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ATTENDANCE CONTROL SYSTEM ON THE BASIS OF WIRELESS SENSOR NETWORK

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ABSTRACT

The common problem of attendance control can be applied to all the areas of human activities - government sector or commercial. Usually it necessitates to create specialized IT infrastructure to solve this problem, for example the electronic gates in the airports, the electronic barriers in the offices and business centers.

This paper is dedicated to the development of attendance control system on the basis of the wireless sensor network (WSN), particularly for the students attendance examination during the academic year. We propose the solution that can be integrated into different kind of environment without necessity of complicated IT infrastructure changes.

General Terms
Information technologies, Efficency, Design, Implementation

KEYWORDS: Wireless sensor network, data acquisition and processing, sensors, card readers, statistics.

INTRODUCTION

The active development of WSN solutions have been started at the beginning of last decade, due to the high technology level, that allowed to produce cheap elements of micro electronic devices. WSN is the indispensable foundation for the Internet of Things concepts, that include telemetry, wireless data transfer, different sensors and power supply elements [1]. The main feature of WSN lays in the topology of data transmit and retransmit through the nearest neighbors, that makes this network very flexible, sustainable and durable against the damages and nodes loss. Such features make WSN applicable to the conditions where the building of cable network is not possible or too expensive. The core elements of the WSN is the sensor module, that is able to send information through the radio channel, named Mote, and the retransmit station (transmitter), that can receive signal from the Mote and send it further to the destination address through the pre-configured network topology. The Mote originally consists of 4 elements: the radio tract; processor, battery and sensor of different type (light, infrared, sonar, temperature, humidity…). The retransmit module is the joint knot between different Motes and the central processing and storage system, that is able to receive data, accumulate data from different Motes and then send them further according to the data flow path. The existing specification of WSN includes the possibility of Motes and Transmitters failure, and due to that fact introduces the ability of the data exchange path change according to the current state and position of all the elements in the WSN. Hence that, WSN technology allows to solve multiple problems of resource monitoring and management. The more detailed information about WSN contained in the IEEE 802.15.4 specification [2].

The two level hierarchical topology WSN introduced in this paper is used to design attendance control system for the students during the academic year that allows to get rid of the paper control by instructors.

The paper covers technical problems of WSN design process – characteristics configuration of wireless devices to choose the optimal power supply, transmitter and receiver according to the building topology construction to provide

best price and reliability. The integration of hardware and software solution problem into full circle electronic control of education process.
The proximity cards readers are considered to be used as sensors, integrated into wireless network device called Mote, that are mounted in the wall in classes. The usage of wireless Motes allows reducing costs on the infrastructure changes – such as power lines and data cables, because Motes work from integrated autonomous battery power supply.

The Service Oriented Architecture (SOA) [8] is considered for design and modelling of centralized software with ability of integration additional modules and existing information systems.

The problem of attendance control today is one of the monitoring elements for the students' progress. Most of the Universities has their own centralized security system for the entrance control on the territory integrated with borders nowadays. This paper proposes further integration of proximity cards readers used for entrance control to the University territory, for solving the problem of attendance control. The proposed WSN solution for this particular problem is considered as an optimum between price and reliability, because it does not require the infrastructure changes in local wired network and power supply. The process of attendance control is becoming more reliable, objective and seamless using proposed solution.

The automation of this process provides the ability to obtain automatic statistics data:

- The total percentage of attendance for profile courses;
- The total number of absence;
- Dynamics of attendance for each course.

There are already many use cases of WSN solutions around the world. This paper describes the particular solution for student attendance control that can be extended to solve many other problems of campus including safety using existing topology and additional sensors integrated.

MODELLING

WSN has not only great features, but also features that impose limitations on using it. Among the limitations are – low speed of data transfer, and low distance between devices. This paper proposes two level topology, where on the first level we have sensor devices – Motes, and on the second level – transceivers. The task of the Motes is to gather information from EM-Marine [7] sensor type and produce led or sound indication of successful data processing and transfer. The data transfer uses delivery status protocol.

The content of the data package should have identity number of the card and the maintenance status of device (the energy bank, device status). The preferred position of Motes – is the inside area of each class close to the door, that makes it convenient for the students to put their proximity card during entrance for the lesson, and also makes impossible to put the card to the sensor being outside of the class. The battery capacity should be configured to maintain work through all academic year – 2 semester, around 9 months. All devices should have their identification number and registered in the spatial model of the building, for quick and easy maintenance of them.

Hereby the task is not only in the design of WSN, but also in the development of specialized software for the conducting all concerning business processes.
The typical Mote topology to create the WSN is illustrated on Image 1.

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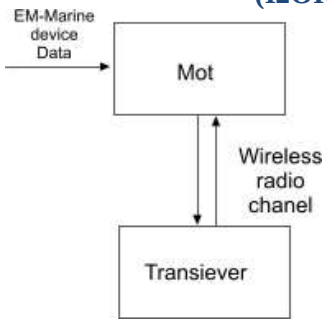

Image 1 – Device Topology

The image demonstrates the data flow diagram and the device work schema. The image 2 depicts necessary configuration of each Mote.

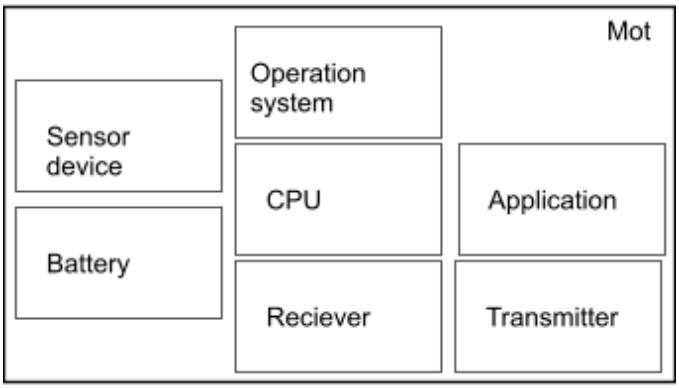

Image 2 – Device Configuration

The image shows the components, that allows to function the Mote as desired for building designed topology of WSN. The data transfer protocols are to be designed and modeled using the specialized software AnyLogic and TermWare [3].

The proposed configuration of WSN uses Motes and Transceivers. Thus the task require the design and modelling position of each element of the network, according to appropriate coverage and distances between Motes and Transceivers, also the type of the construction imposes limitations – the consistence of the walls and doors [4]. The image 3 shows the example of the positioning schema of Motes and Transceiver mounted in the building.

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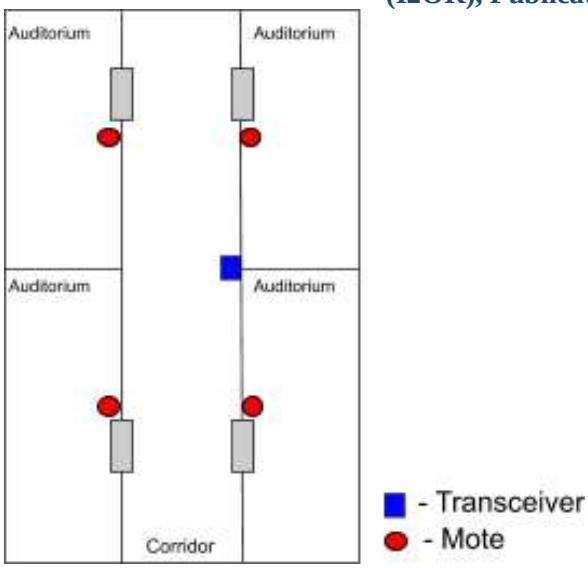

Image 3 – Network Concept

The image shows that all Motes should be in the direct accessibility for the Transceiver using the radio channel. In this particular example we have implemented the simplest model of classrooms disposition, that allows to cover many Motes by only one Transceiver. We consider that real building construction can be different and WSN elements disposition will depend on architectural features of the building. In this case it is obvious to use specialized instruments to make it possible to calculate optimal disposition of devices according to the environmental conditions.

We can find different approaches of building the WSN in the literature – the directional and omni-directional spots [5]. The image 4 demonstrates different coverage patterns that can be used.

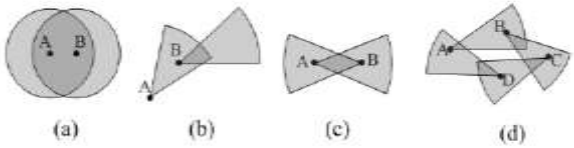

Image 4 – The coverage types of wireless network

The (a) part of the image shows omni-directional spots, and all others are possible configurations of directional spots.

In the task of choosing the right approach it is important to take into consideration the difficulties in the adjustment of directional spots, beside their energy and distance efficiency. In the development and design of WSN solution for our problem we considered that the most effective approach will be the Omni-directional motes, that can be placed anywhere without additional adjustments, and directional Transceivers, that can cover long distances such as corridors.

ARCHITECTURE

The designed architecture is supposed to use Service Oriented Architecture (SOA) approach in the development of the software that provides agile scalability – horizontal and vertical.
For the designed model it is necessary to create next software packages:

1. The Motes application;
2. Transceivers application;
3. Centralized software for the server to process and store data acquired by the Motes.

The system architecture design requires next steps:

- The equipment and mount of WSN in the area (for example University) with Motes, integrated with EM-Marine readers. Each auditorium should have such device, mounted in the wall close to the door;

- Provision of EM-Marine type proximity cards to all the students;
- Connect al the courses to their classes according to the schedule;
- Each student should use his card to verify his attendance by putting it to the reader, mounted in the wall till hearing the positive sound check or led signal.

The data processed by Mote should be sent automatically to the Transceiver and further to the central server of data processing, storage and analysis.

For the development of the application server for data storage and processing it is considered to use open source solutions and multiplatform programming languages, that allow to create multiplatform software independent from operation system platform. In this particular case it is supposed to use Java [9] language and Spring Framework [10] as core component and the MySQL Community Edition [11] as Relational Database Management System (RDBMS). First of all let's determine all core Entities that will be used to design architecture of intended model:

- The Card – named entity determined by next characteristic – card type, unique number. Each physical card has very long period of life thus it can be transferred from graduated student to new one. The price of the card is low, so that it is not critical to consider the percentage of loss. The student entity will not be created in the schema to avoid the duplication of data in integration processes.
- The Mote – named entity determined by the next characteristics – type of the Mote, the production date and the last maintenance date, the position in the building, the registration number and the date of next battery change.
- Transceiver – named entity determined by – type, production date, position in the building, conditions data.
- Logs – named entity to collect all the information acquired by the Motes with integrated sensors. Particularly – the event date (generated by server software), EM-Marine card number.
- System logs – named entity to collect all system messages received by transceivers from motes. The table will collect additional information that is delivered as a part of the package with event from Mote.
- User – named entity required to provide access to the system and modules. Determined by name and login as minimal fields to make the model accessible.
- Roles – named entity to determine the authority levels for each user for the system and modules.

The designed entities model has the relational schema depicted in image 5.

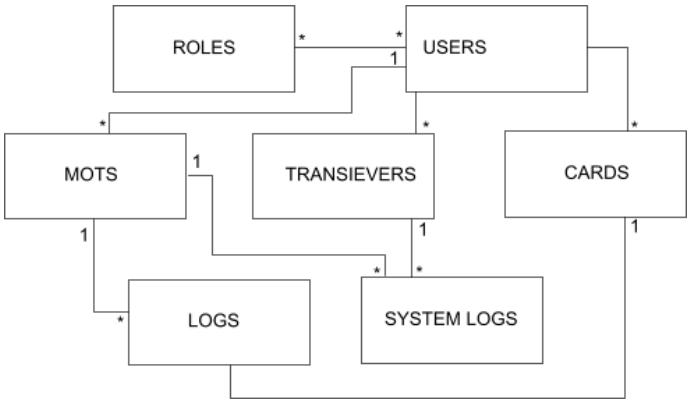

Image 5 – ER Diagram

As we can see, the foundational relational model is simple and does not contain the complicated cardinalities that could lead to productivity issues. The main task is to collect data from WSN, and nothing more.

For the implementation of business process it is necessary to design computational software models and modules that should be next:

1. The module of data acquisition and state store and presentation;
2. The WSN design and modelling module;
3. The attendance control module;
4. The Integration modules with ERP and Scheduling Systems;
5. The Administrative module.

Image 6 demonstrates the schema with modules that constitute the core elements of the attendance control system on the basis of WSN solution.

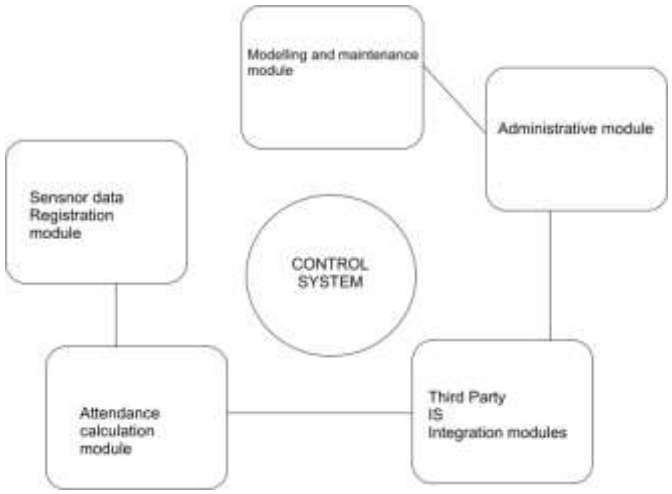

Image 6 – The System Modules Interconnection

DISCUSSION

Proposed solution has number of advantages comparing to the classical wired infrastructure solutions. Such solution can be deployed in any kind of environment, does not require the cable mount, hence it reduces costs. Several disadvantages such as the limited operation term of Motes that is dependent on battery bank capacity and the data throughput should be considered. Problem of losses of cards by students that they have to bring with them and put them to the sensor every day exists too. There are solutions where it is not necessary to touch sensor element with identity card like Radio-frequency identification (RFID), such technologies are based on Digital short range communication (DSRC) standard [6], and make it possible to register object in the range to 50 meters, that can be applied further to solve the attendance control problem. DSRC standard is widely used in the road traffic monitoring problems, toll roads and parking centers solutions.

SUMMARY

The ZigBee specification is already more than 10 years old. The specification determines the stack of the protocols, the lowest level of which uses the standard IEEE 802.15.4. For today we have many evidences of creation practical solutions using WSN, among which are – the control system of energy and water consumption, the centralized heating management systems, security systems, fire safety systems, the labor security systems under bad conditions, the quality dispatching and control systems and many more other applications.

The invasion of the WSN – is everywhere. And the number of tasks that can be solved by rational implementation is growing from day to day.

The provided solution in this paper allows to level up the automation process of attendance control, and is part of the complex development of Smart Campus concept.

The three main tasks of this paper can be determined as:

1. The design of technical solution – integrated sensor device with Mote type transceiver;
2. The optimization problem of device configuration and network topology according to the environmental conditions;

3. The design of SOA software for student attendance control in the Universities.

The proposed solution of these tasks allows totally exclude the human efforts from the business process of student attendance control, that provides objective calculation of student progress and course acquisition and also provides the new instruments for university business processes analysis, the monitoring of students interests and motivation, the trends analysis and more.

By the application of WSN solution we get the advantage to reduce costs on infrastructure changes in the task of attendance control system development. Also – developed only once it provides the ability to increase the number of sensors by using the same topology to solve other tasks, such as security, fire safety, labor safety etc.

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REFERENCES

[1] Kucheryavyi A.E., Internet of Things, Electrosviaz, №1, 2013
[2] Trifonov S.V., Holodov Y.A., Research and optimization of wireless sensor network on the basis of ZigBee protocol, Computer researches and Modelling, T.4 №4, P. 855-869, 2012
[3] Doroshenko A.E., Zhereb K.A., Shevchenko R.S., Using the high level modelling software for wireless sensor network design, Programming problems, №2-3 (Special Edition), P.718-727, 2006
[4] Fielding R., Architectural Styles and the Design of Network-based Software Architectures, Dissertation, 2000.
[5] Zuoming Yu, Jin Teng, Xiaole Bai, Dong Xuan, Weijia Jia, Connected Coverage in Wireless Networks with Directional Antennas, ACM Transactions on Sensor Networks, Vol. V, 2012
[6] Kenney J.B., Dedicated Short-Range Communications Standards in the United States, Toyota InfoTechnology Center, P.1162-1182, 2011
[7] Raghu Das and Dr. Peter Harrop, RFID Forecasts, Players and Opportunities 2014-2024, IDTechEx (http://www.idtechex.com/research/reports/rfid-forecasts-players-and-opportunities-2014-2024-000368.asp?viewopt=desc), 2014
[8] Vinay Singla, The Overlapping Worlds of SaaS and SOA, Microservices Expo, SYS-CON Media, Inc., 2009
[9] Richard Harris, Java Still Top Programming Language Thanks to Objective-C, AppDeveloper Magazine, 2015
[10] Mak, Gary, Spring Recipes: A Problem-Solution Approach, Second ed., Apress, 2010
[11] Baron Schwarts, Peter Zaitsev, Vadim Tkachenko, High Performance MySQL: Optimization, Backups, Replication and More, Second ed., O'Reilly, 2008.