TRANSILVANIA UNIVERSITY OF BRASOV, ROMANIA

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE FACULTY

DEPARTMENT
AUTOMATICS AND INFORMATION TECHNOLOGY

Electric & ICT Team
from
Research & Development Institute ICDT - ProDD

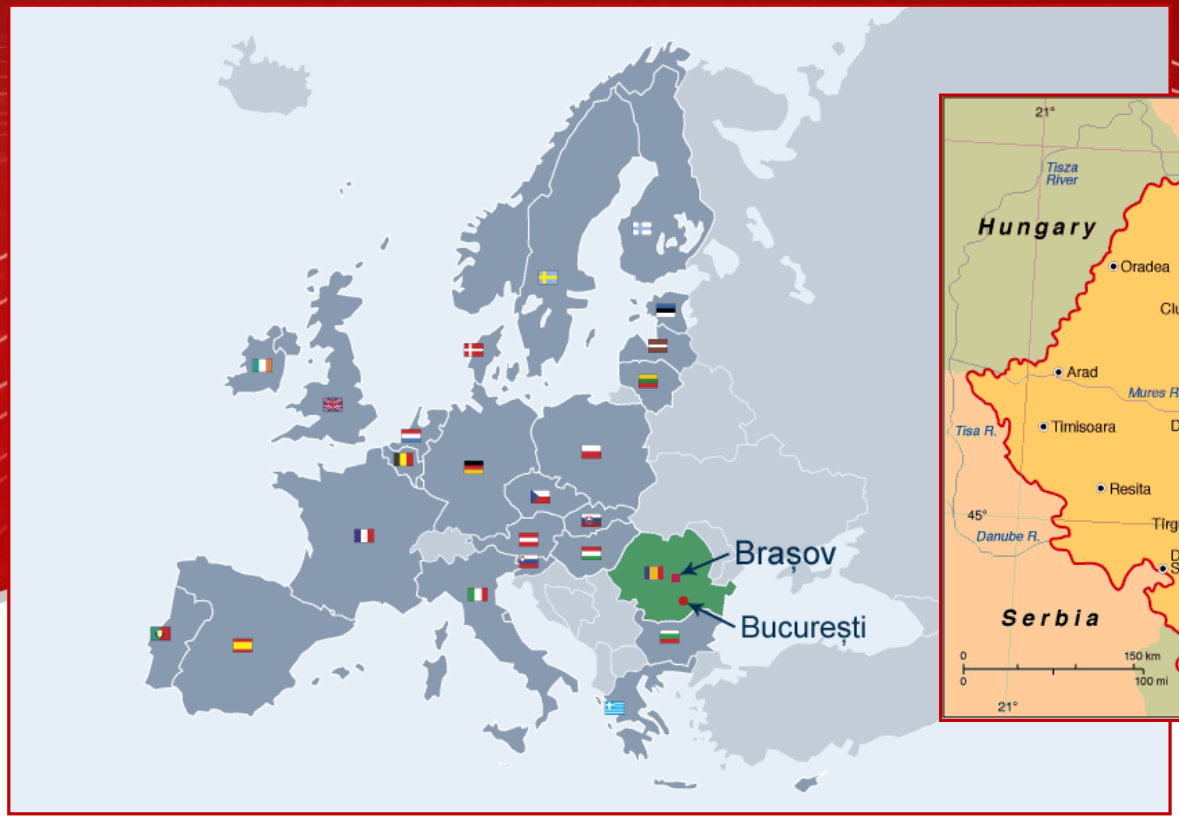
Big data analysis for environmental parameter monitoring services in smart buildings

Strategic Program to Promote Innovation in Services through Open, Continuous Education
INSEED – 20 September 2013, Bucharest

AGENDA

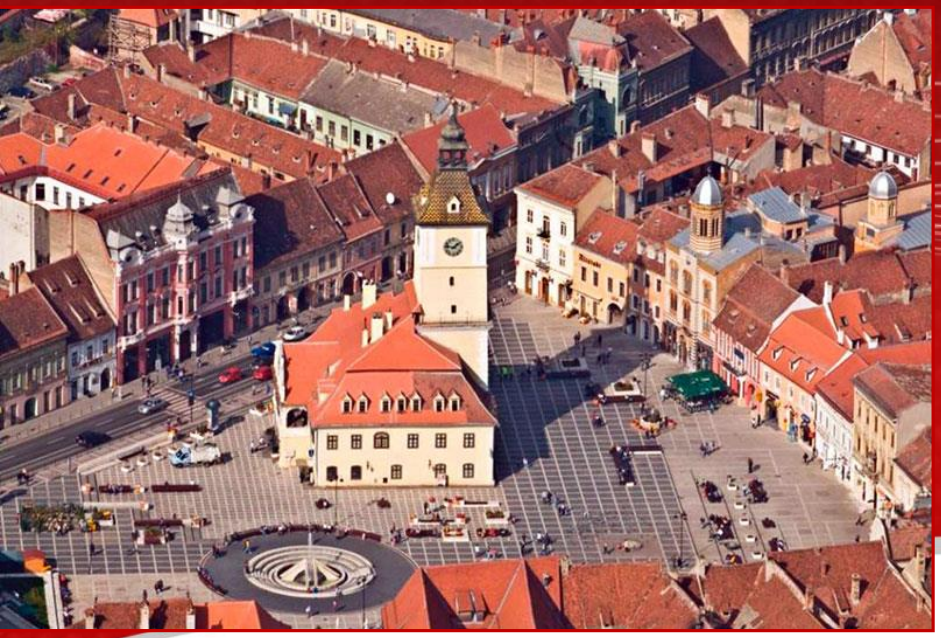
- City of Brasov
- *Transilvania* University of Brasov
- The GENIUS Campus
- Research & Development Institute ICDT – ProDD
- IBM *GREEN* Data Center
- Smarter Buildings: Intelligent Distributed Workspace for Efficiency in the GENIUS Campus
- Comfort demands – evolution - Employees efficiency – Comfort characteristics - Comfort types -
- Network device implementation
  - Wireless network Implementation
  - Monitoring system
  - Sensor network implementation
  - KNX automation system
- Other types of applications

City of Brasov – Best city to live in Romania ☺



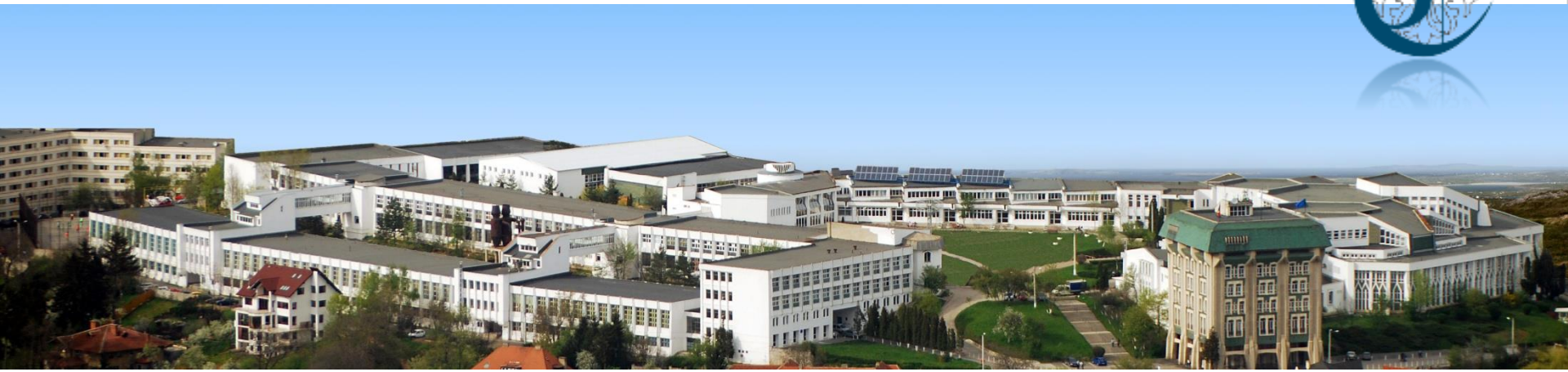
- Old cultural city, hosting **the first school** in Romania
- Multinational and multilingual area (Romanian, Hungarian, German citizens)

City of Brasov – Best city to live in Romania



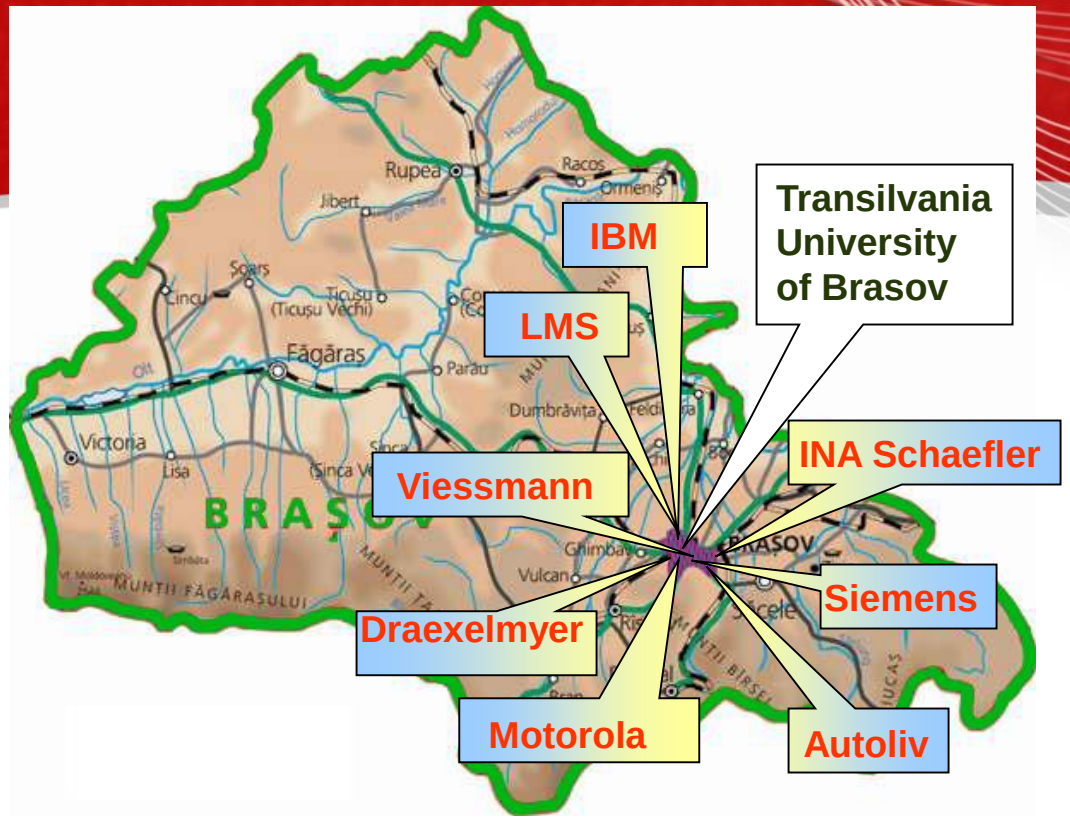
Transilvania University of Brasov

- State University, founded in 1948
- "Full Confidence" in the national evaluation
- Ranked among the first at national level for Research of Excellence
- Extended cooperation with European universities



Collaboration with local companies

- Developing new education and training courses: masterate
- Developing infrastructure (laboratories) in partnership with companies
- Applied research
- Joint research in Ph.D. programs



The GENIUS Campus

- The R&D Institute: High-Tech products for Sustainable Development: PRO-DD
- A new structure for advanced research on Sustainable Energy:
- The **Green, ENergy Independent University CampuS** GENIUS

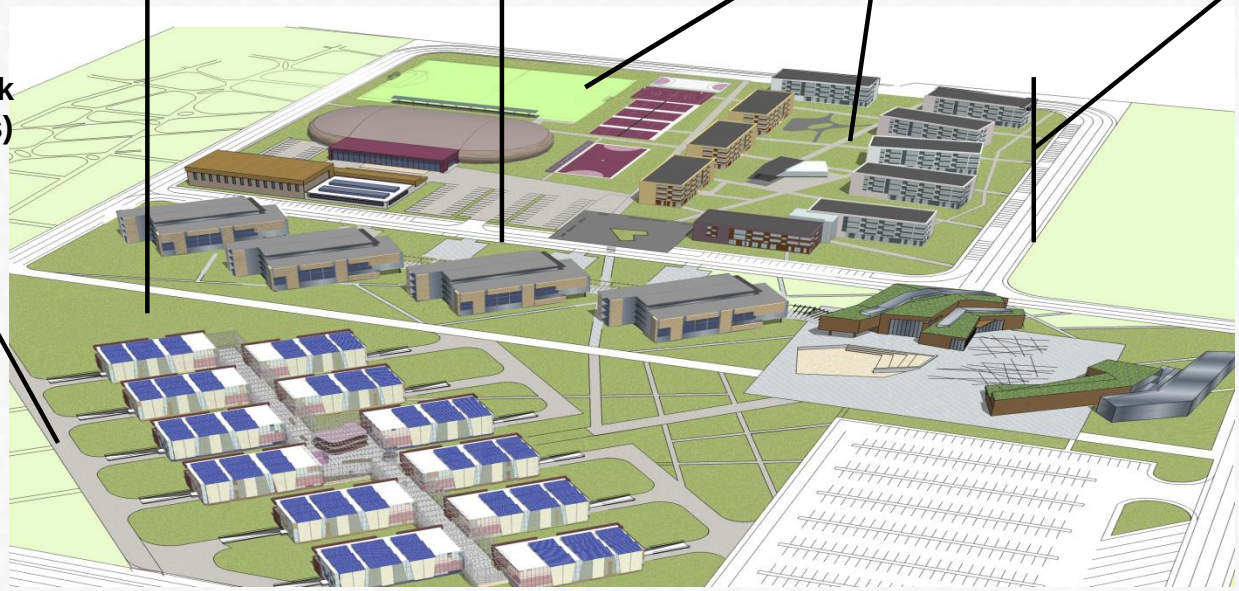
Phase 1
The Solar Park (RTD Projects)

Phase 1
RTD Institute (Structural Funds)

Phase 2
Education Area (Regional Funds)

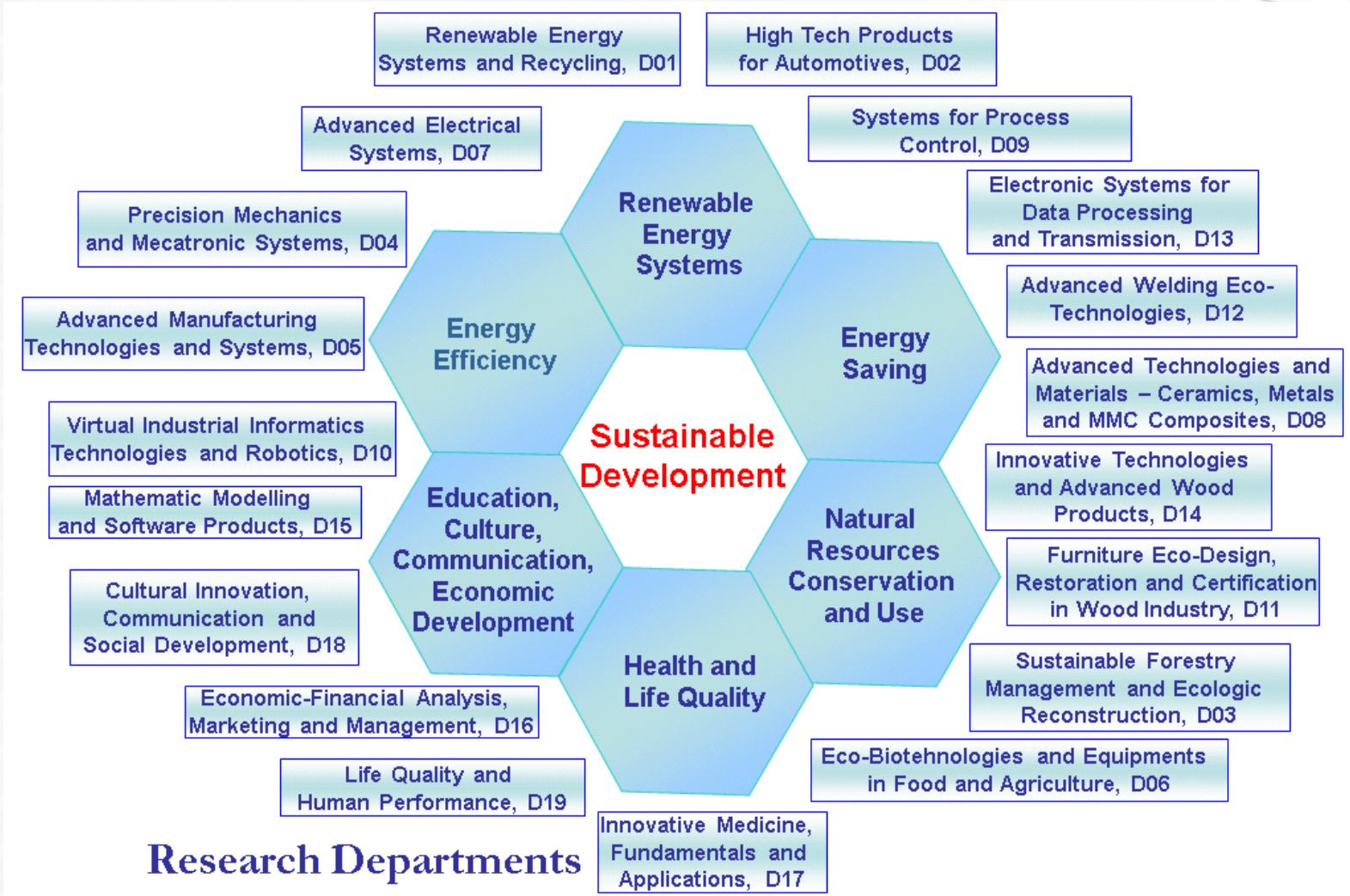
Phase 2
Students Facilities (Governmental & Regional Funds

Phase 3
Business Center (Structural Funds)
Clusters research providers + research direct and indirect beneficiaries
Technology Transfer



1. **Research**
2. **Education**
3. **Technology Transfer**

Research & Development Institute ICDT – ProDD



The GENIUS Campus – R&D Institute ICDT PRO-DD

- The R&D Institute: High-Tech products for Sustainable Development: PRO-DD

The Solar Park

- PV Platforms
- 2MWp PV
- Residential buildings testing optimised solutions for integrating renewables

The PRO-DD Institute

12 Laboratories (3 floors) - Smart Buildings:

-Renewables: solar thermal, PVs and heat pumps

-Monitoring and data acquisition

Outdoor: testing stands for optimising complex sustainable energy solutions

Indoor: advanced research centre on Sustainable Energy

Financing: 2009 – 2013 (Structural Funds)

The GENIUS Campus – R&D Institute ICDT PRO-DD

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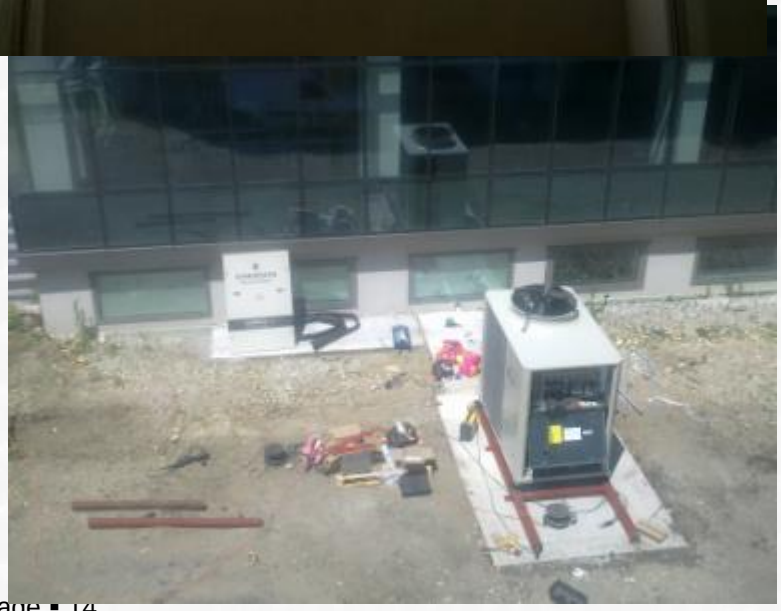
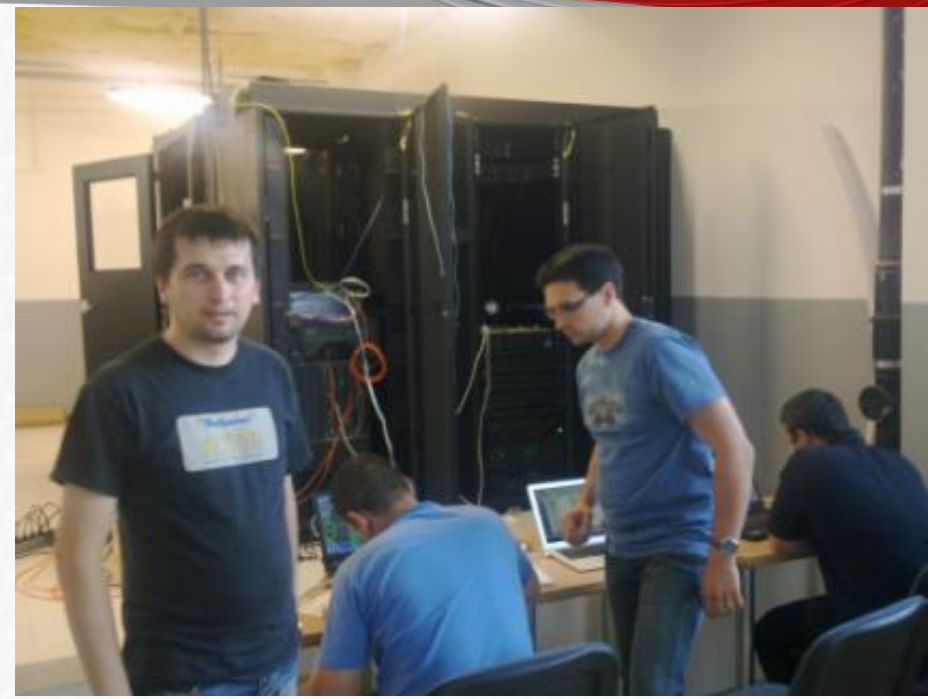
The GENIUS Campus – R&D Institute ICDT PRO-DD

R&D Institute ICDT PRO-DD – IBM *GREEN* Data Center



R&D Institute ICDT PRO-DD – IBM *GREEN* Data Center



R&D Institute ICDT PRO-DD – IBM *GREEN* Data Center

- Data Center and platform for delivering software and multimedia services for all the research centers of the Institute;
- Service oriented architecture;
- Cloud computing solution based on a Blade framework;

- Design Principles taken into account:
  - Centralize computing resources
  - Reduce electricity consumption
  - Reduce operating costs

BladeCenter Servers

R&D Institute ICDT PRO-DD – IBM *GREEN* Data Center

- PRO-DD Data Center Hardware Equipment characteristics
  - Number of processors: 29
  - Number of processor cores: 174
  - RAM Memory: 1440 GB
  - Video Memory: 6 GB GDDR5
  - Storing capacity: 28TB
  - Computing power: approx. 1TFlops

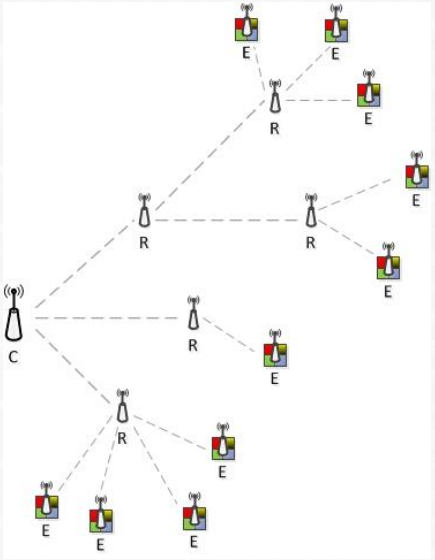
Smarter Buildings: Intelligent Distributed Workspace for Energy Efficiency in the GENIUS Campus

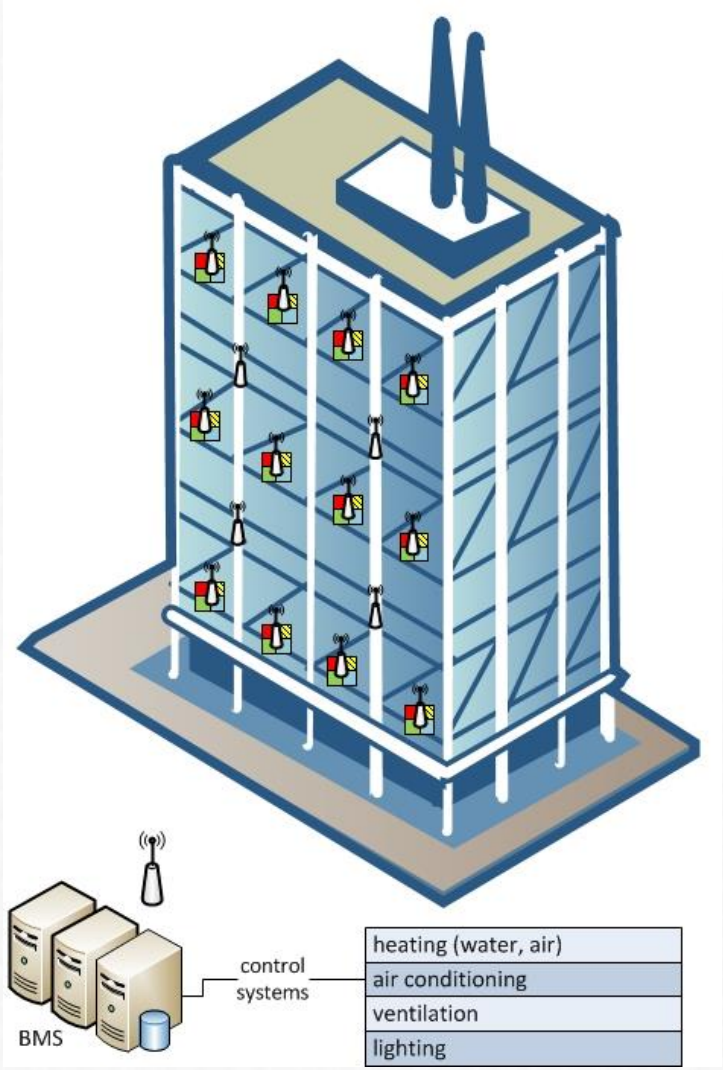
- Proiect *IBM Share University Research*, 2009-2012
- Development of a global model for buildings and office spaces of the R&D Institute ICDT – ProDD;
- Proposal and designing of a distributed data acquisition and control architecture based on wireless sensor, actuators and computer networks for delivering on increased efficiency, an improved security, a high reliability and an economical maintenance for all 12 buildings of the Institute;
- Connecting of the multiple control systems (lightening, HVAC, power energy sources) and of the multiple locations – remote control over internet and wireless, event monitoring and alarms;
- Creating of the facilities for treating the whole institute as a laboratory for studying of the parameters of the buildings and installations with a view to design, develop and test of BMS - Building Management System – solutions.

The main research project

- **Main goals:**
  - implement a wireless sensor network (WSN) for ambient conditions monitoring and control
  - integrate building systems together (central information storage, monitor and control)
  - increase the energy efficiency
  - increase the comfort of the occupants

at the end of the work a comparison is done for determine the efficiency of the obtained results

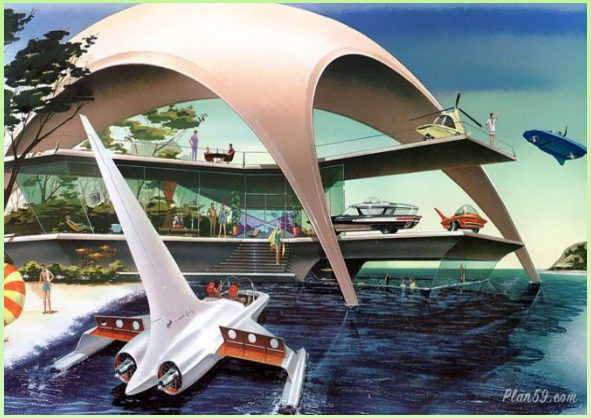




Comfort demands - evolution

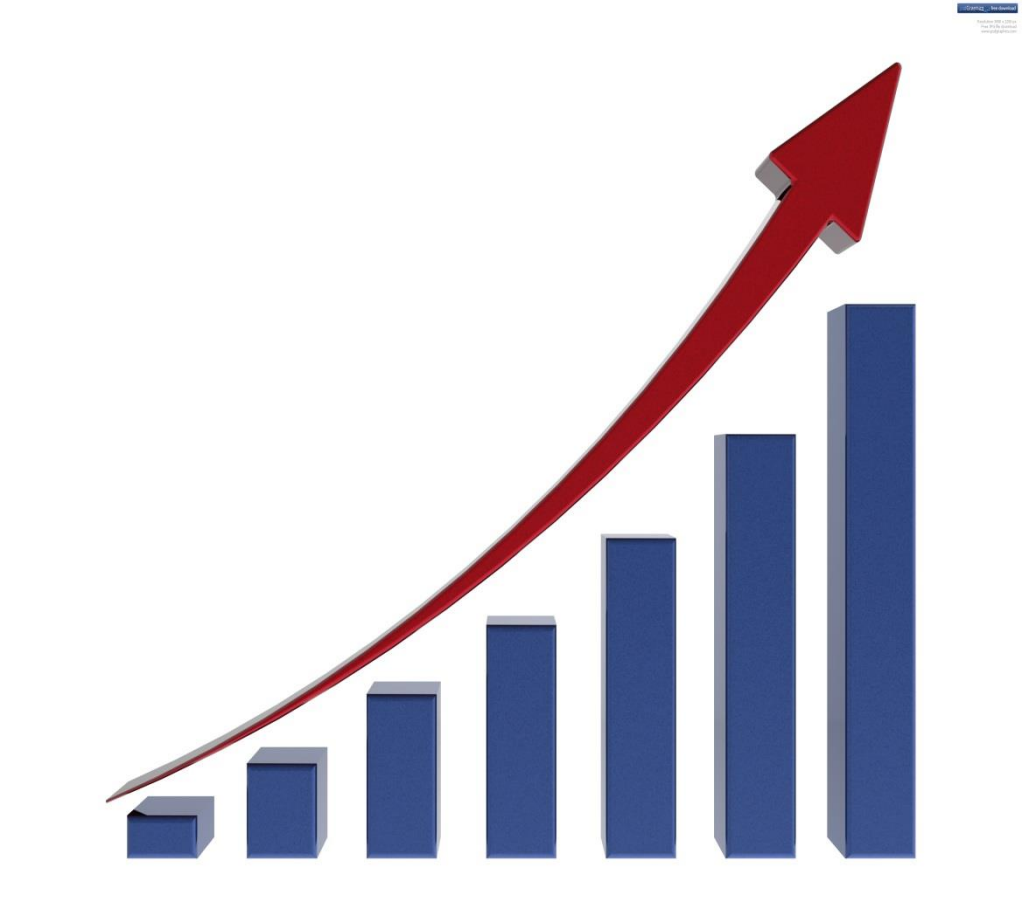
long time ago …
(simple life style)

present
(complex life style)



future
(more complex life style)

Employees efficiency



- a person could accomplish successfully its activities as long there are no external factors which to disturb him (e.g. heat, cold, noise, low air quality)
- if the comfort is satisfied also the maximum efficiency of the employees is ensured
- a low decrease in employees efficiency for a big company represents a huge lost of time and money

Employees efficiency

- At a new office building design
  - the initial cost and energy efficiency are the first points analyzed
  - the people's comfort (with influence to their productivity) is less discussed

As observations:

- people spend 80-90% of the time from their lives indoor
- the lighting, heating, air conditioning, ventilation systems ensure comfort to the occupants of the building
- it is not possible to reach the highest level of comfort, since could not exist a maximum for it, but we could make one step further into the future and create better conditions for our indoor lives

Comfort characteristics

- *comfort* = all existent conditions from a space for which a person will not prefer a different space with other conditions
- *ISO 7730* defines the thermal comfort as that condition of mind which express satisfaction with the thermal environment (thermal neutrality – when a person doesn't feel too warm, either too cold)
- *comfort* = a complex concept that depends on a set of external and internal factors.
- Maybe it is easier to define what it means, but it is more complicated to convert the definition into physical parameters and establish relations between them (create equations that will permit a mathematical analysis)

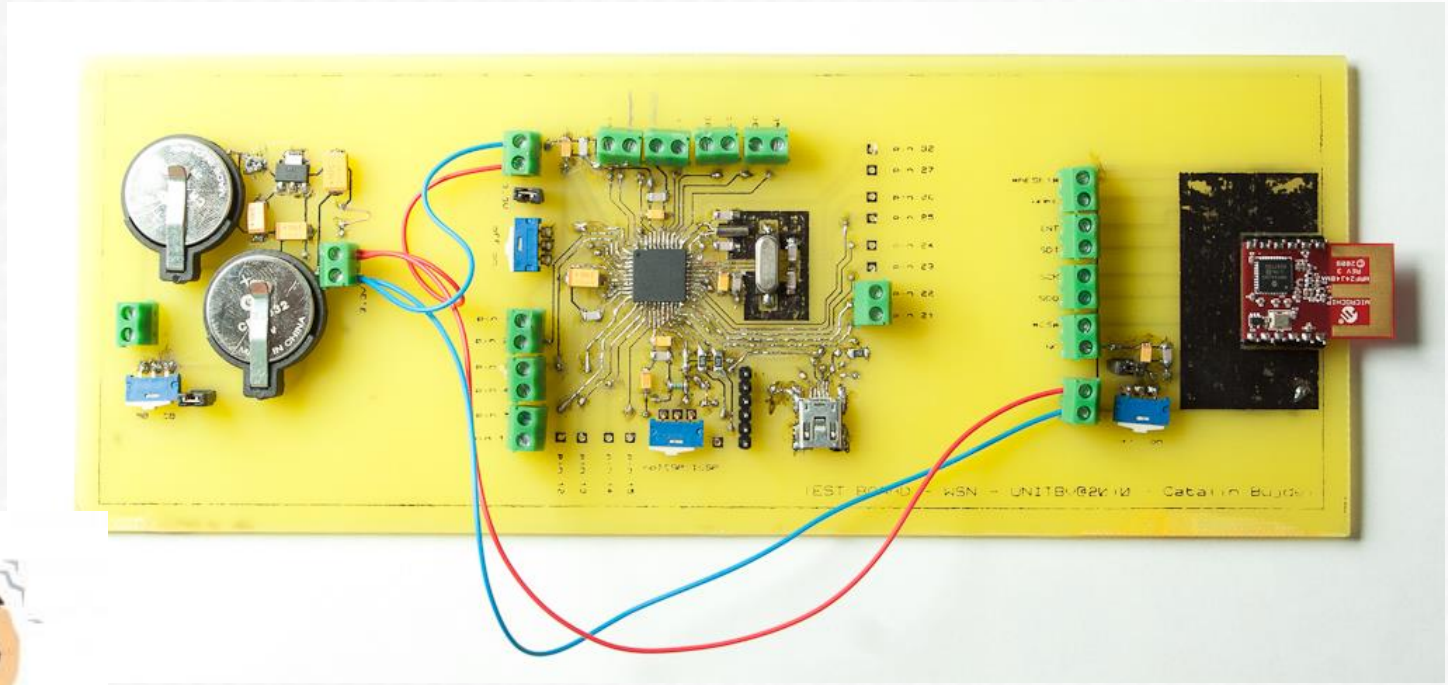
Comfort types

- The indoor comfort could be described from multiple points of view:
  - ***thermal***: temperature, humidity and air velocity (very import type of comfort)
  - ***visual***: light intensity and other factors which could influence a person view
  - ***acoustic***: maximum level of noise or repeatable noise
  - ***air quality***: parameters which characterize the air conditions and are suitable for respiration and human health (e.g. oxygen level, pollutions level)
  - *stability*: without uncomfortable movements, vibrations or shocks;
  - *security comfort*: feel safe at the working place;
  - *daily timetable*: a constant daily timetable will not influence the life habit;
  - *economical factors*: the fear of insufficient funds for proper living.

- A person could feel comfortable from some points of view but uncomfortable from other points of view.

Network device implementation

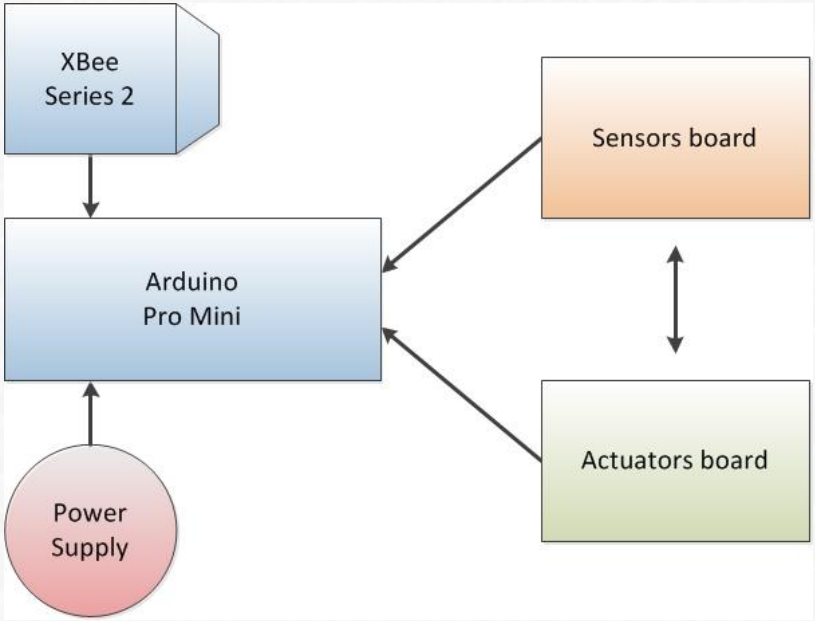
- We tried a “from 0 implementation” strategy:
  - The majority of the devices are expensive and doesn’t have a general format;
  - It was developed the power supply module, the processing module and radio module.

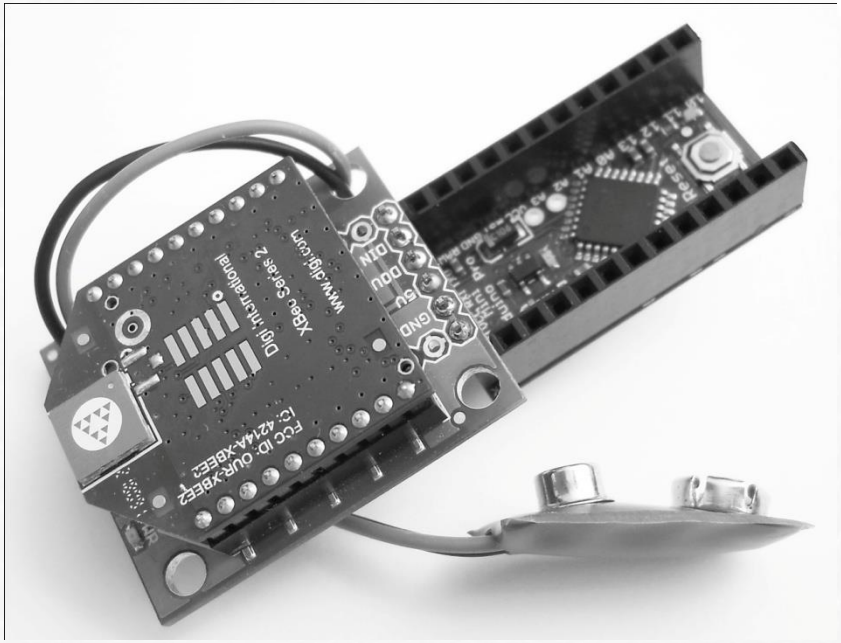


-> *conclusion*: insufficient time for accomplishing all the objectives, so we decided to use existent modules.

Network device implementation

- The new solution implies using of the components: Arduino Pro Mini, XBee and extension modules with sensors.

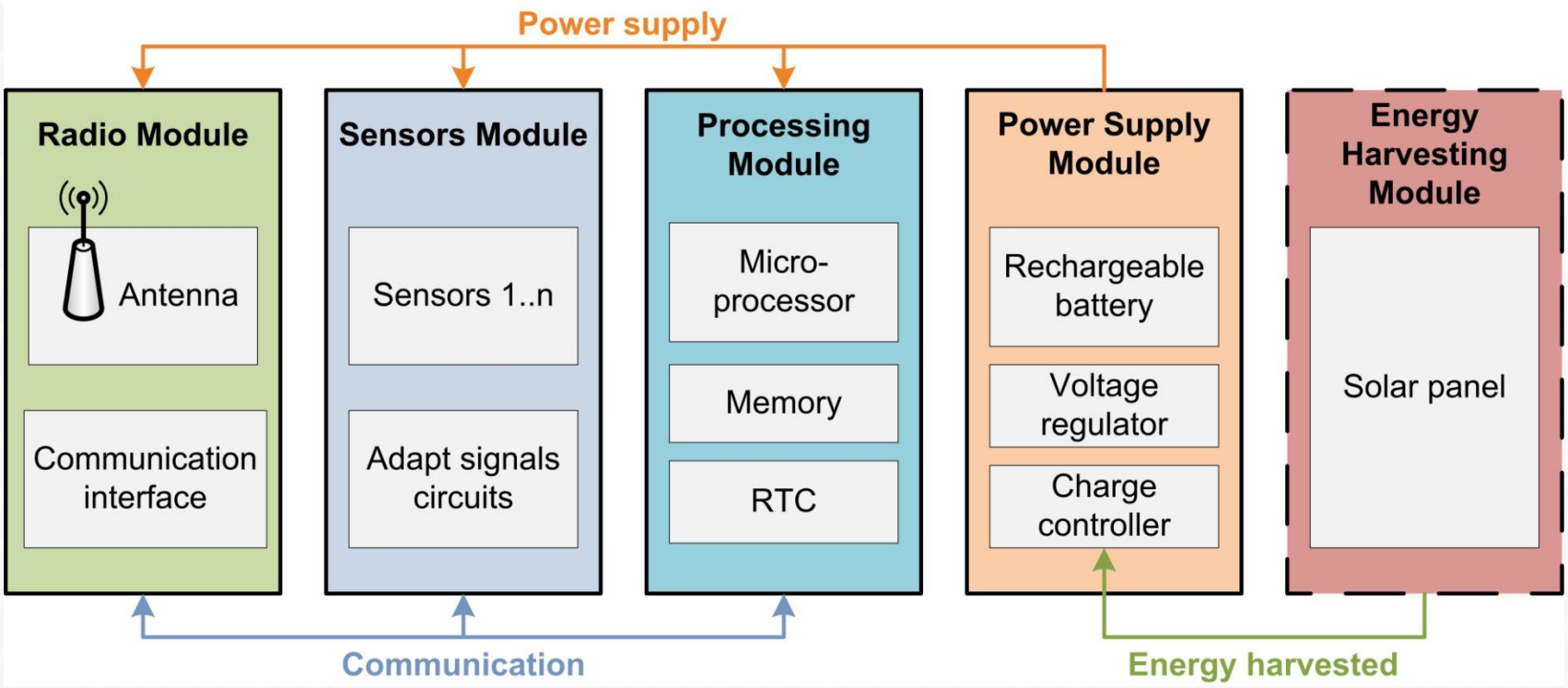




Network device implementation

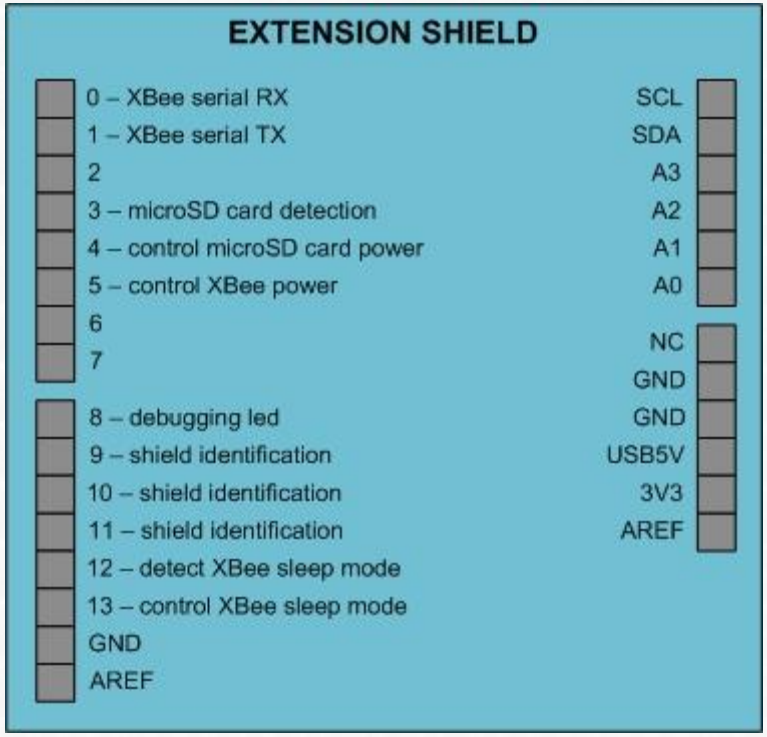
- The next solution is based on using the platform Seeeduino Stalker v2, Xbee and the extension modules (with sensors and driving elements).

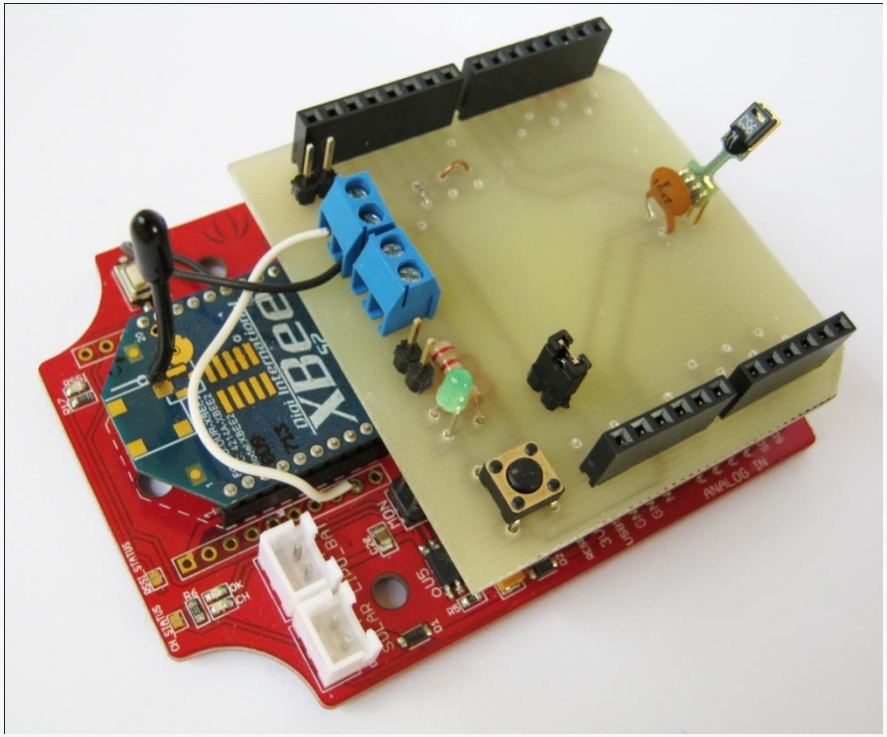
Network device implementation



Network device implementation

- The extension module with sensors (based on a general format)
  - SHT71 (temperature, relative humidity);
  - Thermistor (temperature).



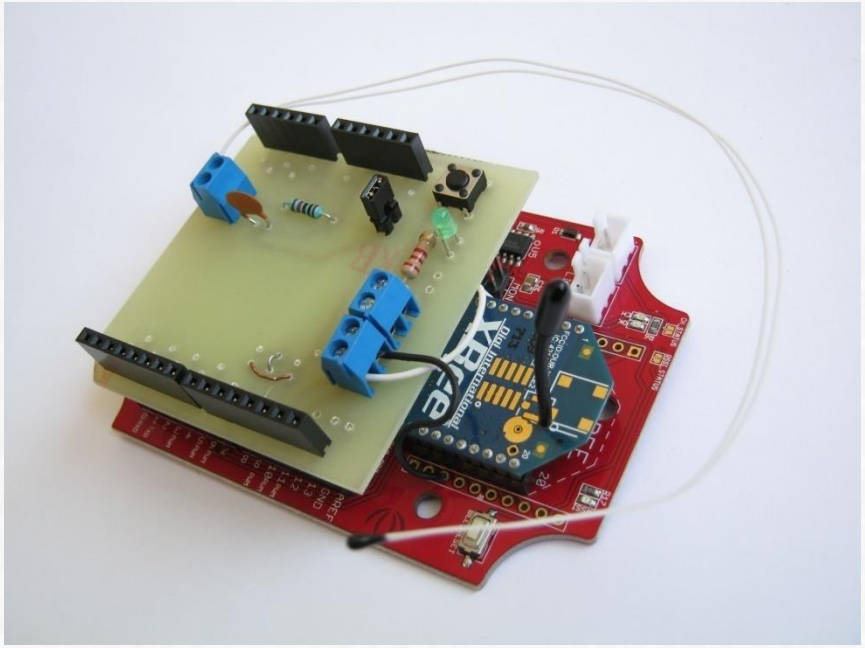


Wireless network Implementation

- Aprox. 80 network nodes

Wireless network Implementation

- The network was initially distributed in a classroom from one of the laboratories.



Wireless network Implementation

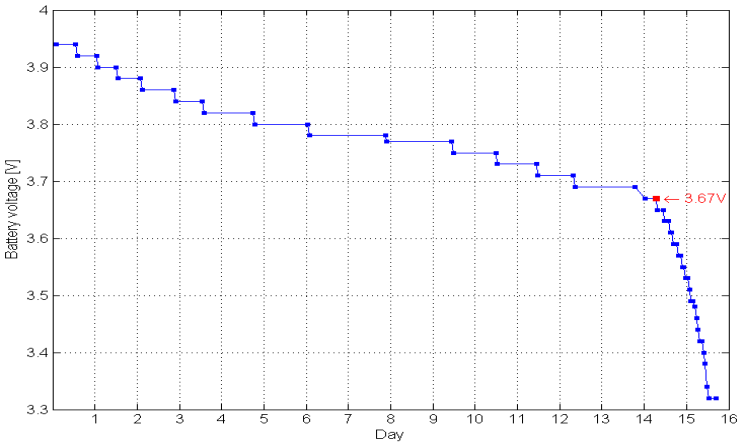
Router nodes

Coordinator node

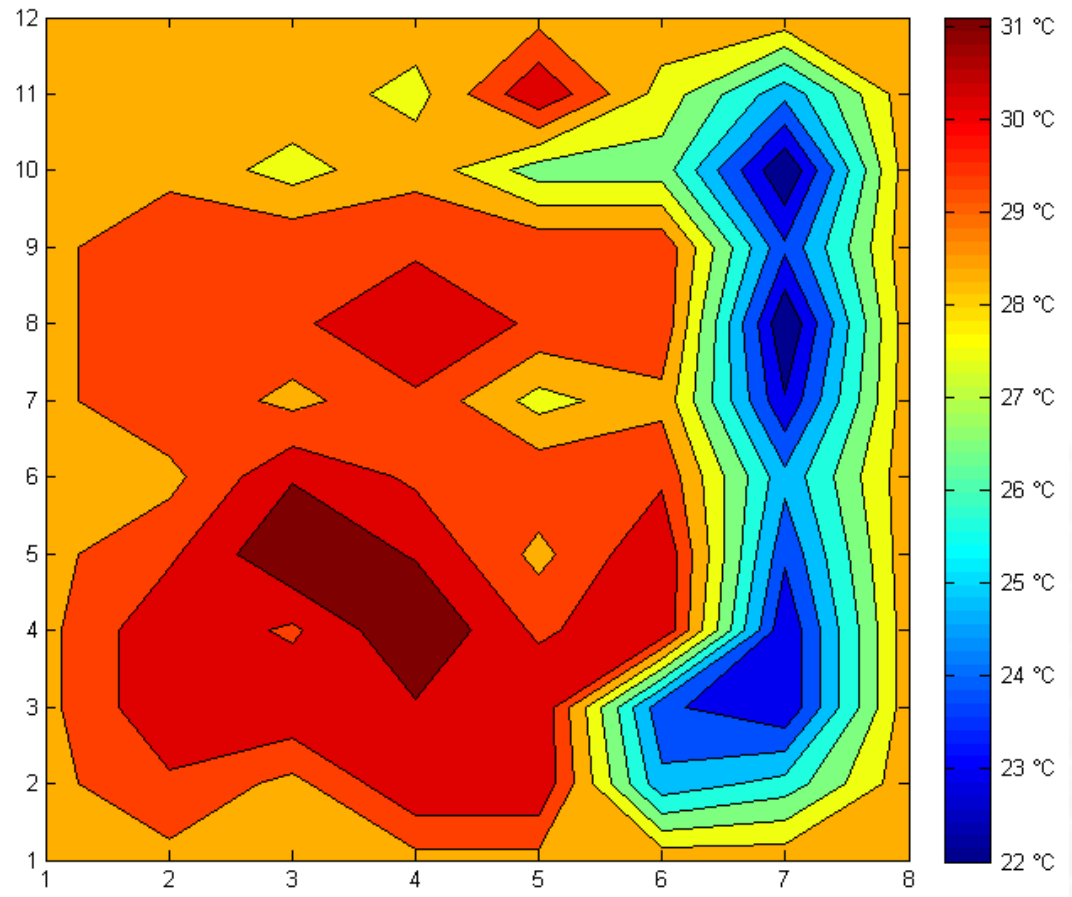
Terminal nodes

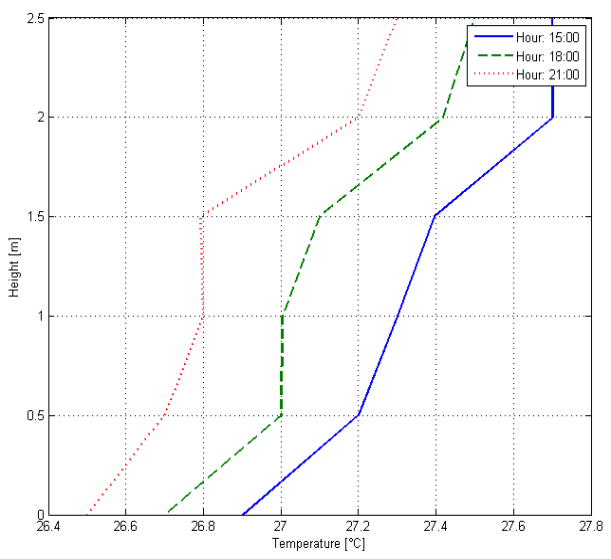
Initial analysis

Energy consumtion



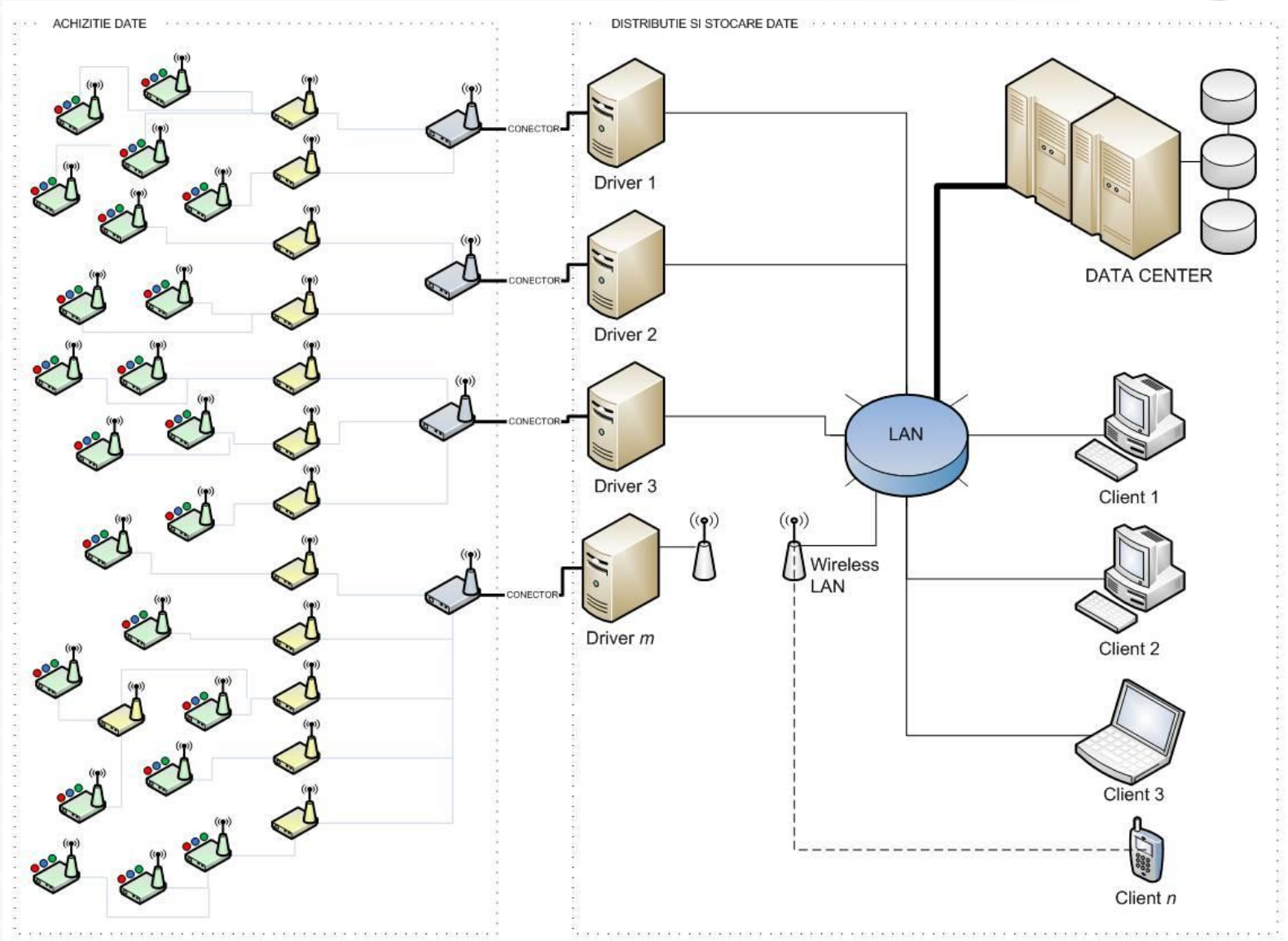
Temperature distribution in horizontal plan





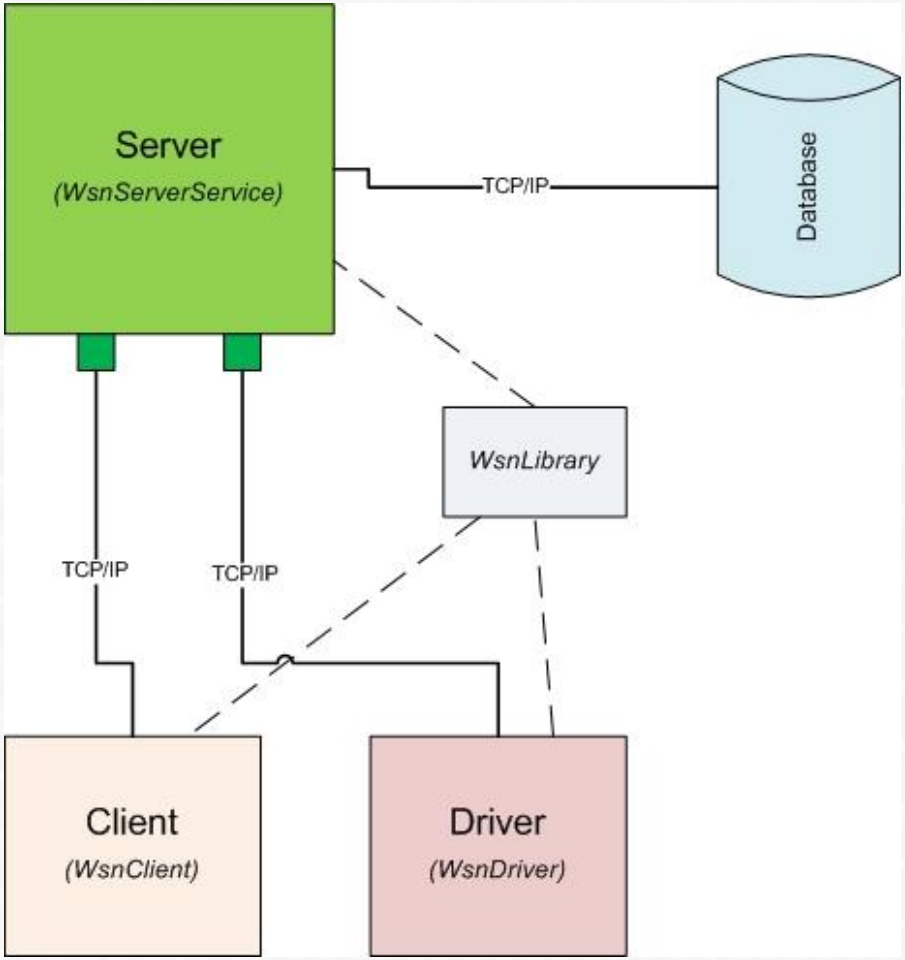
Temparature variation in vertical plan

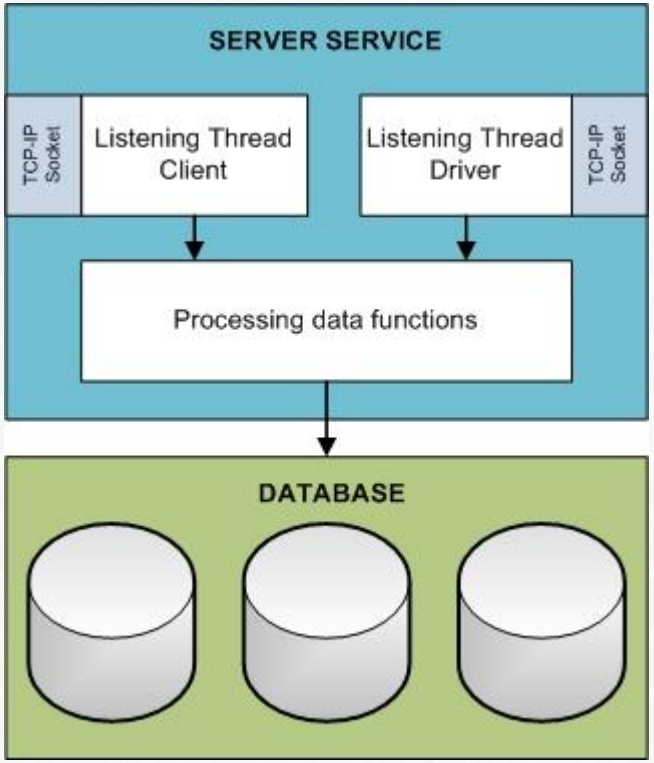
Monitoring system architecture



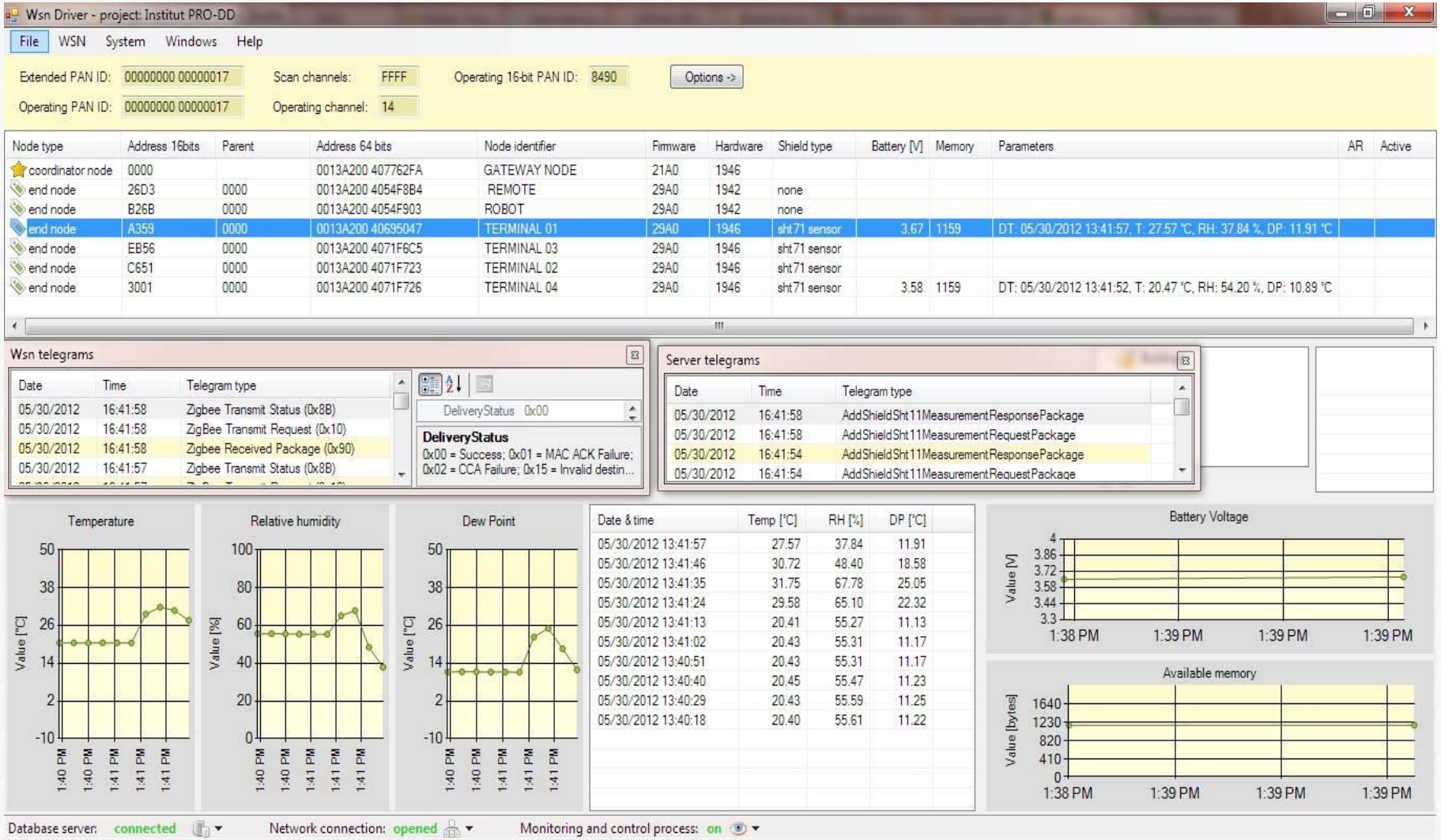
Monitoring system

- Software components and connections

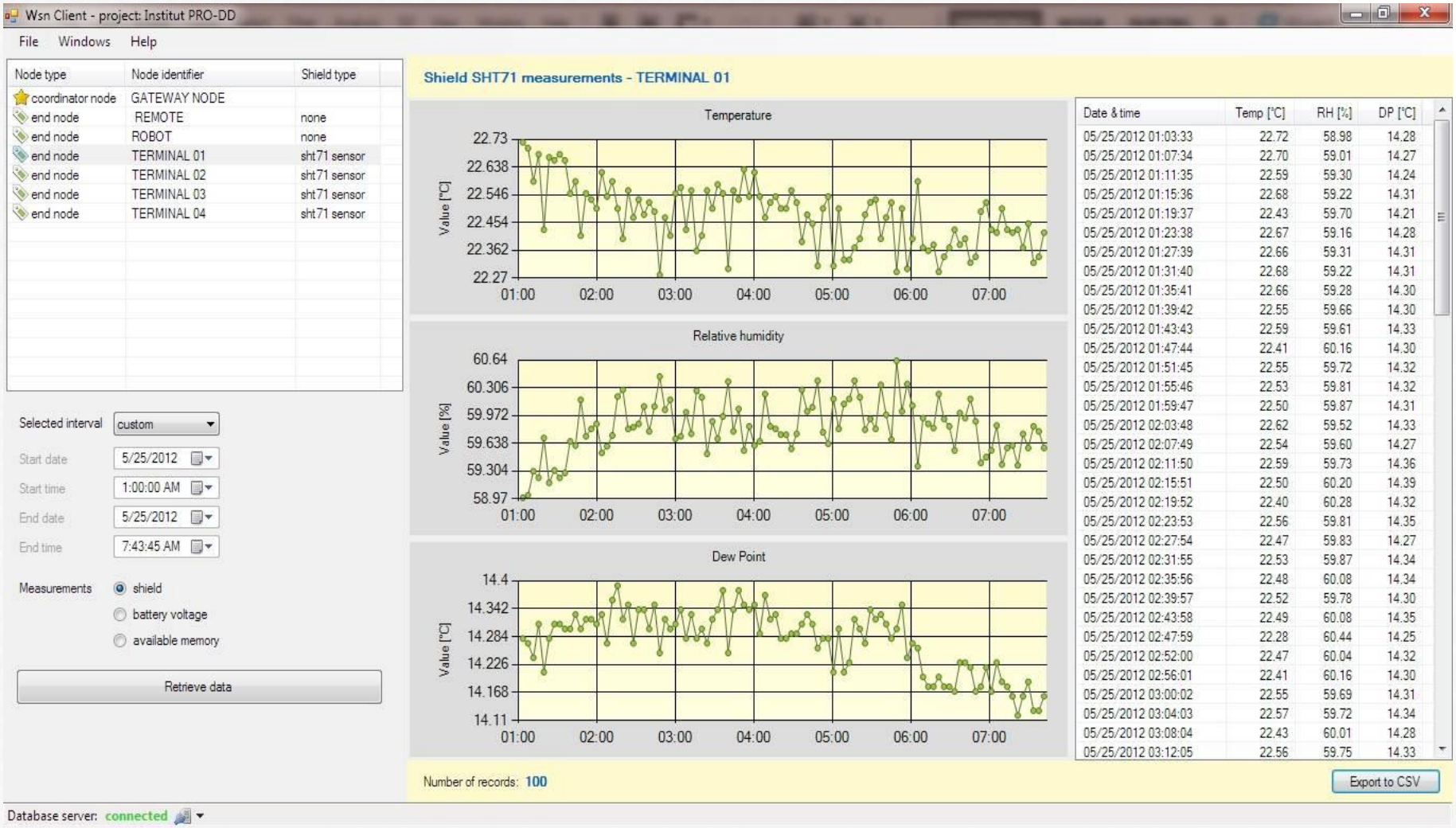




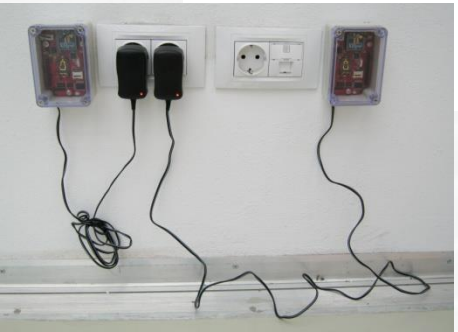
Monitoring system – Driver application



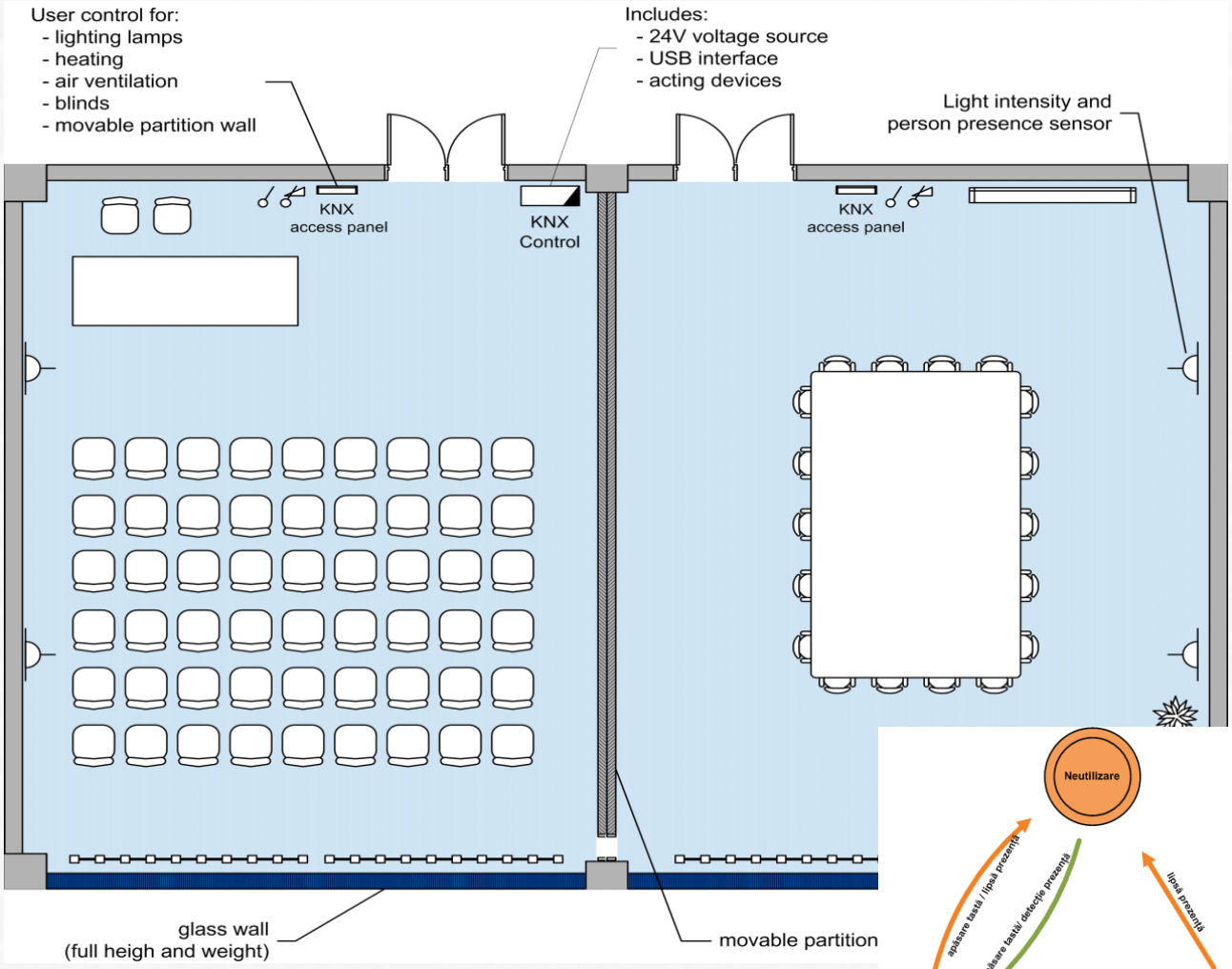
Monitoring system – Client application



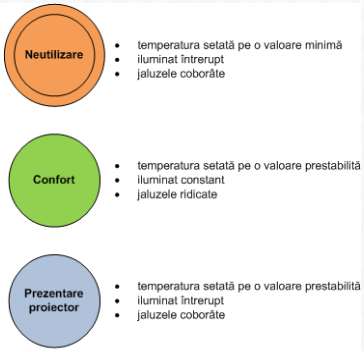
Sensor network implementation



KNX automation system

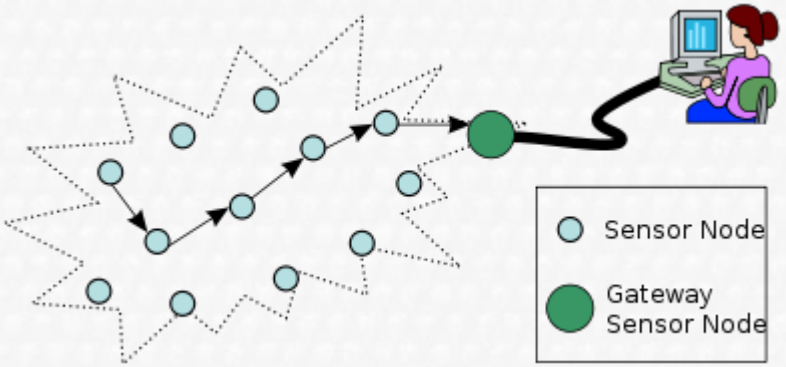


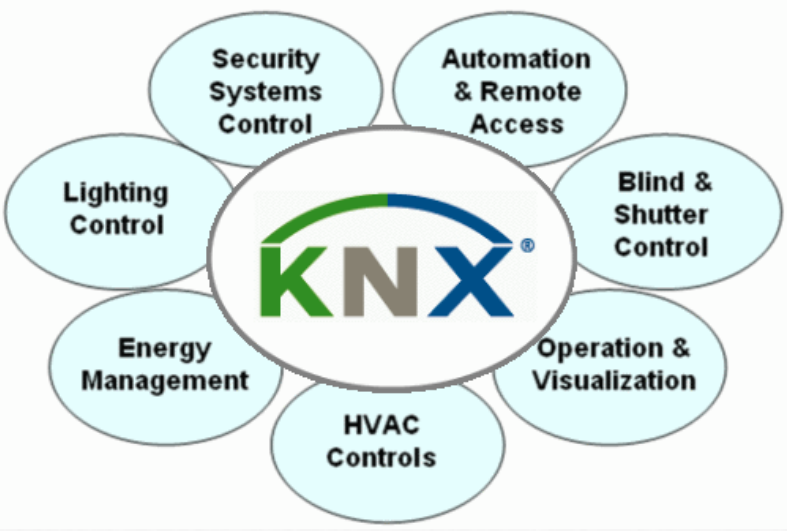
- Lightening control
- Heating control



KNX automation system

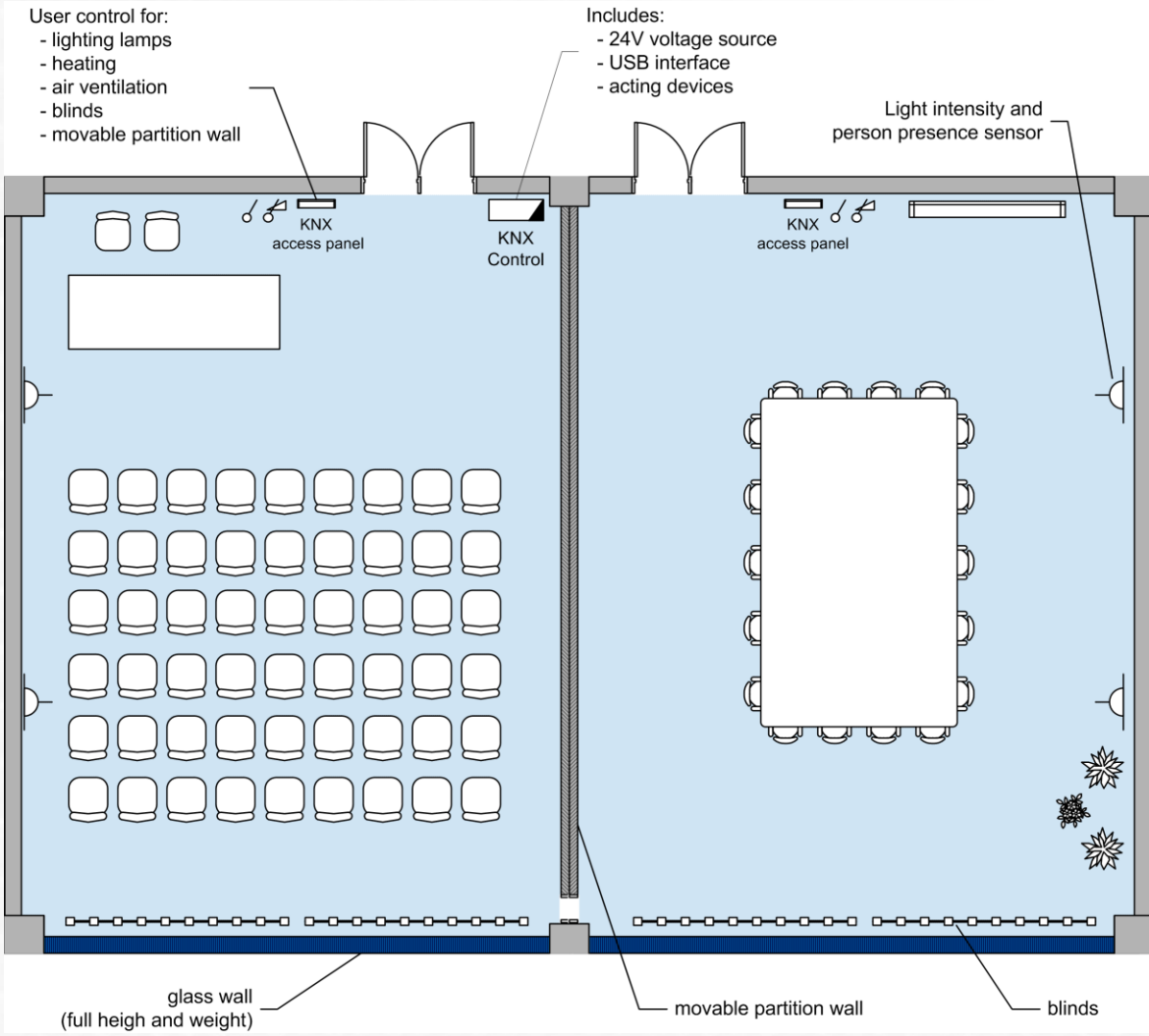
- KNX system, a small part of a BMS (Building Management System)
- integrate the KNX system with a Wireless Sensor Network (WSN) - both of them could monitor parameters and control different systems.





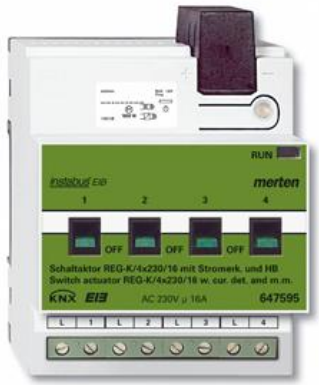
KNX automation system

- configurable classroom
- the cost of the KNX system is quite high but after installation it should produce an increase of the comfort and decrease of the energy consumption.
- another advantage of this type of system is that it could be easily reconfigured. It is possible to save different configuration (scenes) into the system memory and load them for specific usage situations.



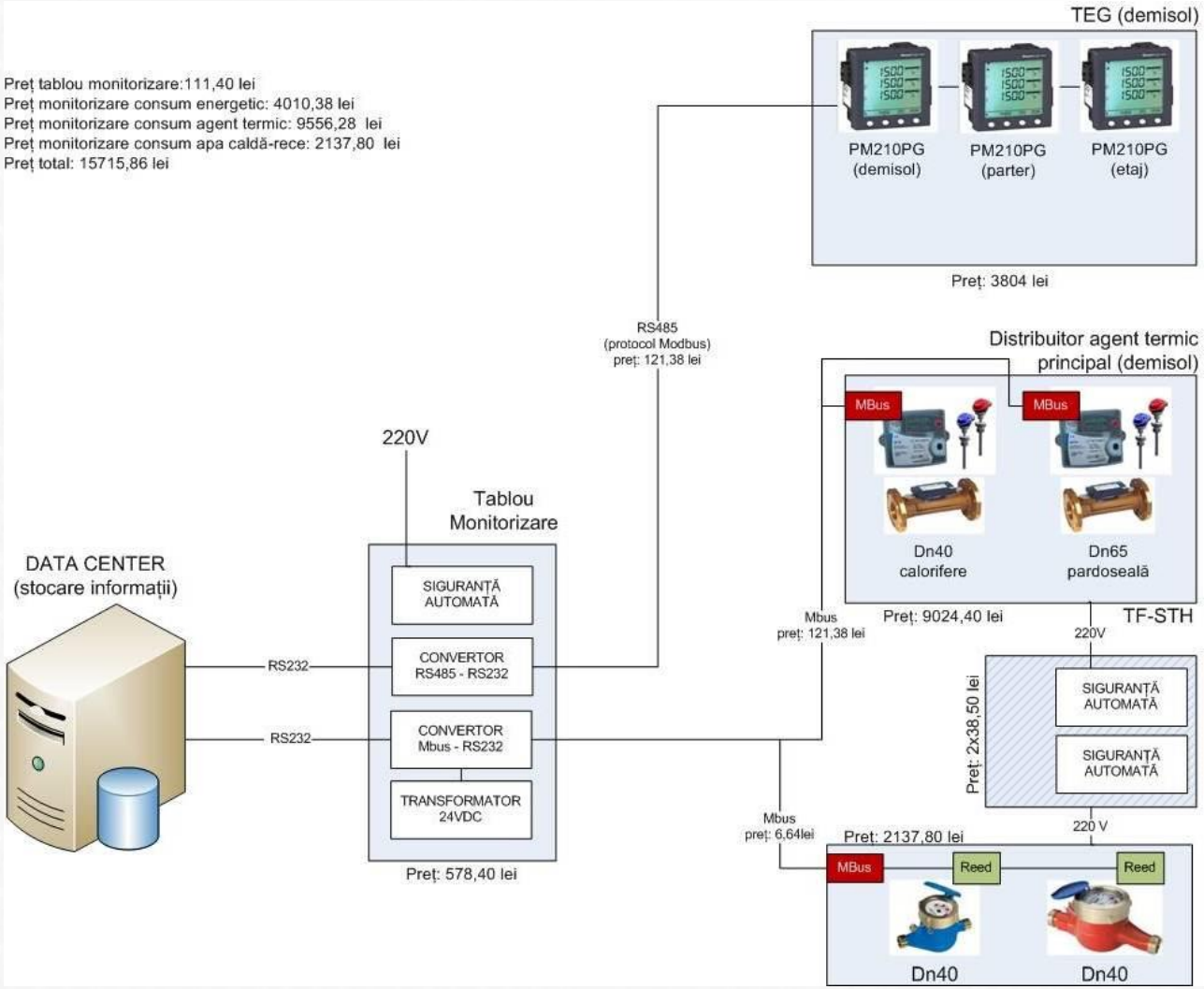
KNX automation system

- the main components of the KNX system:
  - *24V Voltage Source*;
  - *USB Interface*;
  - *KNX acting devices*;
  - *KNX access panel*;
  - *movable partition wall*;
  - *Blinds*;
  - *lighting*;
  - *light intensity and movement detection sensors*;
  - *heating*.

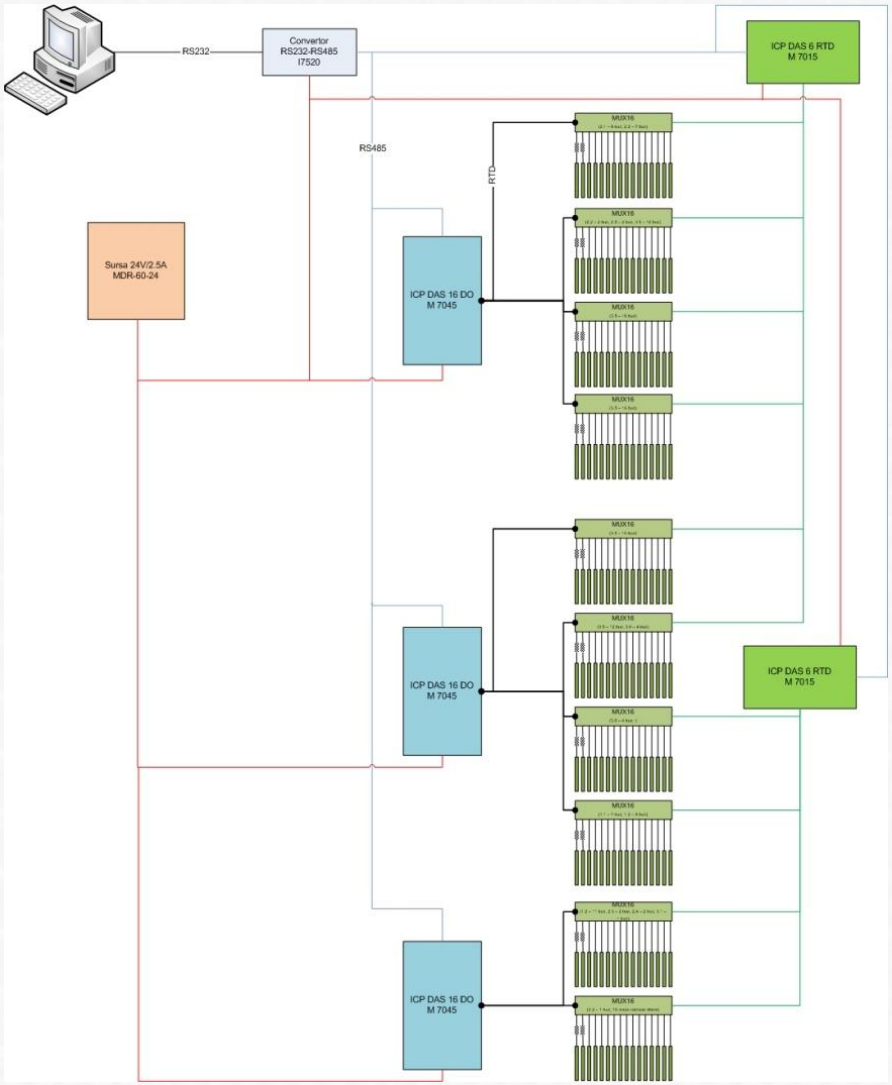


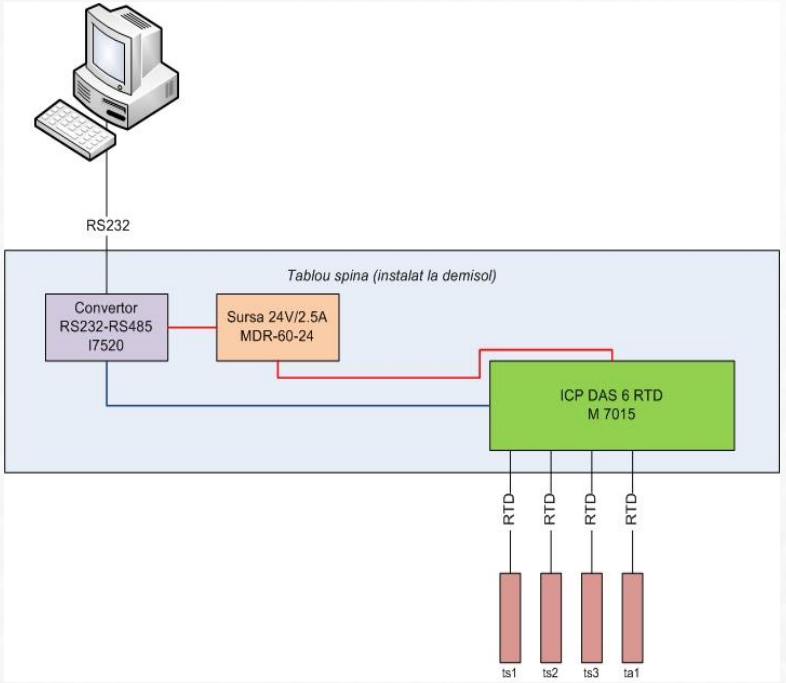
Other monitoring possibilities

- Electric power
- Thermal energy
- Water

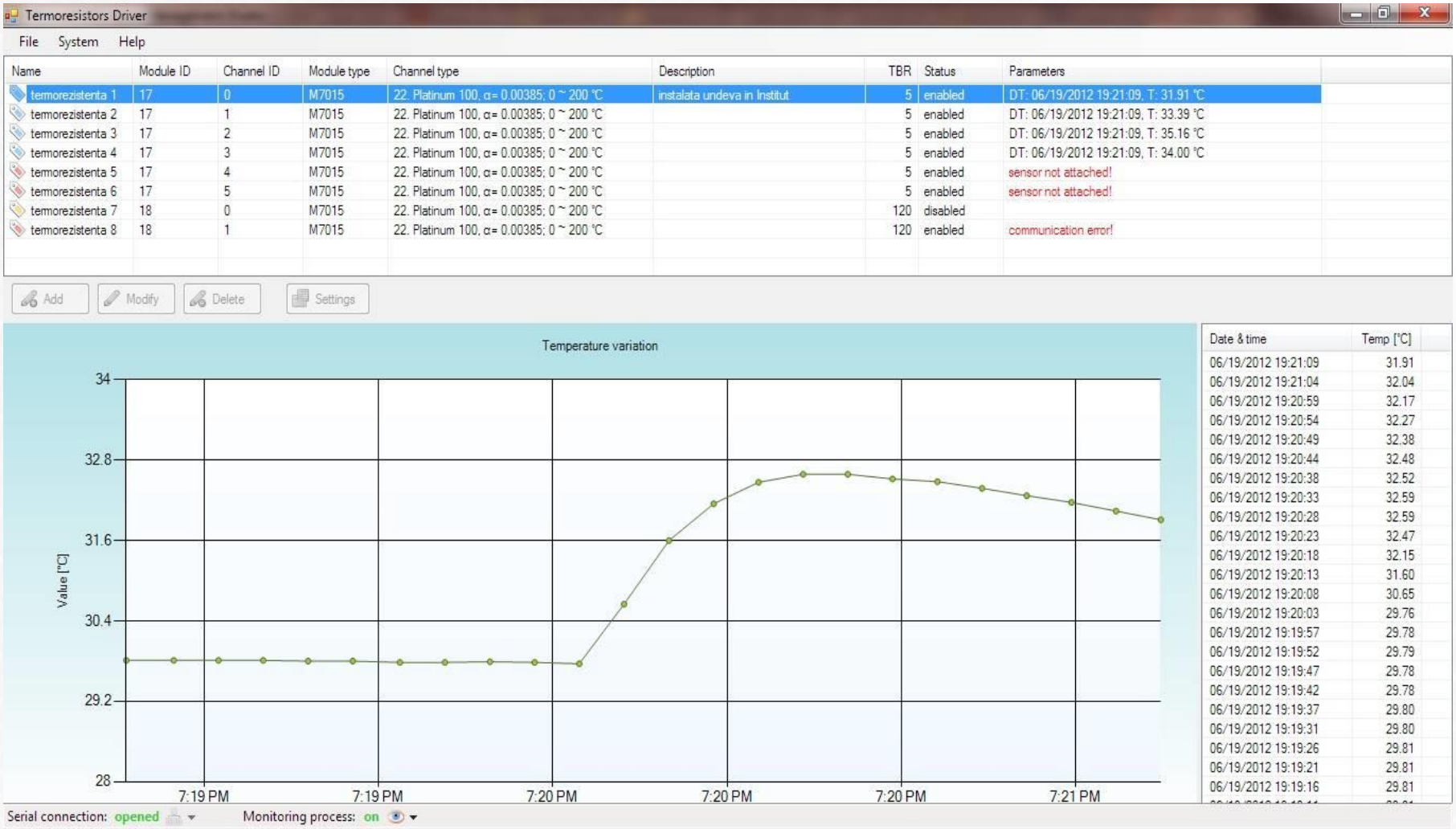


Floor temperature monitoring



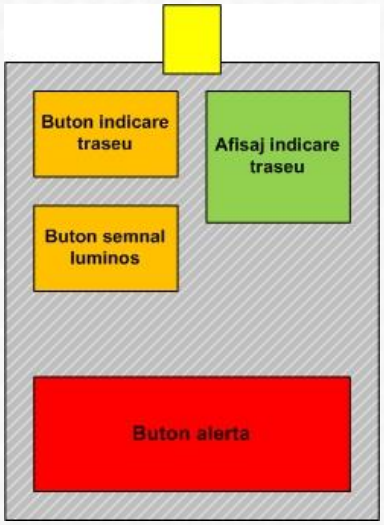


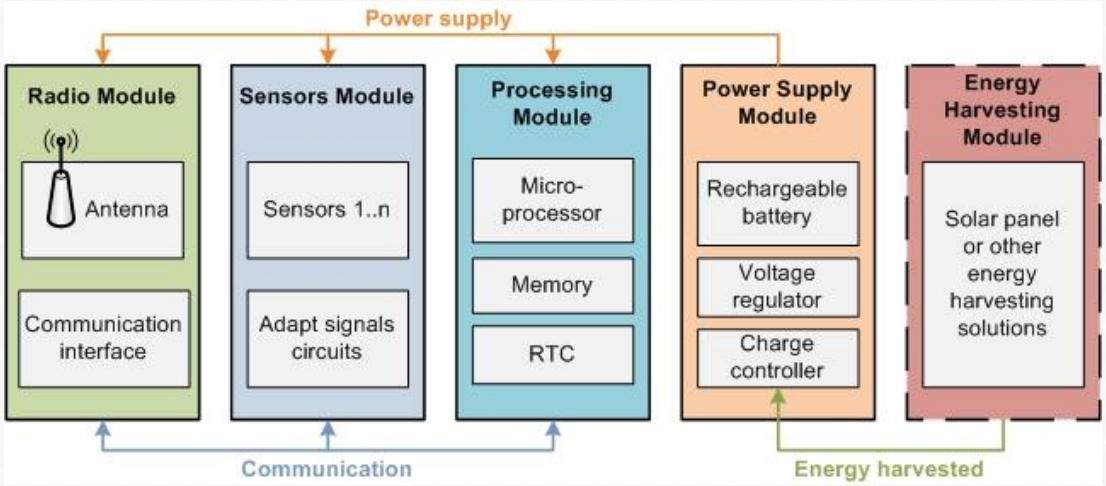
Floor temperature monitoring

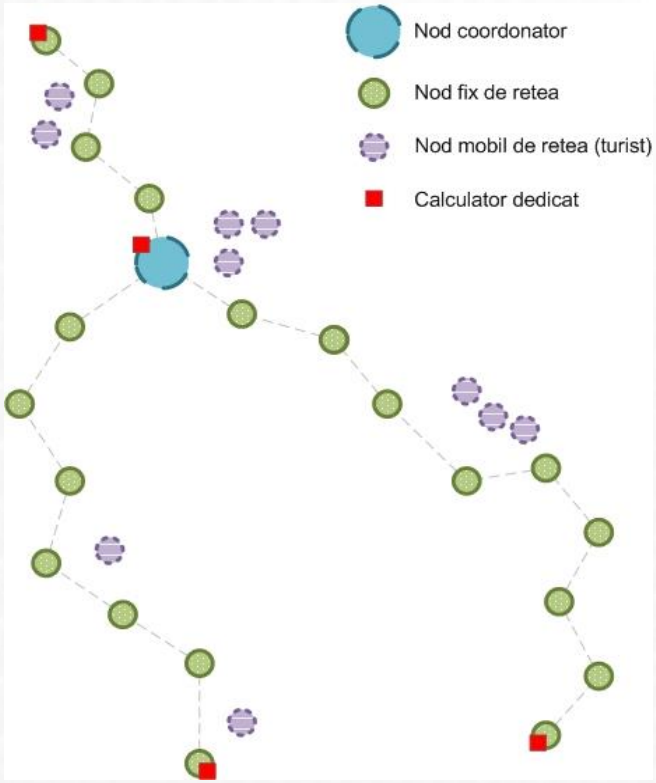


Other type of application

- *Partnership* Programme
- *SMTSM* – Designing, developing and implementing of a monitoring system for tourists in mountain spaces, with a view to increase the safety and to offer support in case of necessity.







Thanks a lot for your attention !

DEPARTMENT
AUTOMATICS AND INFORMATION TECHNOLOGY

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Strategic Program to Promote Innovation in Services through Open, Continuous Education
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