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Leverage from the EU 2014–2020
European Union
European Regional Development Fund

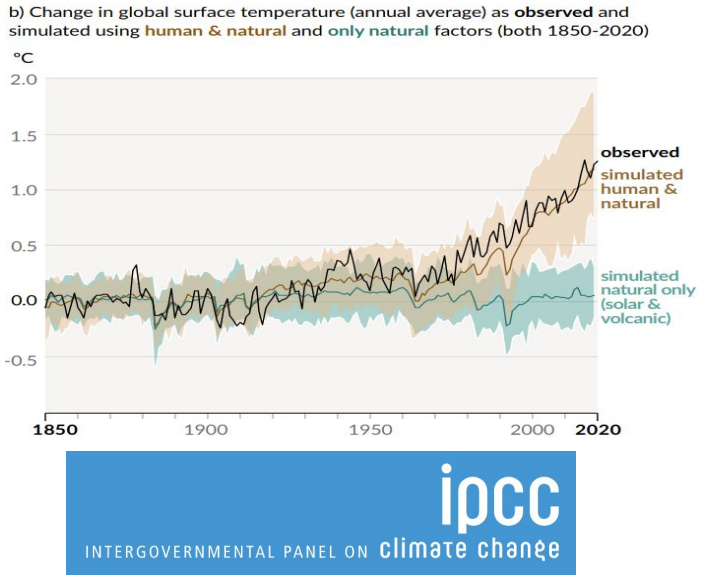
The Requirements and Challenges of Visualizing Building Data

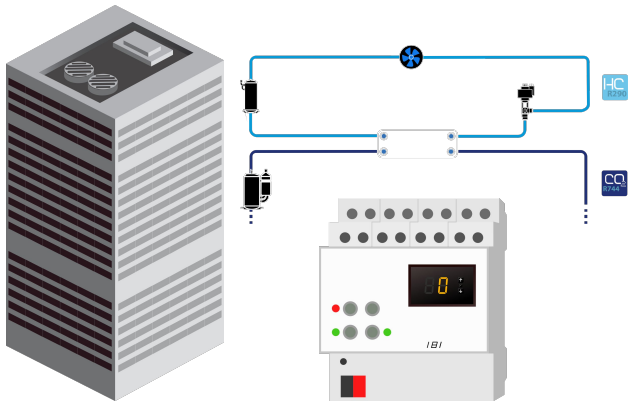
Mikko Nurminen, Antero Lindstedt, Mika Saari, Petri Rantanen
Tampere University, Information Technology and Communication Sciences (Pori), Finland

MIPRO 2021, September 27 - October 1, 2021

Motivation: saving energy with visualizations?

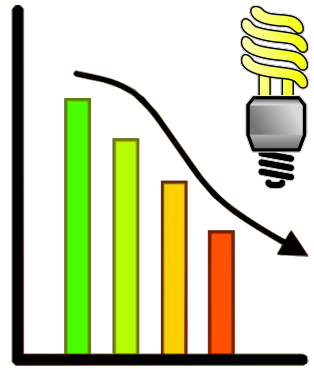
- Global warming and risks it poses are linked to energy production
- Building systems cause significant in energy consumption, including heating and cooling
- One way of reducing buildings-related energy consumption is increasing users awareness of their energy consumption
- Using visualizations to reveal to users how much energy is used, and by which systems in buildings, is a important trend in energy consumption research





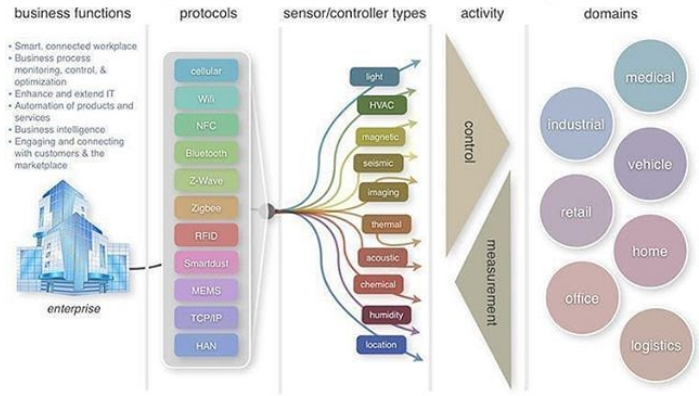
Awareness aspect of energy consumption

- In our previous survey of applications for apartment energy consumption monitoring several studies showed that increased level of awareness of energy consumption led to efforts to save energy
- In a study comfortable living conditions meant warm buildings
  - but this comfort could be reached with actions that were not energy intensive
  - greatest motivator for saving energy was saving money



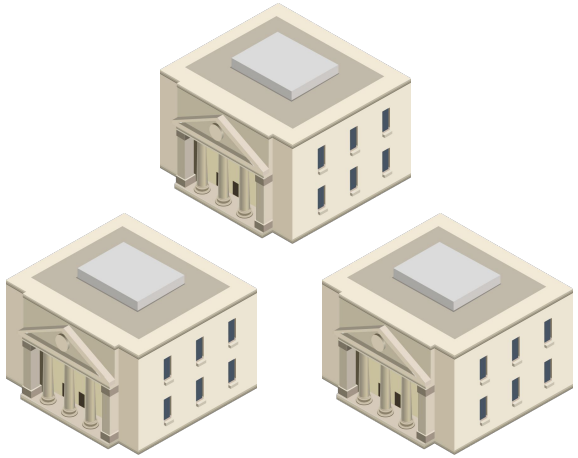
Building data is Big Data

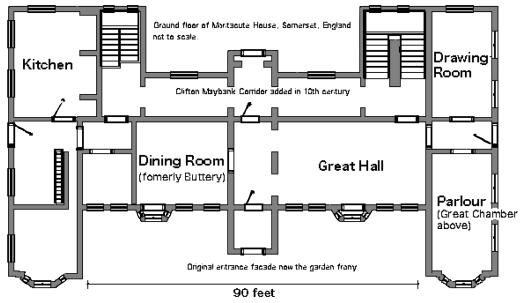
- We defined building data as any data which is measured or calculated by building systems and/or sensors and which can be gathered by DataSites service
- Building data is typical Big Data in terms of its velocity, volume, and variety
  - Variety: data from different systems is heterogenous: varied data formats, units of measurement, frequency of sending data. Also
  - Veracity: building systems and sensors are modified and even replaced during the lifetime of a building
  - Volume and velocity: building systems, sensors, and IoT systems create voluminous amounts of data
- System which creates the visualizations must be able to handle Big Data

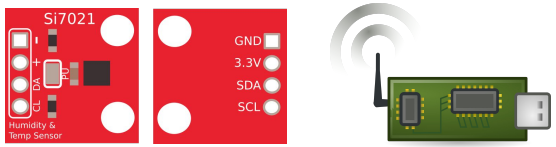


Requirements for visualizing building data

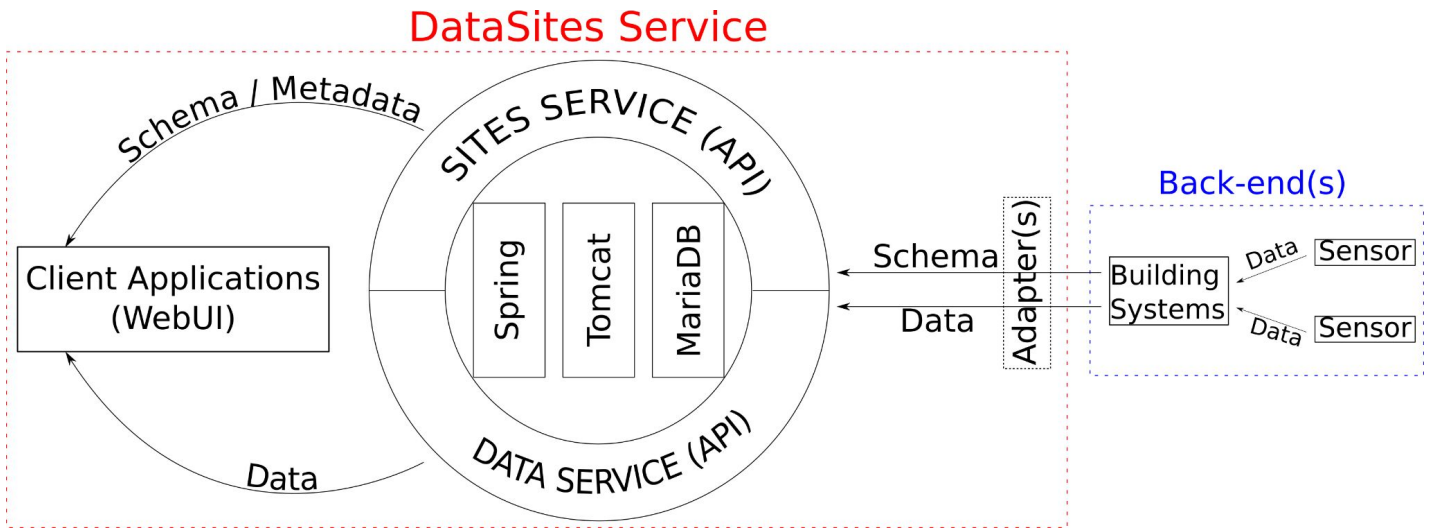
- Data has to be shown in its context (room, floor, ..) and in understandable form
- Context: layout of a building ***site*** can be complex: numerous ***buildings***, ***floors***, ***rooms***, ***spaces***, and of course ***sensors***
- ***Virtual layers*** can be used to represent floors, rooms, etc. in visualizations of a building site
  - creators of the visualizations must be able *create, update, and remove layers* as needed
  - creators must be able to to arrange layers hierarchically
  - creators must be able to *place **sensors** on the layer*, and change their position in the layer, move the sensor to a new layer, or even remove the sensor
- Building data often is time series data which requires specific tools, such as a time series database like InfluxDB







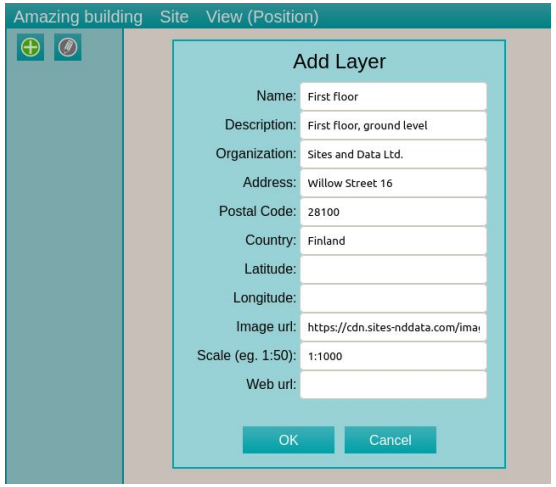
DataSites service and WebUI visualizations



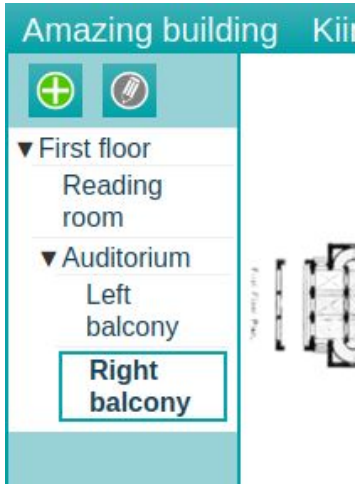
- We created a ***DataSites service***, as presented previously
  - communicates with building systems
  - offers data from building systems in a uniform data format to client applications
- We created a ***WebUI client application*** for visualizations
  - building site with layers and sensors
  - visualizations for sensor data

Example: creating a site

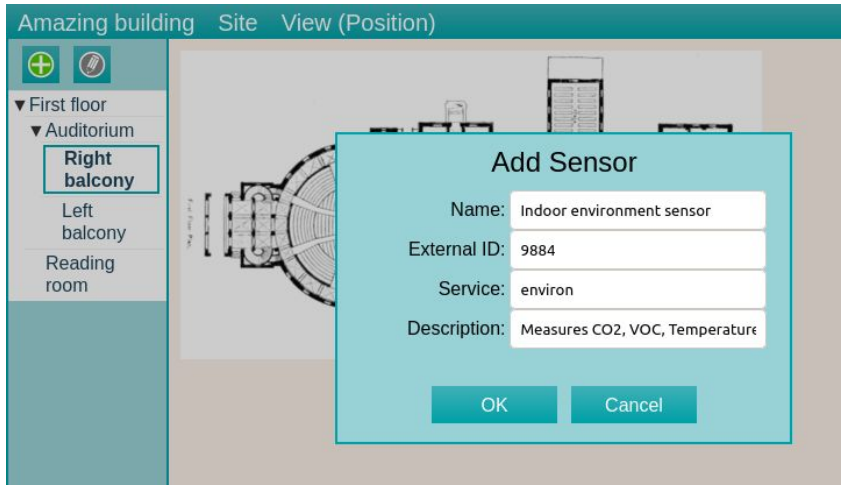
1. Creating a building site



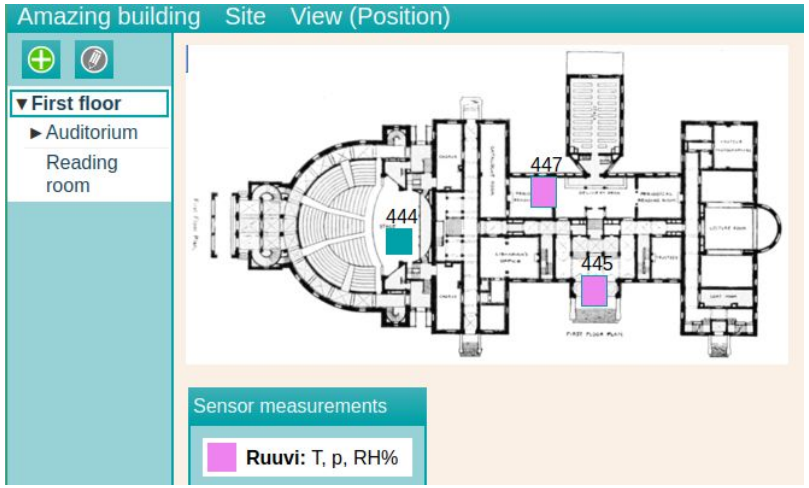
2. Adding a layer to the site



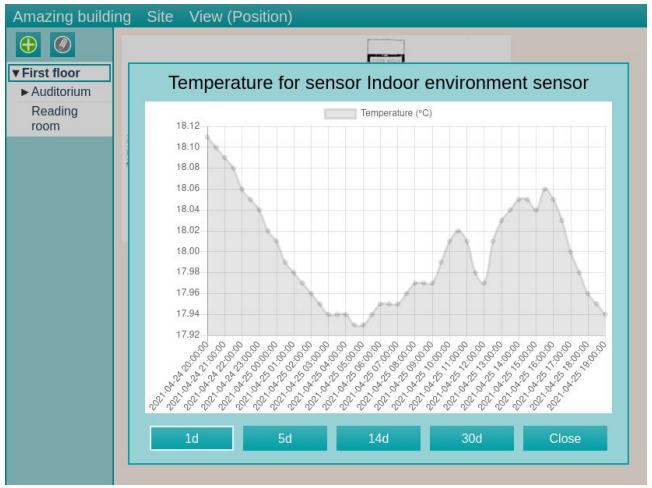
3. Site's layer hierarchy



4. Adding a sensor to a layer



5. Three sensors placed on a layer



6. Visualization of a time series

Possible future improvements

- visualize the connections between changes in energy consumption and their effects on the living conditions
  - for example when heating a room: reducing room temperature 1 degree would result in less energy needed for heating, reduction of 2 degrees would lead to greater reduction
- creating the adapters is time consuming, explore possible ways of re-using existing code
- for residential buildings, DataSites could be developed as a Home Energy Management System (HEMS), including In-Home Displays (IHD)
- a study in our review indicated that energy saving actions had increased positive community spirit among building's residents. DataSites could incorporate this finding by introducing feedback features such as crowdsourcing energy saving ideas

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