# MODERN DIAGNOSTIC EQUIPMENTS IN ENERGETIC MEASUREMENT

**Bártfai Zoltán[1], Blahunka Zoltán[1], Lefánti Rajmund[1],**
[1] Szent István University, Faculty of Mechanical Engineering
bartfai.zoltan@gek.szie.hu, blahunka.zoltan@gek.szie.hu, lefanti.rajmund@gek.szie.hu

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**Abstract:** wireless sensor network is a new technology at field of measurement. Our Institute use wireless sensor network in various applications. Wireless sensor networks are very useful in agriculture environment. It is able to measure in a big area, for a long time. Using ad hoc sensor network in HVAC application is also comfortable. Just place the sensors and ready for measuring. In this article we introduce a measurement what can help to optimize the heating system of our university.

## 1. DIAGNOSTIC, WIRELESS SENSOR NETWORK

The latest infocommunication technology systems extend our measurement possibilities. In our Institute we studied wireless sensor network for different applications. Wireless sensor network is a new concept in measurement. Small motes consist of power source, microcontroller, sensors and RF communication. They can measure the real world parameters and forward them into a data center.
What is it good for?
Using wireless sensor network we are able to measure
- in big area,
- for a long time,
- numerous types of parameters of real world environment.

The RF transmission uses special low energy protocol. ZigBee (IEEE 802.15.4 standard) is designed for low bandwidth communication. Measuring 5 parameters with 16 bit accuracy equals 10 bytes of information. Sending the parameters once per seconds needs very low bandwidth. Because of low energy the communication range is quite short. Depending on the RF chip and the amplifier the range can be some 10 meters, or some 100 meters.
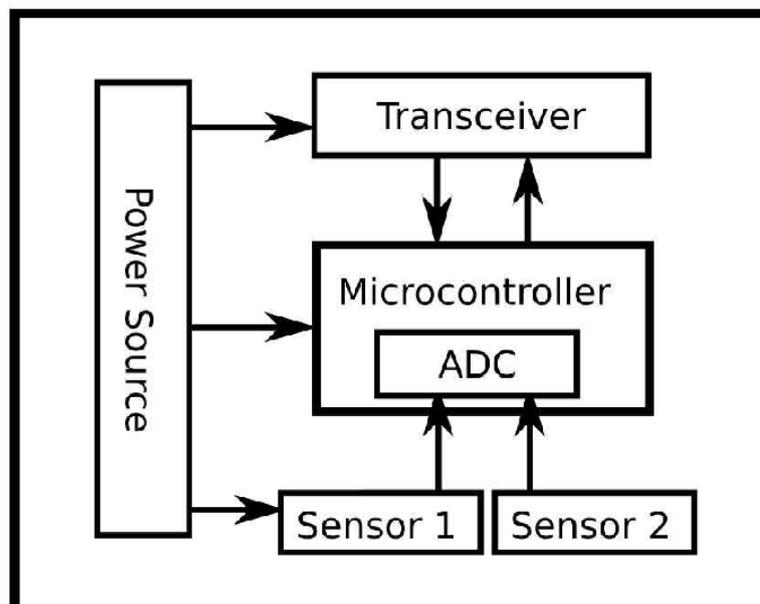


*Figure 1. block diagram of a wireless sensor network node*

As figure 1 shows the node consists all of the components for measuring, processing and sending the physical world parameters. The power source is usually 2 peaces of AA batteries. If charging is possible, we can use chargeable batteries. Batteries have the advantage of having a higher voltage level, so the RF communication range is bigger than in case of charging systems.

Microcontroller runs at some MHz that is enough to process ADC (Analog Digital Converters) and control the communication. Mote uses ADC to convert the sensor values into digital bytes. The mother board consists of all of the infrastructural components. Sensors are another peripherial extension board. So you can choose a sensor board with necessary sensors or simply use ADC converters with external sensors (for example special chemistry detectors).
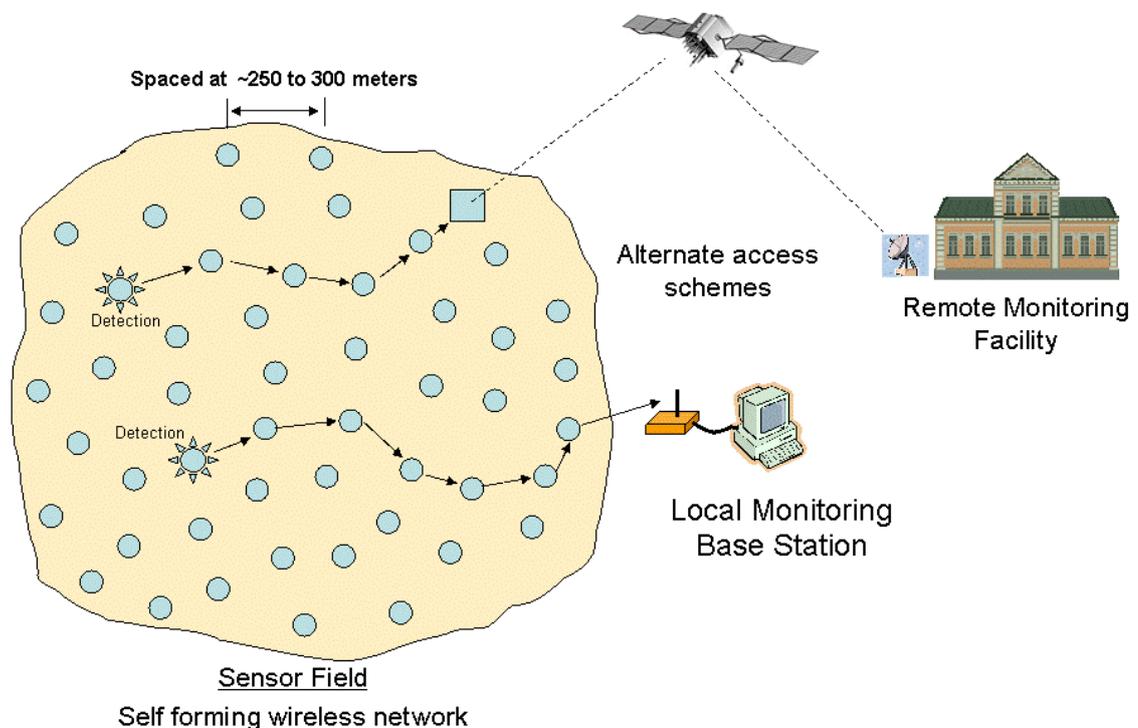


*Figure 2. Wireless sensor network architecture*

Figure 2 shows a tipical wireless sensor architecture. The small blue circle symbolises a mote. As mentioned earlier the mote is able to measure and send information. Because of limited RF range, the mote sends the information only to the closest neighbour. When neighbour receives the packet it sends it to the next neighbour until the packet arrives to the data center. The route of the data packet depends the topology of the current network. Usually there are many available routes to the data center. This makes wireless sensor networks very robost. Despite of one mote being crashed (for example due to low voltage) the rest of the network is still able to measure and communicate.

In the data center the measured values are stored in a database. The database can be any SQL storage. Our system uses Postgree SQL. The tables store the phisical values and some additional information, for example date and time of measurement, moteID

(name of the mote), voltage level of the mote, RF signal strength. Storing the values in a SQL database has many advantages:

- SQL servers can store large quantities of information (for example, measuring 100 points for a year)
- There are many tools to process data in SQL databases
- There are capabilities of remote access.
- Through the internet, we can reach the measurement information from any place of the world. This is a good way to share the measurement results.

Advantages of wireless sensor network measurement:

- using ad hoc network (no wires, no installation)
- collect information from a wide range (many places)
- long time measuring (months, years)

## 2. MEASURING

Our Institute planned the measurent of the temperature of a lecturing hall. (figure 3)
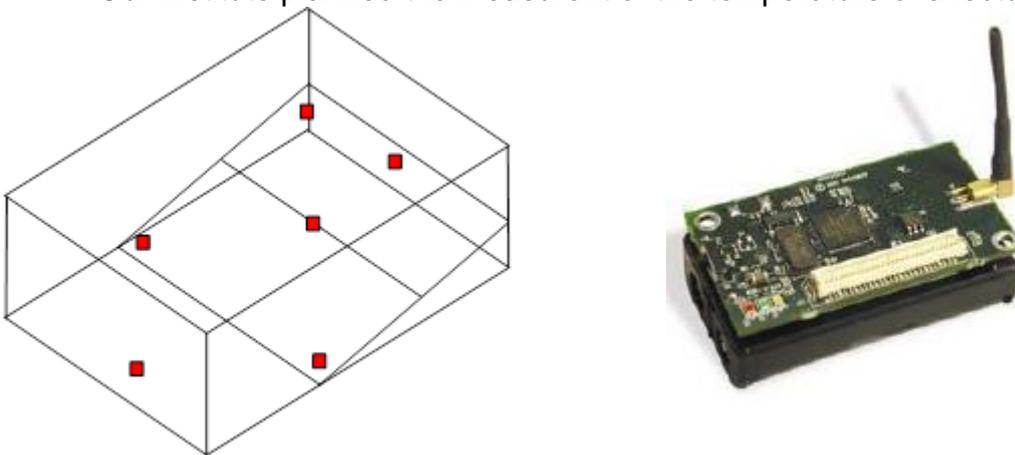


*Figure 3. Positions of motes in the hall, and a photo of a mote*

This measure represents the advantage of using wireless sensor network. After placing the motes, the network is ready for measuring. We would like to demonstrate the dependecy of temperature and vertical position.
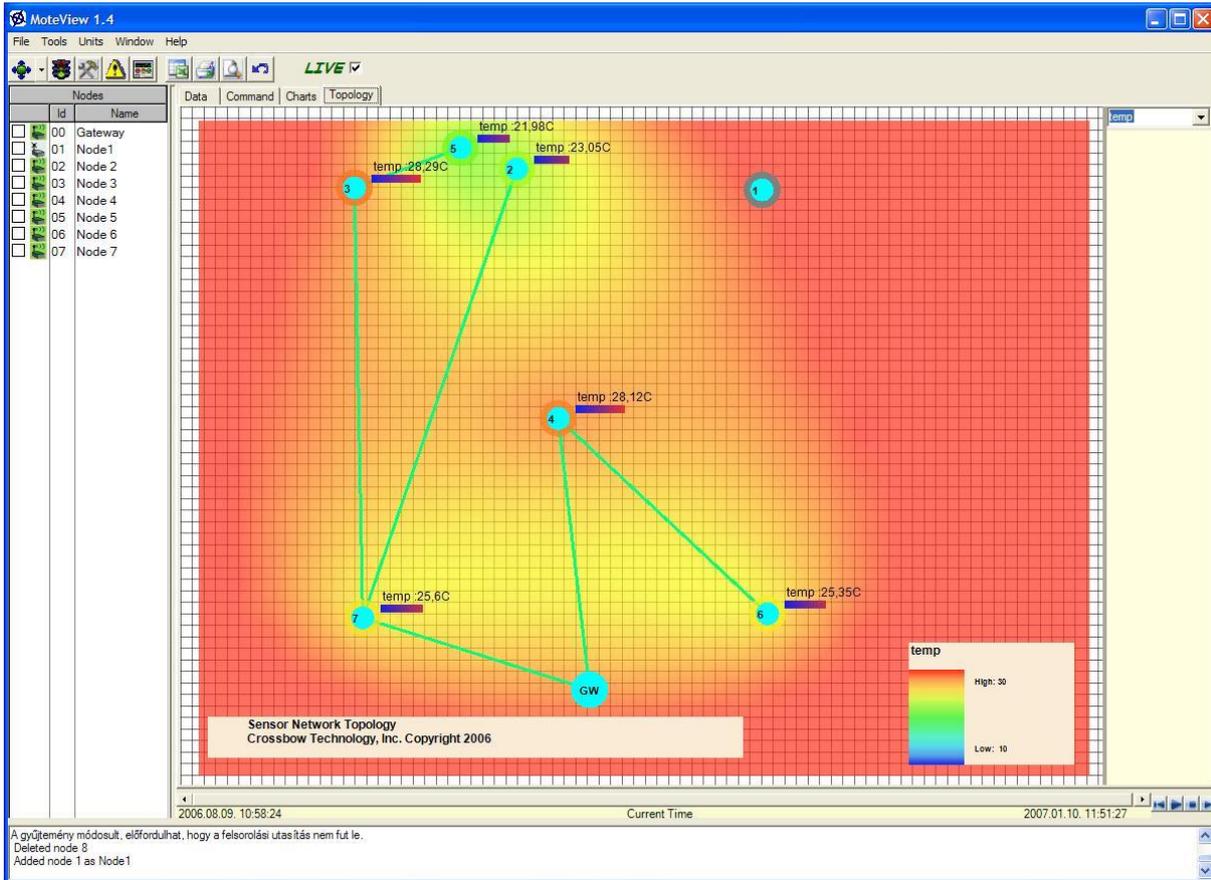
*Figure 4. Result of hall temperature measurement*

As figure 4 shows every point has a different temperature. As we expected the lower points have lower temperature while points in the end of hall are very warm. Students in 28 degree Celsius are not able to listen. Optimising the heating system can improve their concentration and in addition reduce the energy consumption.

The old heating controllers have just a few sensors. Using wireless sensor network we can get much more detailed information about a building's temperature.

Figure 4 shows the MoteView application. On the left pane there is a mote list. The colour of the mote shows its status: it is green when the mote have recently received a message. In case of a dead mote first it turns yellow, then red.

In the main screen there is a „map" of motes. It is not a real map, these motes don't have GPS or any other positioning system. The motes can be placed on the map by drag and drop, using the mouse. By placing the motes correctly on the map tab we can see level colouring just like on a traditional map's height levels. There are other tabs to check all detail information about wireless sensor network.

On the map tab we can check the radio connetions beetwen motes. For example only mote7 and mote4 are connected directly to the gateway. Other motes send the information through them. The longest route is mote5-mote3-mote7-gateway. Ad hoc topology is a big advantage of wireless sensor network as they enable self management - one doesn't have to configure the network connections, it chooses the best possible routing.

### 3. CONCLUSION

There are many new technologies among measurement systems. Sensor technology also developes rapidly. Sensors are getting each time smaller and smarter. The latest sensors have temperature compensation and automated calibration.

Wireless sensor networks can be very useful in many applications. In agriculture (quite big area), HVAC (heating, ventilation, and air conditioning) many measuring points in a building using this technology opens a new way of thinking. We are able to measure in much more detail as before. Optimising the energy consumption leads towards green engineering.

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