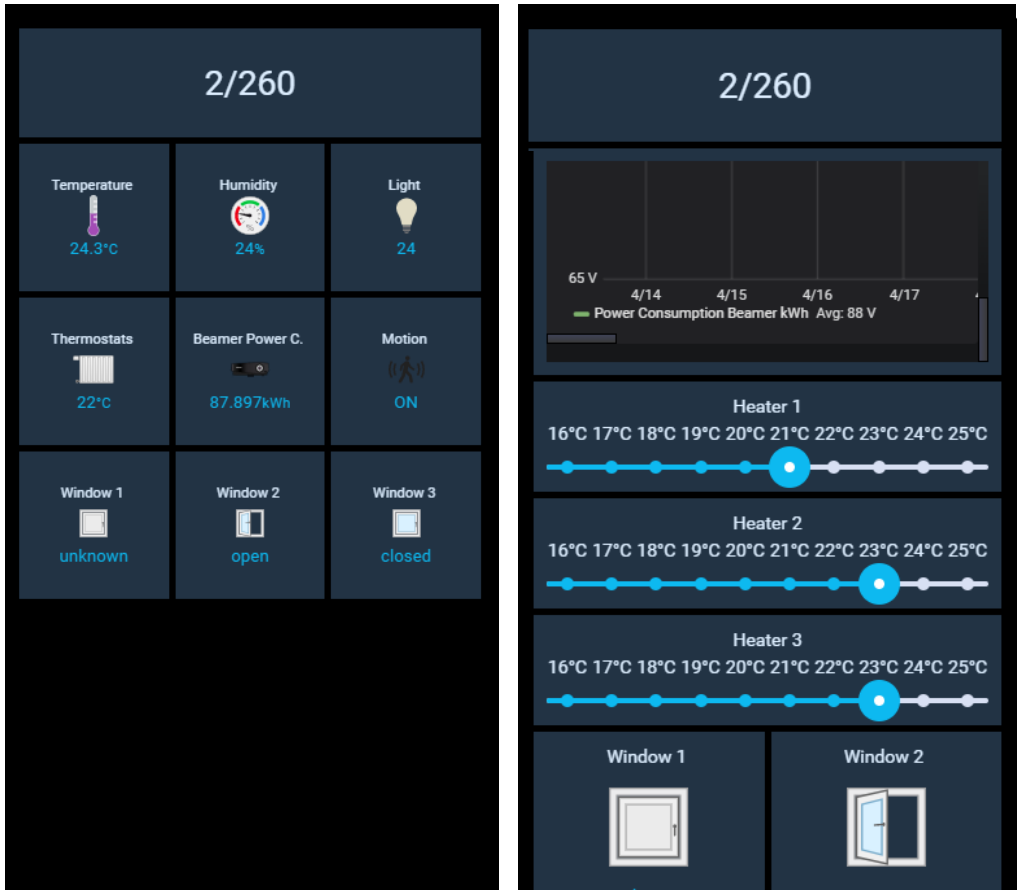
**Requirement Smart Public Building:**
**User authentication and authorization (groups)**

A simple example:

- Basic users, e.g. students (read)
- Privileged users, e.g. staff (control per room)
- Admins, e.g. technical staff (control, analyse)

openHAB is not designed to manage access for different user groups and authentication for a large number of users.

**At present:** secured with reverse proxy (basic auth), LDAP connection will be examined.




Different HABpanel dashboards for basic and privileged users (mobile view)

# Proof of Concept: Distributed systems

## Scaling the smart home to multiple buildings

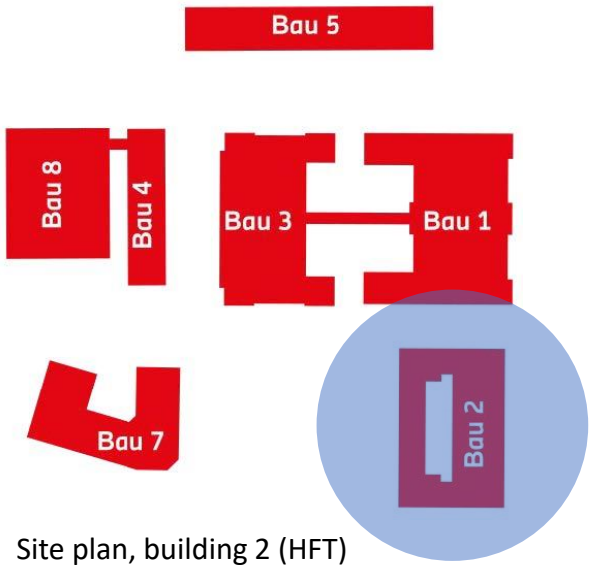
openHAB typically is running in private homes, implying smaller buildings or apartments.

**Requirement Smart Public Building:**
**Management of large / multiple buildings**

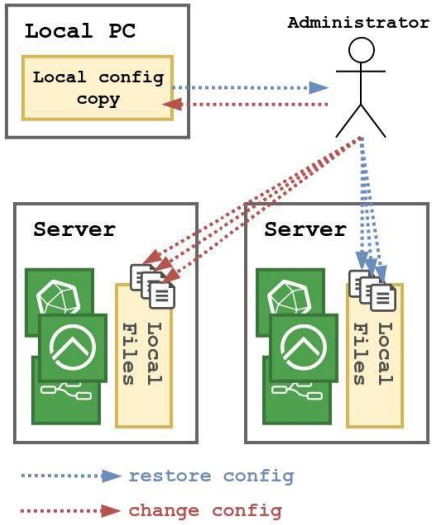
**HFT building 2:**

- 5 floors (offices, lecture and working rooms, computer center, library …)
- 2 basement levels (workshops, technical facilities, e.g. meters)
- ~ 7.000 sqm in total

➢ Limited range of wireless sensor networks
➢ One server: single point of failure




Site plan, building 2 (HFT)




Distributed systems (A. Dobler)

**Possible solution:**
Running multiple openHAB instances/sensor gateways.

➢ Tedious installation procedure and maintenance for each instance and its services, error prone.

# Proof of Concept: Distributed systems

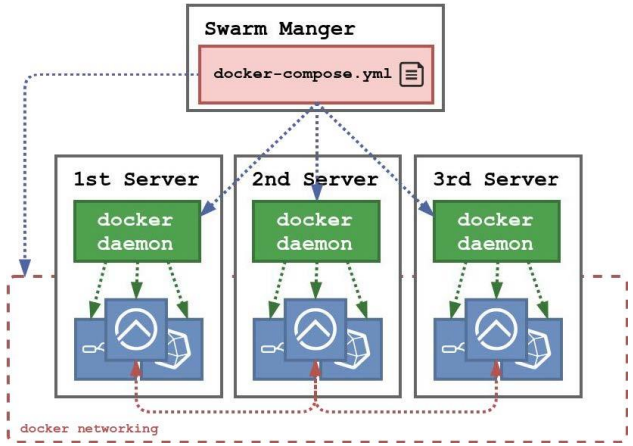
Maintenance of multiple openHAB instances via Docker and Docker Swarm

**Concept:**

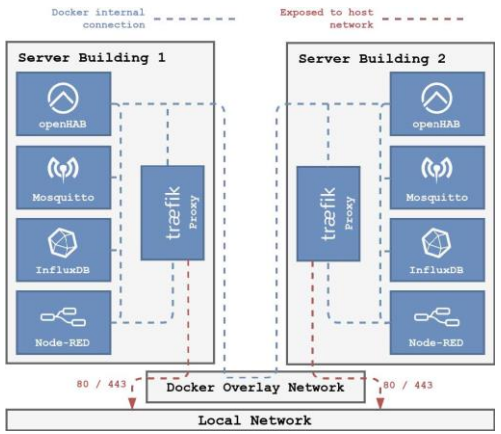
- Docker to capsule openHAB instances and further services
- Docker Swarm to manage the cluster
- Nodes (physical/virtual) can join and leave the swarm
- A “building manager” creates and controls the setup (not obligatory)

**Benefits:**

- No manual setup and installation
- Higher network security
- Backup and restore (Volumerize)
- Physical and virtual redundancy
- Machines can be easily exchanged




Deploying with containers (A.Dobler)




Secure networking (A.Dobler)

Github (moving to GitLab):
https://github.com/Dobli/openhab-pb-stack

# Proof of Concept: Smart Metering

## Smart water and electricity meters at HFT

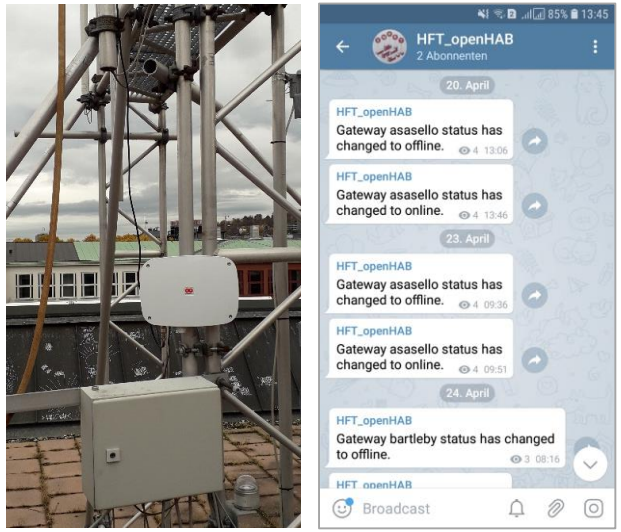
THE THINGS NETWORK REGION STUTTGART

### 1. Building the infrastructure for LoRa:

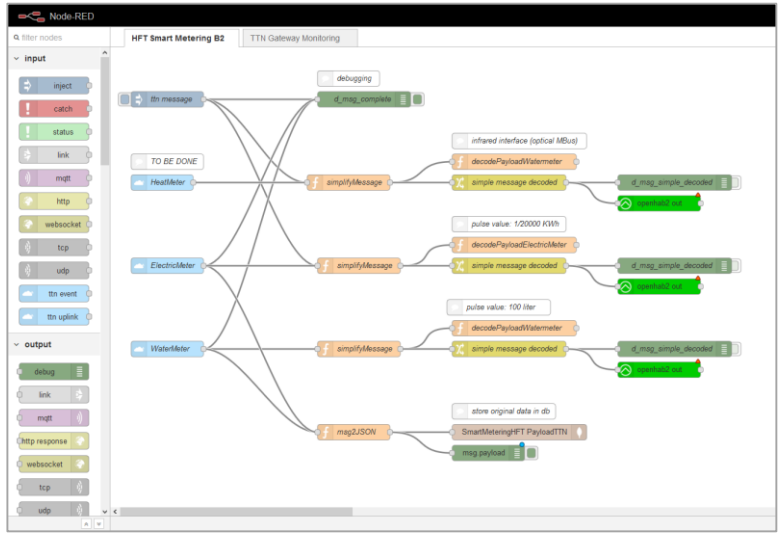
- Installing two LoRa gateways at campus
- Managing the fleet with Balena.io
- Telegram bot sends status to channel

### 2. Retrofitting the meters:

- Upgraded meters send data via LoRa to TTN
- TTN to openHAB uses MQTT and NodeRED
- ➢ Remote reading, consumption overview, data for EMAS (Eco-Management and Audit Scheme)




TTN gateway at rooftop, bot alerts via Telegram




Upgraded water and electricity meters in building 2, NodeRED flow from TTN to openHAB

# Proof of Concept: More LoRaWAN use cases

In progress: people flow metering in realtime, status of parking lots

**01**
Counting people with open source software: the **Paxcounter** detects Bluetooth and WiFi signals of mobile devices. Privacy: no MAC addresses are stored. New use cases **inside a building**, e.g. in working rooms and hallways.

**02**
Status of parking lots: The Bosch **parking lot sensor** detects, wether a (non-)parking area is occupied. Usage at the campus e.g. fire brigade zones, e-charging stations.


Paxcounter TTGO ESP32 (Sebastian Müller)

Above: Parking Lot Sensor (Raspi in comparison)
Below: visualization of 7 days occupation from a pilot project in Herrenberg (Jerg Theurer)

# Proof of Concept: Failures

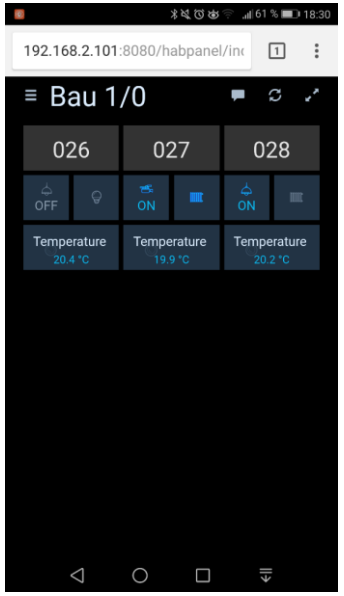
Things, that do no longer work or do not work as was hoped for

**Location based services with Bluetooth beacons:**
Providing users and visitors of a building **easy access to room data** when close to it … no longer possible without a mobile app (Android Nearby Notifications were rejected).

Alternatives: QR codes, Near-field communication (distance to device, familiarity), displays.

**Room occupancy:**
**Occupancy in lecture rooms** with silent working is not reliably detected via PIR, also no hint on the number of people in a room to analyse utilization.

Alternatives: Paxcounter (indirect, OSS, affordable), radar (sensitivity, price).


Above: LBS with Bluetooth beacons (M. Böhm)

Left: PIR sensor for occupancy detection (K. Müller)

# Outlook

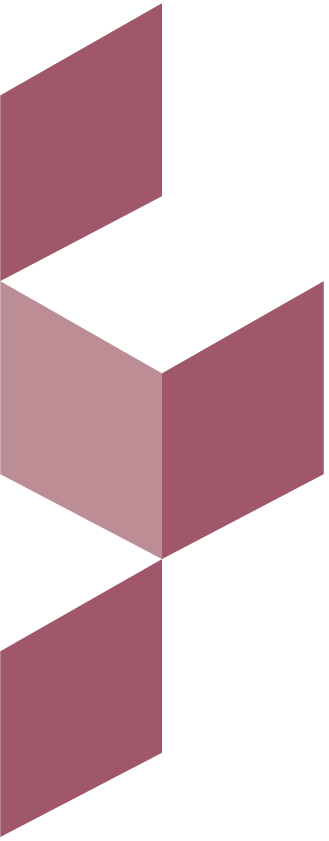
Next steps in the Smart Public Building

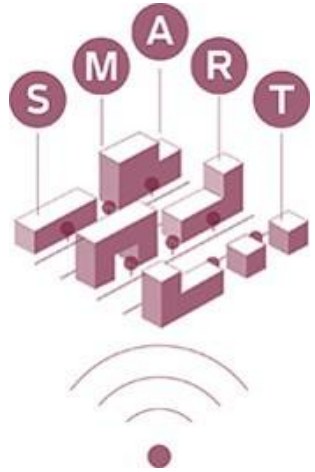
- **Extension** of the basic installation:
  - devices, buildings, technologies
  - definition of rules for automation
- **Measurements** of energy consumption
- **User management** (roles, permissions)
- Exploring **further applications** of smart (home) technologies in public buildings
- **Proof of Concepts** implementation
- Further **seminars and BA/MA theses**
- Develop **teaching material** (DigiLab4U)

# Upcoming events

Workshops and events related to SPB and openHAB

- **openHAB workshops** (starting autumn 2019)
  - e.g. at the i_city hackathon in November
- **LoRaWAN hackathon** at the HFT Stuttgart (April 2020)
- **Academic conference Smart Public Building** (autumn 2020)
  - Proceedings SPB 2018 (Open Access): https://t1p.de/o2r5





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Smart Public Building in GitLab (public):
https://t1p.de/7k05
https://transfer.hft-stuttgart.de/gitlab