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WSN Open Source Development Platform: Application to Green Learning

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Abstract

The dominance of Wireless Sensor Networks (WSNs) in the area of physical computing is expected and is unquestionable. As happened to all the emerging technologies after receiving the attention of a significant number of researchers, in order to ensure long term existence, the dissemination of their use must spread over a wider audience through simple and efficient educational projects. Towards this direction the current paper presents the development of a prototype, open source, multilevel, educational system based on WSN principles and oriented to "green" technology applications.

Keywords: WSN; Open Source Prototyping; Green Learning; Visual Programming

1. Introduction - Motivation

The term of physical computing was introduced in order to describe the design and implementation of interactive physical systems by means of corresponding software and hardware that can sense and respond to the analog world. In the last twenty years, technological education has widely used digital technology (from personal computers to web-based technologies), leaving aside the use of traditional learning materials. Supported by the extensive use of powerful microprocessors (uP) the idea of using physical computing in students' experiments and projects could be an expected event. Unfortunately, we

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cannot state that there is a widespread use of this technology as this didactic resource faces two major difficulties: physical computing technology is expensive and teachers are not accustomed to working with software tools that need experience in developing and programming. Modern educational theories develop learning schemes that are based on the use of motivation when a student is faced with stimuli. The effective use of physical computing can provide informal learning in situ leading the students and users in a series of playful learning by following a specific chain of actions: Learning motivation – application demonstration – building practice [1].

WSNs proved their importance and are expected to dominate in physical computing applications the next years. A scientific area that seems highly benefited from WSNs is the environmental and renewable energy applications [2]. There is no doubt that today's students must include the above scientific area in their knowledge arsenal. Keeping in mind all the previous statements the next step that seems inevitable and expected: how we can combine WSNs as physical computing tools in order to provide environmental oriented experiments and educational projects for students. The advantages from such a learning approach are clear: deconstruction of traditional boundaries between distinct learning environments, strong search capabilities, interaction, effective learning and familiarization of state-of-the-art technologies. A learning environment capable of providing the above advantages must fulfil some basic requirements as below:

- Ease of use: Students without computer experience must be able to use.
- Adaptability: student's needs and skill must define system's boundaries
- Suitability: Subjects must provided with various ways of gathering the learning outcome (e.g. a solar energy experiment must be carried out by means of different sensors)
- Availability: operations and functions must be available using simple procedures (e.g. adding a new set of sensors must be a common procedure independent from sensors' type)
- Usefulness: actions and dissemination must be in familiar forms

Learning through physical computing and especially by means of WSN has shown slow growth because the configuration of such an infrastructure requires knowledge that usually teachers do not have. The challenge here is how we are able to provide hardware and software platforms that will engage the use of WSNs in school projects and experiment and will fulfil the above requirements.

Our proposal merges the use of open source solutions along with a newly developed graphical user interface (GUI). Under this approach schools can purchase low-cost material and sensors. Hardware implementation is based on the Arduino [3] open source prototyping platform which ensures implementation easiness and expansion simplicity. The corresponding software is based on the Processing [4] language along with kid's oriented GUI.

2. Design and Implementation

2.1. Hardware

The hardware modules consists of four subsystems: i) the data logging and controlling block, ii) the sensors block, iii) the communication block, iv) the processing block. Communication block is based on ZigBee modules. The datalogging and controlling block as well as the processing block are built around the Arduino modules which based on AVR's ATMega328 uP. It is not the most appropriate solution for building WSN (since it doesn't provide extensive sleep modes and doesn't offer the embed level of other WSN oriented uPs) but it has several advantages over similar approaches [5-7] that will overcome the above limitations:

- Rapid prototyping: from the initial design to the final product only few simple steps required
- Standardisation of add-on modules and extensions: Each hardware module (e.g. sensor, actuator e.t.c) is built following specific hardware rules and comes with corresponding libraries. End users grab plug-n-play modules, decreasing rapidly the prototyping time

- Open source hardware - Very low cost -Extremely popular: There are more than 100,000+ Arduinos on the market, a number that is rapidly growing [8].

Each hardware module can operate in two modes: as node module or as base station (Fig.1). The node module holds also the sensors and the ZigBee radio (used as router) whereas the base station is equipped only with ZigBee radio (used as coordinator). Node modules used to acquire data, possibly pre-process them and send them through base station to students' computers for further processing.

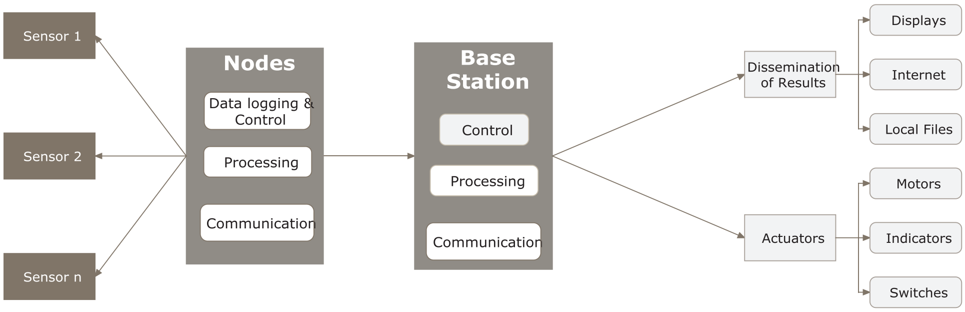


Fig. 1. Architecture of the system, in block diagram form representing the data flow

2.2. Software

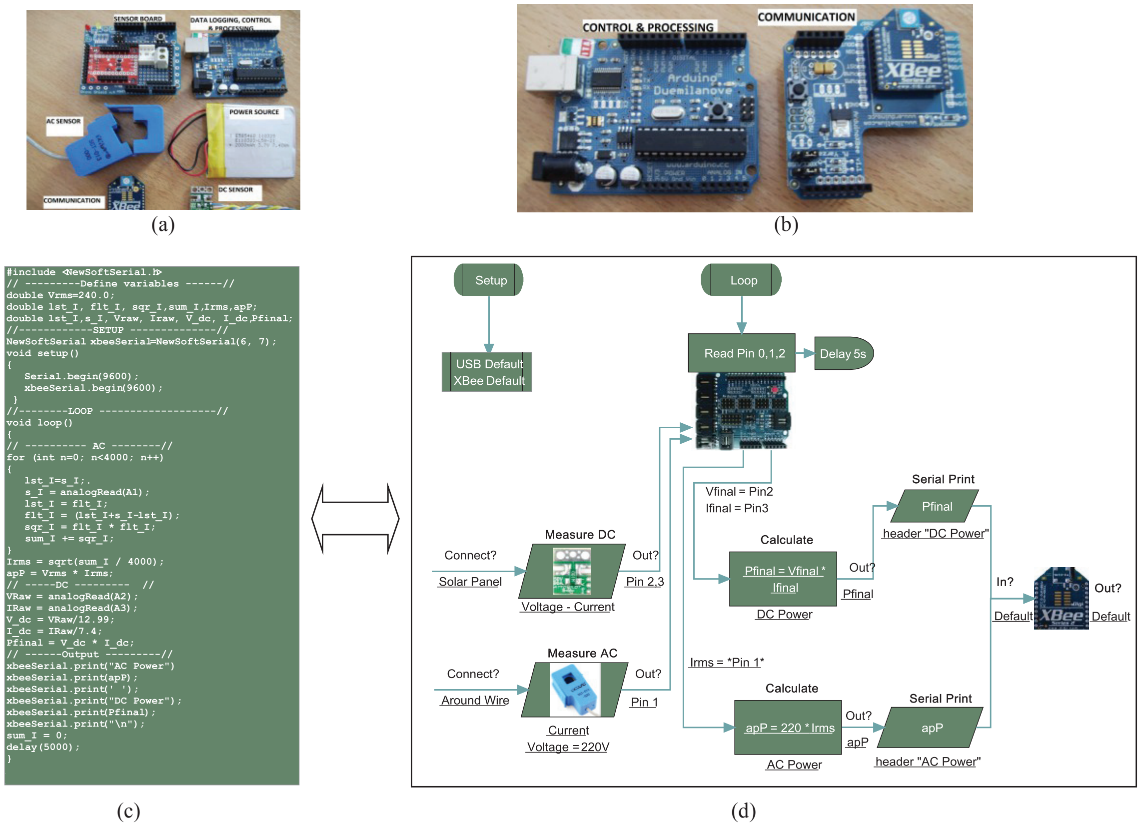
From the scope of the project, it is obvious that the final users must not be forced to handle communication parameters such as ZigBee channels, addresses, negotiation schemes etc. The communication part of each hardware module is embedded in the code that will be loaded in every programming cycle in order to relax the users from configure the ZigBee radios: Every time a new code is uploaded to the uP, the preconfigured ZigBee code block is uploaded also. A typical structure will contain two main structures: setup (responsible for initialization and configuration) and loop (the main program which runs continuously.

The software for programming the Arduino uP (and through them building the WSN projects) is public available (http://arduino.cc/en/Main/Software). There is no need to alter this programming environment since it proved its reliability. For this reason we focus on the adaptation of a visual programming environment that will be very easy for students to use it. The concept of the proposed GUI is to allow students to define their programming procedures simply by dragging graphical objects and connecting them to create a sequence of actions from sensing to publish results. It is implemented in Java and results are provided in various forms that are familiar to students' knowledge: webpages, real time plots, csv text files and libraries for publishing to popular social networking sites.

3. Case Study

The use of renewable resources belongs to the foundations in environmental-friendly projects. Towards to this direction we present a solid experiment that facilitates students to environmentally oriented school projects. Students must calculate the energy balance between a set of renewable resources and consumer device. Energy provided by solar panels and wind generator where the consumer device is a light bulb. Students must measure the charging current that provided by renewable energy resources using two modules, the consuming energy by a third node and sending the data to the data station (the fourth module) which is connected to a PC. By using simple calculation formulas they are able to derive approximative results about the produced and consumed energy. In this way they form a mesh WSN without focusing on its design and implementation but only on its functionality which is the wireless transmission of sensors' measurements. Details of the implementation are provided in Fig.2

Subsequent use of similar experiments could lead the students to extensive use of sensing the environment study projects, stimulate them for the concept of power saving while at the same time introduce them safely to the concepts and uses of WSNs.




```
#include <NewSoftSerial.h>
// ---------Define variables ------//
double Vrms=240.0;
double lst_I, flt_I, sqr_I,sum_I,Irms,apP;
double lst_I,s_I, Vraw, Iraw, V_dc, I_dc,Pfinal;
//------------SETUP --------------//
NewSoftSerial xbeeSerial=NewSoftSerial(6, 7);
void setup()
{
   Serial.begin(9600);
   xbeeSerial.begin(9600);
 }
//--------LOOP -------------------//
void loop()
{
// ---------- AC --------//
for (int n=0; n<4000; n++)
{
   lst_I=s_I;.
   s_I = analogRead(A1);
   lst_I = flt_I;
   flt_I = (lst_I+s_I-lst_I);
   sqr_I = flt_I * flt_I;
   sum_I += sqr_I;
}
Irms = sqrt(sum_I / 4000);
apP = Vrms * Irms;
// -----DC ---------  //
VRaw = analogRead(A2);
IRaw = analogRead(A3);
V_dc = VRaw/12.99;
I_dc = IRaw/7.4;
Pfinal = V_dc * I_dc;
// ------Output ---------//
xbeeSerial.print("AC Power")
xbeeSerial.print(apP);
xbeeSerial.print(' ');
xbeeSerial.print("DC Power");
xbeeSerial.print(Pfinal);
xbeeSerial.print("\n");
sum_I = 0;
delay(5000);
}
```

Fig.2. (a) Node module; (b) Base station module (for PC connection); (c) Raw code implemented in the measuring node and (d) Visual programming using the proposed GUI

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