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USING OPEN-SOUCE HARDWARE FOR SOLAR POWERED WIRELESS SENSOR STATION RESEARCH

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Abstract: In recent period we are witnesses of the growing importance of Internet of Things, Wireless Sensor Networks and similar technologies. All these technologies have in common deployment of a large number of outdoor stations and nodes in certain scenarios. Because of the outdoor location of the nodes, as well the need for efficient energy consumption, the very important question, which emerged together with the implementation of these scenarios, is the question of sensor station power supply. The solar powered sensor stations show itself as the most efficient, economical, and practical and sometimes only possible solution for outdoor environments. In this paper is presented approach in using open-source hardware for building prototypes of solar powered wireless sensor stations. The sensor station platform is also presented in this paper, as well as the analyses of presented platform usage in academic institutions for research and teaching.
Keywords: solar powered sensor station, open-source hardware, wireless sensor station

INTRODUCTION

In variety of emerging technologies in modern days we are witnesses of the growing importance of IoT (Internet of Things) [1,2,3], WSN (Wireless Sensor Networks) [4,5] and similar technologies. Those technologies opened wide range of new possible usage scenarios such as smart cities, smart home, smart agriculture, smart environment, smart water, etc. All these technologies have in common one thing - the deployment of a large number of outdoor stations and nodes in certain scenarios. According to the prognosis in 2020 in world will be around 26 billion of intelligent devices [6]. The growth of IoT devices is presented in the figure (Fig. 1). Considering the large projected number of IoT devices the question of power supply for these nodes becomes more important. Importance of this question increases because it is realistic to expect that the large number of projected 26 billion of devices will be deployed at outdoor locations. So, the efficient energy consumption of sensor stations and need for avoidance of frequent battery changes in order to ensure enough supply power becomes main motivation for this research. The idea is to find the way to provide low-cost, efficient and flexible platform to be used in academic institutions for research and even teaching of these topics. Using this approach, the possibility to make experiments with application of solar powered sensor stations becomes reality in academic and research institutions with no pressure to their budgets.

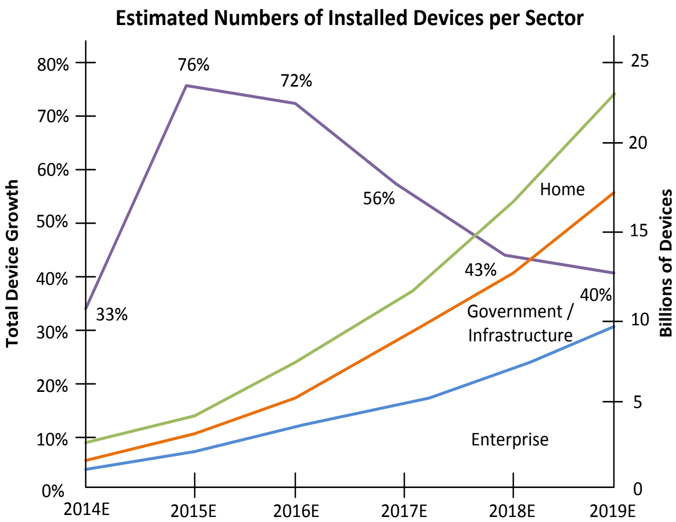

Figure 1. Estimated number of installed IoT devices in the World until 2019 [7]

In this paper is presented an approach of using open-source hardware platforms for solar powered sensor nodes in teaching and research at academic institutions. The paper is structured as follows: after the introduction, in the second chapter is presented the platform with its main components, together with the open-hardware principles. In the third chapter is presented the experience in usage of the proposed platform. The conclusion and the further work are given in the last chapter.

PLATFORM BUILT ON OPEN-SOURCE HARDWARE

Open-source hardware

According to the [8] Open Source Hardware (OSHW) Statement of Principles 1.0 - open source hardware is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design. The hardware's source, the design from which it is made, is available in the preferred format for making modifications to it. Ideally, open source hardware uses readily-available components and materials, standard processes, open infrastructure, unrestricted content, and open-source design tools to maximize the ability of individuals to make and use hardware. Open source hardware gives people the freedom to control their technology while sharing knowledge and encouraging commerce through the open exchange of designs.

Generally, this approach in defining the open-source hardware principles provided creation of the largely supported market with compatible and low-cost products. These principles also made those components more available and allowed the development of small electronic devices, especially in the field of IoT, accessible to everyone. In a way, open-source hardware principles powered up the development and expansion of IoT.

Solar powered Wireless Sensor Network platform

Platform presented in this research is build upon the Arduino Uno microcontroller board [9,10]. The components of the platform are presented in Table 1 and on Figure 2. The basic component of the platform is Arduino UNO. Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, etc. It is one of the most popular microcontroller board open-source platforms in the world. Considering it open design, there is variety of clone boards or similar boards of other producers that are available on the market. Due its wide popularity and number of variants it is hard to estimate how much copies are sold in the world up to date. Before, in our institutions, some research related to usage of this platform in academy courses [11,12] were made as well as on other academic institution throughout the world.

The solar charger shield is a stackable expansion board that enables battery power to the Arduino UNO. It allows usage of various batteries with voltage of 3.0V to 4.2V to shift it up for 5V output needed to Arduino. This shield is also designed to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit. The maximum current provided by the board can get up to 600mA which is more than enough for all Arduino configurations, a three times more than the power consumption of the presented sensor station. A micro USB connector, on the shiedd, is also useful to charge the battery connected directly to the PC via USB cable.

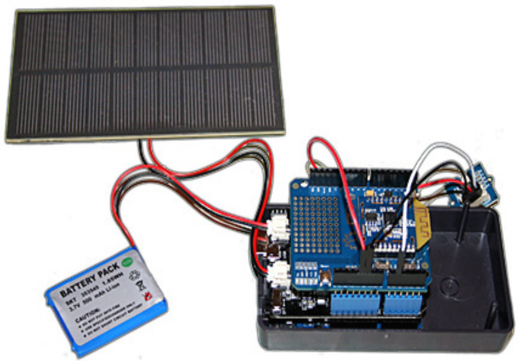

Figure 2. The solar powered platform based on Arduino UNO and solar shield

Table 1. Platform for solar powered wireless sensor station

No.	Item No.	Description
1	Arduino UNO Rev 3	Microcontroller board based on Atmel AT386
2	Solar Charger Shield v2.2	Expansion module designed to enable power from various batteries that has the voltage of 3.0V-4.2V to shift up for 5V output needed for Arduino, or to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit.
3	Solar panel	1.5W solar panel with dimensions 81x137mm
4	500mAH LiPo Battery	Polymer Lithium Ion battery 500mAh
5	XBee shield	Expansion module for Arduino designed for mounting communication modules based on Bee socket
6	Mesh Bee	Communication module design for ZigBee protocol
7	Temperature and humidity sensor	DHT22

Solar shield in this example is used in combination with the 1.5W solar panel with dimension 81 x 137mm. Solar panel is attached to the shield with 2-pin JST 2.0 PH connector. The solar panel is used to supply Arduino Uno and charge battery attached to the same board. The attached battery has smaller capacity - 500mAh and it is polymer Li-on battery. With the two LEDs on the board it can be seen if the battery is charged (red light) or if the battery is full (green light). With above components the autonomous power supply is provided, but the sensor station still lacks the communication and sensing capabilities.

In order to make this station outdoor sensor node, this station needs communication module and sensor. The communication module which is included in the configuration is Bee socket based module Seeedstudio Mesh® Bee [13,14]. MeshBee® is a 2.4 GHz wireless ZigBee RF module. It uses microchip JN516x from NXP that enables several different standards-based ZigBee mesh networking [15,16]. It supports ZigBee Pro stack. It has indoor/urban range up to 30m and outdoor line-of-sight range up to 100m. Its receive sensitivity is -95dBm, working frequency is 2.4 GHz and it operates at following data transmission rate: 4800, 9600, 19200, 38400, 57600 and 115200 bps. It has socket compatibility with well known Digi International XBee communication modules [4,17] (2 x 10-pin sockets). Its connectivity with Arduino solar platform is allowed using Tinysine XBee shield v2.

The Seeedstudio Mesh® Bee communication module on this solar station is configured as Router [4] and it has wireless communication with central network module with a role of Coordinator [4] attached to PC. This configuration with one Coordinator and one Router is needed in order to establish ZigBee network or ZigBee PAN. In this way, solar powered station transmits sensor collected data to the computer.

In order to make this station the sensor station, at least one sensor should be used. In this particular scenario is used digital temperature and humidity sensor – DHT22. This sensor collects the data and station send its every 10 seconds to the ZigBee Coordinator device directly attached to PC (Figure 3). The time period is determined with the program uploaded to the station. On a PC is installed simple prototype application for collecting the data with logging the received temperature and humidity values together with the code of the sending station, data and time of the data retrieval.

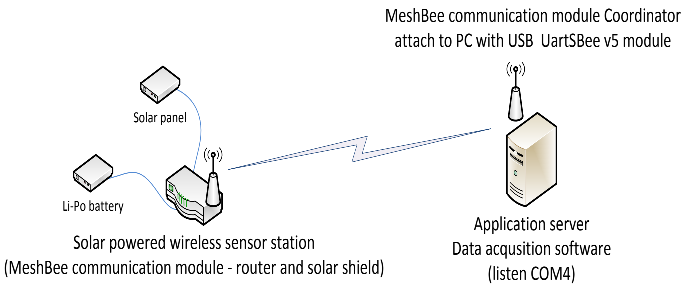

Figure 3. Network made with solar powered wireless sensor station

RESULTS AND DISCUSSION

The goal of this paper was to show the possibilities of using the open-source hardware in academic institution for the research related to solar powered wireless sensor stations. The platform presented in the second section of the paper is tested for a short time and it worked well during the testing period. The station is power supplied combining Li-Po battery and solar panel. The collected and successfully sent temperature data are presented at Figure 4.

During the operation, station collected temperature and humidity data and sent it via ZigBee network to the remote PC station. In this test conditions, the station is located only 5m from the sensor station. The longer ranges are possible as well up to 30m in indoor/outdoor non-line-of-site environment and up to 100m in line-of-sight conditions in outdoor environment. These ranges are declared by the manufacturer and they are proved by the experiments taken at our institution for indoor usage [18].

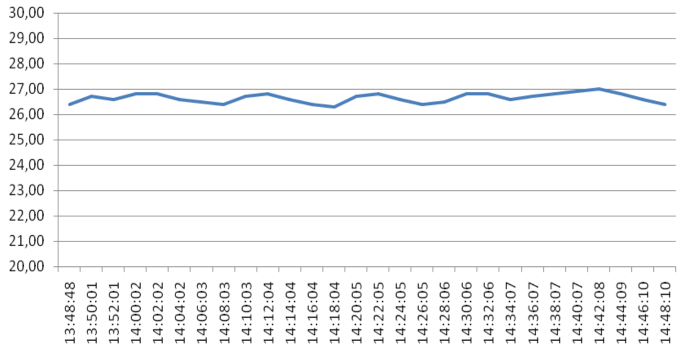

Figure 4. The measured values for temperature during the station test work

In this stage of the research, the process of monitoring and analyzing of solar charging, battery drain and behavior of the station under the different conditions connected to UV radiation intensity are not performed. One of the major obstacles for accurate and useful measurements is caused by two factors. One factor is that in this stage only one small capacity battery is available for the research. The second factor is rather high energy consumption needed to establish and maintain ZigBee connection. In order to continue the research on this topic, the power consumption of the solar sensor station should be measured and optimized as well. After that, the experiments with the higher capacity battery should be made as well as with the larger size and higher power solar panels.

Nevertheless, considering that Arduino platform is specially designed for DIY (Do It Yourself) projects and prototyping, all components are easy to assemble. This is a solder less platform which makes these stations easy to improve, reprogram and reconfigure. These capabilities make proposed platform very suitable for usage in the research at academic institutions. Also, this platform can be used in teaching process, because it will allow students much space for hand on labs and making experiments with different configurations.

CONCLUSION

In this paper it was presented the possible usage of open-source hardware at academic institutions for researches connected to the solar powered wireless sensor stations. This research is motivated with the growing importance of WSN and IoT platforms, and it has the special focus on outdoor deployed autonomous sensor stations.

Considering the enormous expansion and growth of the number of such stations projected for the next 5 years and beyond, the research connected with the most economic and most manageable power supply for such stations becomes important for the academic institutions and their researchers in multidisciplinary fields.

The open-source hardware offers low cost, well designed electronic components. One set of these components is used to assembly ZigBee based solar powered sensor station. Also, open-source hardware platform is used to form complete network for sensor data acquisition consisting in this case only with two nodes (Figure 3).

The created platform worked well during testing period and proved itself as a platform functional enough to be used in research facilities. Considering that this platform is easy to be reconfigured and that with additional equipment it may be used for monitoring and experimenting with the solar power wireless sensor stations and IoT devices, we can say that the proposed platform is useful and suitable environment for the research and teaching in academic institutions.

Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[19].

REFERENCES

[1] Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, John Wiley and Sons, Ltd., UK, 2014.
[2] C. Pfister, Getting Started with the Internet of Things, O’Reilly Media, Inc., USA, 2011.
[3] M. Schwartz, Internet of Things with the Arduino Yún, Packt Publishing, UK, 2014.
[4] R. Faludi, Building Wireless Sensor Networks, O’Reilly Media, Inc., USA, 2011.
[5] S. C. Mukhopadhyay, Wireless Sensor Networks and Ecological Monitoring, Springer-Verlag Berlin Heidelberg, Germany, 2013.
[6] J. Rivera, R. van der Meulen, Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units By 2020, http://www.gartner.com/newsroom/id/2636073, December 12, 2013.
[7] J. Greenough, “The 'Internet of Things' will be the world's most massive device market and save companies billions of dollars”, http://www.businessinsider.com/how-the-internet-of-things-market-will-grow-2014-10, Business Insider Inc, Apr. 14, 2015.
[8] Open-source Hardware Association, Official site, http://www.oshwa.org/definition/, retrieved, September 2015.
[9] M. Banzi, Getting Started with Arduino, O’Reilly Media, Inc., USA, 2009.
[10] J. Oxer, H. Blemings, Practical Arduino Cool Projects for Open Source Hardware, APress Press, USA, 2009.
[11] D. Dobrilovic, Z. Stojanov, B. Odadzic, "Teaching application development for RFID/ZigBee networks using open source hardware", Proceedings of 2014 IEEE X International Symposium on Telecommunications (BIHTEL), 27-29 October 2014, pp 1-6, DOI: 10.1109/BIHTEL.2014.6987641, Sarajevo, Bosnia and Herzegovina, 2014.
[12] D. Dobrilovic, Z. Stojanov, B. Odadzic, V. Sinik, "Platform for teaching communication systems based on open-source hardware", IEEE Global Engineering Education Conference EDUCON 2015, 18-20 March 2015, pp. 737 - 741, DOI: 10.1109/EDUCON.2015.7096051, Tallin, Estonia, 2015.
[13] O. Wang, MeshBee® Open Source ZigBee RF Module User's Manual, Seeed Technology Inc., 2014.
[14] O. Wang, MeshBee® Open Source ZigBee RF Module CookBook, Seeed Technology Inc., 2014.
[15] S. Farahani, ZigBee Wireless Networks and Transceivers, Elsevier Ltd., UK, 2008.
[16] H. Labiod, H. Afifi, C. De Santis, WI-FI, Bluetooth, ZigBee and Wimax, Springer, Netherlands, 2007.
[17] Digi International Inc. official site, XBee/RF Solutions, http://www.digi.com/products/xbee-rf-solutions, retrieved September, 2015.
[18] D. Dobrilovic, Z. Stojanov, V. Sinik, "Testing Zigbee RF module applicability for usage in temperature monitoring systems, Proceedings of IEEE International 22nd Telecommunications Forum TELFOR 2014, 25-27 November 2014, pp. 415-418, DOI:10.1109/TELFOR.2014.7034436, Belgrade, Serbia, 2014.
[19] D. Dobrilović, J. Pekez, E. Desnica, M. Lambic, Using open-souce hardware for solar powered wireless sensor station research, The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015