Model conception and functional testing of Internet - ZigBee based system for measurement and control

Ivo Dochev[1] and Rumen Arnaudov[2]

Abstract – **This paper presents the model conception of Internet-Zigbee based system for measurement and control. The model defines bloke diagram and parametric method for functional testing.**

Keywords – **measurement and control, Internet, ZigBee.**

I. Introduction

The remote measurement and control require communication area to be build. An opportunity is the using of computer networks. This enables the measurement and control realization without building new communication networks. Another possibility is the using of ZigBee wireless network. Thereby avoiding the need to place communication cables, to ensure coverage of a given measurement territory.

The purpose of this paper is to define the model conception of Internet-ZigBee based system for measurement and control. This article has proposed a mathematical model that allows using a test to determine the probability of occurrence of error. This in turn is directly related to the quality of the services.

II. Model conception of Internet-ZigBee based system for measurement and control

The model conception of Internet based system for measurement and control is shown on Fig. 1 [1, 2, 3, 4]. The model includes: user part, a measurement part, and a communication area (local area network, Internet and ZigBee network)[5, 6, 7]. The user part includes the user communication program. The measurement part includes: the control and measurement system, the measurement procedure manager, the data store manager, ZigBee communication modules and ZigBee network.

The algorithm describing processes in the model of Internet-ZigBee based system for measurement and control, is shown on Fig. 2. The algorithm starts with user connection to the Internet server by communication program. After legally registration the user chooses the measurement mode and channel. The user can choose different control points that are separate from the location of each measurement ZigBee modules. The next step is the configuration data transmission to the computer network. After data receiving the Internet server starts the initialization the ZigBee network process of measurement control. After receiving the measurement data the software program performs data processing of the selected parameters and transmits them back to the user. The data obtained are displayed in graphical and tabular form. The algorithm finishes with two options. The first option is the program return to the main menu, and start of a new measurement. The second option is ending of the program.

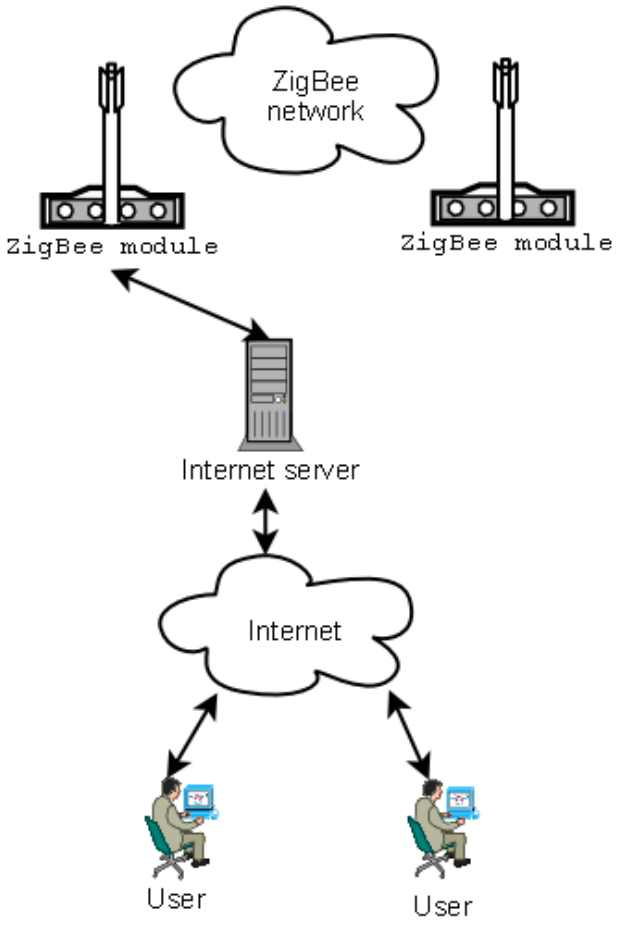

Fig. 1. The block diagram of the Internet-Zigbee based system model for measurement and control

[1]Ivo Dochev is with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: idochev@tu-sofia.bg.

[2]Rumen Arnaudov is with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria. E-mail: ra@tu-sofia.bg.

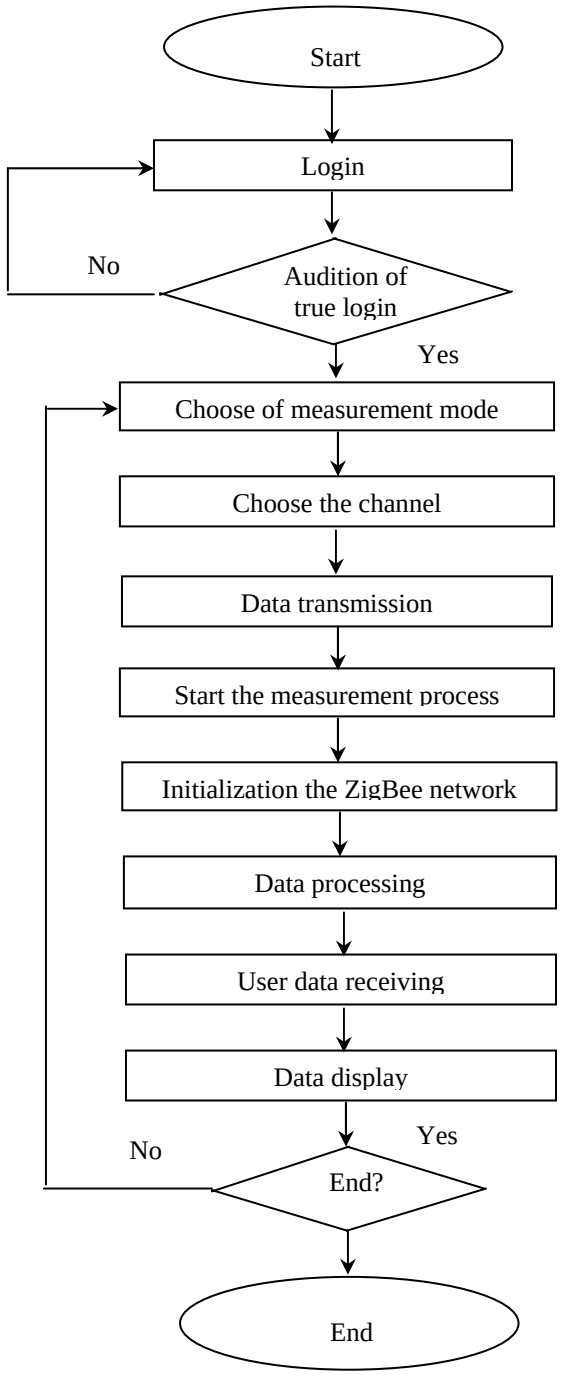

Fig. 2. The algorithm implemented for processes in the Internet-Zigbee based system model for measurement and control

III. PARAMETRIC METHOD FOR FUNCTIONAL TESTING OF THE INTERNET - ZIGBEE BASED SYSTEM FOR MEASUREMENT AND CONTROL

The model conception of Internet-ZigBee based system for measurement and control, allows five group of parameters to be defined:

- User – defines the user interface parameters;
- Net - defines the computer network parameters;
- Prog - defines the program part parameters;
- Dev - defines the measurement system part parameters and ZigBee network;
- Conn - defines the association parameters between the program and measuring system part.

Therefore, the parametric method for functional testing can be described by the following equation [5]:

$$IVIQM = IVIQM_{\text{User}} + IVIQM_{\text{Net}} + \\ + IVIQM_{\text{Prog}} + IVIQM_{\text{Dev}} + IVIQM_{\text{Conn}}, \quad (1)$$

where IVIQMUser, IVIQMNet, IVIQMProg, IVIQMDev, IVIQMConn are the particular matrices.

The matrix IVIQM defines the realization quality of Internet-ZigBee based system for measurement and control. The matrices IVIQMUser, IVIQMNet, IVIQMProg, IVIQMDev, IVIQMConn define the realization quality of different groups (user interface, computer network, program part, measurement system part and association parameters between program and measure system parts). Every one of the matrix can be defined as product of parameters element matrix and weight element matrix [8]:

$$IVIQM = \sum_{l}\sum_{i,j} k_{i,j} = \sum_{i,j}\left(u_{i,j} w_{u\,i,j}\right) + \sum_{i,j}\left(n_{i,j} w_{n\,i,j}\right) + \\ + \sum_{i,j}\left(p_{i,j} w_{p\,i,j}\right) + \sum_{i,j}\left(d_{i,j} w_{d\,i,j}\right) + \sum_{i,j}\left(c_{i,j} w_{c\,i,j}\right), \quad (2)$$

where $\|k_{i,j}\| = \|r_{i,j}\| \otimes \|w_{i,j}\|$, $r_{i,j}$ are elements of the parametric matrix (**u**, **n**, **p**, **d** and **c**), $w_{i,j}$ are elements of the weight matrix, l is The number of defined groups.

The parametrik matrices are defined as follows:

- u is the matrix of parameters related to the user interface, and w_u is its weight matrix,
- n is the matrix of parameters related to the network, and w_n is its weight matrix,
- p is the matrix of parameters related to the program part, and w_p is its weight matrix,

- d is the matrix of parameters related to the measuring system and ZigBee network, and w_d is its weight matrix,
- c is the matrix of parameters related to the associations between the program and measuring system part, and w_c is its weight matrix.

All elements of matrices u, n, p, d and c are technical parameters of particular function or combination of functions. Sizes of matrices are defined by number of technical parameters. The matrix **u** can be presented in the form [8]:

$$\mathbf{u} = \begin{vmatrix} u_{1,1} & u_{1,2} & \cdots & u_{1,j} \\ u_{2,1} & u_{2,2} & \cdots & u_{2,j} \\ \vdots & \vdots & \vdots & \vdots \\ u_{i,1} & u_{i,2} & \cdots & u_{i,j} \end{vmatrix} \quad (3)$$

The user interface parameters include: kind of communication program, setup of regulation, selection of measurement parameters, displaying, storing, and data processing. Parameter values are defined by the following equation [8]:

$$u_{i,j} = \begin{cases} \dfrac{N_\mathrm{b}}{N_\mathrm{t}}, & N_\mathrm{t} \neq 0 \\ 0, & N_\mathrm{t} = 0 \end{cases} \quad (4)$$

where

- N_b is the number of incorrect behaviors;
- N_t is the number of carried out tests.

Analogously to matrix u matrices n, p, d and c can be built up, corresponding to the user interface, the network, the program part, the measurement system part and the association parameters between program and measure system parts, respectively.

The weight matrices w_u, w_n, w_p, w_d and w_c are built in the manner analogous to the matrices u, n, p, d and c. It means that each weight corresponds to specified parameters or a combination of parameters. The weight matrices can be built up according to the measurement scenario or to the model base on the data flow and data processing scheme in Internet based system for measurement and control.

Hence the architecture of the weight matrix w_u is [8]:

$$\mathbf{w}_u = \begin{vmatrix} w_{u1,1} & w_{u1,2} & \cdots & w_{u1,j} \\ w_{u2,1} & w_{u2,2} & \cdots & w_{u2,j} \\ \vdots & \vdots & \vdots & \vdots \\ w_{ui,1} & w_{ui,2} & \cdots & w_{ui,j} \end{vmatrix} \quad (4)$$

The weight value is defined by the equation [8]:

$$w_{ui,j} = P(A \cap B) = P(A) * P(A/B) \quad , \quad (5)$$

where

- P(A) is the probability of the event A occurance,
- P(A/B) is the conditional probability of the event B occurance, if event A already has occured.

After the definition of the elements of matrices, the values of matrix IVIQM are calculated from the equation (1). If the value matrix IVIQM tends to 0, the Internet based system for measurement and control works with good quality. If the value IVIQM tends to 1, the system works with poor quality, and have to be improved.

IV. CONCLUSION

Development of telecommunications has led to significantly expand areas of application of ICT in education. In recent years, shows great interest in the use of telecommunications networks for remote monitoring, measurement and management of various physical quantities and parameters: environmental and metrological parameters, energy and operational parameters, residential use, transmission of digital data of electromagnetic field intensity and etc.

Many of the information communication module type M2M (Mashine To Mashine), connected in a wireless network provide a wide range of opportunities for collecting, processing and transmission of large amount of information from the surrounding world. In such a system may include sensors for measurement, control and monitoring, security and fire systems, devices for energy report parameters facilities management and positioning, etc.

In the paper we have defined the model conception of the Internet - ZigBee based system for measurement and control, which includes the block diagram and algorithm implemented of processes. The model defines the parametric method for functional testing. The quality of the system can be assessed and eventually improved. This model allows to determine which units are most likely to occur error. This in turn makes it possible to process (program or apparatus) these units and thus a reduction of the probability of occurrence of error for the entire measurement system.

This model can be used for a variety of measurement systems based on network technology.

ACKNOWLEDGEMENT

Research results are presented in this publication are funded by internal competition of TU-Sofia 2009

REFERENCES

[1] R. Arnaudov, I. Dochev, I. Ivanov, A. Kunchev: Application of data acquisition system in Internet for control and diagnostics. In: Proc. Conf. Energy and Inf. Systems and Technol., vol. III, Bitola, Macedonia, 2001, pp. 614-619.

[2] R. Arnaudov, I. Dochev, Ya. Angelov: Internet system for control and diagnosis of communication apparatures. In: Proc. Nat. Conf. Telecom - 2001, Varna, Bulgaria, 2001.

[3] T. Nieva and Wegmann, A.: A Conceptual Model for Remote Data Acquisition Systems", Proc. of 19th Int. Conf. on Conceptual Modeling - ER`2000, pp. 354-368, Salt Lake City, Utah, USA, 2000, October.

[4] G. Grimaldi, S. Rapuano, T. Laopoulos: State of Art of the Distributed Measurement Systems for Industrial and Educational Purposes. Proc. of the Third IEEE Workshop on Intelligent Data Acquisition and Advanced Comp. Syst.: Technol. and Appl., pp. 289-294, ISBN: 0-7803-9446-1, 2005, Sept.

[5] Zigbee-Alliance, "ZigBee Specification," http://www.zigbee.org/

[6] Webster J.G., Measurement, Instrumentation and Sensors Handbook, CRC Press, 1999

[7] IEEE 802.15.4a-2007 : Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs), IEEE

[8] M. Florczyk, W. Winiecki, The parametric Method for Functional Testing of Virtual Instruments, Proc. of the Third IEEE Workshop on Intelligent Data Acquisition and Advanced Comp. Syst.: Technology and Applications, pp. 310-315, ISBN: 0-7803-9446-1, 2005, Sept.