



Energy Consumption in Wireless Network Control System Data Transmission

K.Sanakkian¹, R.Kannan²

¹Department of Electrical and Electronics Engineering

²Head of the department Electrical and Electronics Engineering

^{1,2}Nehru Institute of Engineering and Technology, Tamilnadu, INDIA.

Abstract: The wireless sensor network control system communication protocol brings the additional challenge of providing stability of the closed loop control system compare to traditional wireless communication system; in this paper we give a optimization algorithm for increase the life time of battery using energy consumption in WNCS, the objective of the optimization is consume the energy in the battery connected wireless node data transmission, the constraints of problem is reduce the maximum transmit power, The formulation comprises communication system parameters including transmission power, rate and scheduling, and control system parameters including sampling period. the result of the optimization WNCS give the energy less data transmission, the simulation demonstrate the proposed method perform the very close to closed loop net work and very advantage then traditional method.

Key words: WSN,Zigbee,Controll system,ARM.

I. Introduction

The wireless data transmission is the most advanced version over traditional point to point communication, the wireless data transmission in the Sensor Network control system is the much better then point to point communication. In this paper, the wireless data transmission in sensor network control system is proposed with energy consumption method, the energy consumption in wireless network control system means the data from the sensor unit was not send continuously, instant of continues data transmission the data will send when the sensor detect error, this will obtained by Energy consumption data transmission with error detection algorithm. In the existing model of WNCS will send the system data to the controller with particular time delay, due to this operation the battery connected sensor network will lost the energy, overcome this problem we go for Energy consumption with error detection algorithm. The Data Transmission in WNCS is optimized with scheduling algorithm; Scheduling algorithm is designed with Earliest Dead Line first algorithm (EDF) with error detection. After detecting the error the transmission unit will send the data to the controller unit with scheduling algorithm.

II. Existing System Models and Problems

A. Introduction about Existing models

Wireless network control system with battery connected sensor network communication was implemented with energy consumption is achieved by continues data transmission only, the existing models is design with above principle overcome this we go for proposed model.

B. Life Cycle Analysis

Wireless Networked Control Systems (WNCSs) are spatially distributed systems in which sensors, actuators, and controllers connect through a wireless network instead of traditional point-to-point links in 2009. [9]. In this they said the wireless transmission was very efficient compare to the point to point communication, the implementation of the wireless network was low cost, less physical parameters. The point to point communication need physical contact between senders and receiver, but in the wireless network no need physical contact. WNCSs have a tremendous potential to improve the efficiency of many large-scale distributed systems in industrial automation, WNCS will change the automation industrial to wireless communication between the controller and sensor unit, this wireless communication is used to improve the industrial security and control in 2008 [4]. NCS (network control system) is connected with wireless communication, example zig bee,WiFi, etc., and research trends in NCS in 2010[12]. Co-design of wireless communication and NCS, in this they said the communication system will be designed parallel time of network control system design in 2011[11]. Wireless network control system the communication between the transmission unit and receiver unit has some interval, that interval will be will have some delay schedule [14]. The protocol about the industrial control application, they farm the set of code or rules for communication between the industrial application and

the controller unit [12]. The system for minimum energy data transmission between the industrial machine and the control unit, they developed the algorithm for minimum energy data transmission that called Energy minimizing schedule algorithm (EMSA) in 2014[1].

In the algorithm they give the delay time for the every sensor node, the every sensor will send the data of the machine with every delay time, the delay time will increased in the model. So the battery life time will increase because the time of sending the data only the transmission unit will turn on,

C. Disadvantage of existing models:

The WNCS was having battery connected sensor network, the life time of battery is low, and the detection and rectifying speed of error in the system is very poor. Therefore, to overcome these problems we go for proposed system.

III. Proposed Model

A. Theoretical Background

The theoretical back round of this model is sensor network will connect through the wireless communication network, the wireless communication in the WNCS model is ZigBee transceiver. The communication between the sensor unit and the controller unit will be monitor or control by scheduling algorithm. The scheduling algorithm has the principle of Earliest Dead Line first algorithm (EDF) with error detection. In this algorithm the transmission unit will transmit the sensor system data's to the controller when the system cross the threshold point, this called error in the system. The communication unit is used inside the industrial area only so we use the ZigBee communication; if the industrial area is wide means we use the WiFi communication. The joint optimization of controller and communication systems taking into account all the wireless network induced imperfections including packet error and delay; the parameters of the wireless communication system including the transmission power, rate and scheduling of the network nodes; and the parameters of the controller including the sampling period. The objective of the optimization problem is to minimize the power consumption of the communication system whereas the constraints guarantee the stability of the control system and the schedulability in the communication system. The original contributions of this paper are listed as follows:

We provide a framework for the joint optimization of controller and communication systems encompassing efficient abstractions of both systems, which may lead to broader adoption and real-world deployment.

We formulate the joint optimization of controller and communication systems for MQAM modulation in a network containing multiple sensors communicating with their corresponding controllers as a Mixed Integer Programming problem. We propose an efficient solution method for the formulated optimization problem based on the analysis of the relations between the optimal values of the decision variables.

We prove the energy saving of the proposed joint optimization problem over the traditional separate design of controller and communication systems and the closeness to the optimality of the proposed solution method via extensive simulations.

B. Design Methodology

The WNCS was developed with the Network control system model, in industrial they each and every system was connected with the sensor unit; the sensor unit will send data to controller if the system sensor detects the error. The each and every system will scheduled by the algorithm, the which system will have the earliest dead line that system will send the data first if the two sensor detect the error at the same time. The scheduling algorithm was used in the Energy Consumption is Error Detection with Earliest Deadline First Algorithm (EDEDFA). The communication unit was ZigBee transceiver, the zigbee unit was turn on when the sensor detect the error, the communication unit have TDMA MAC technique method, the TDMA is used for scheduling communication between sensor node and the controller unit,

C. EDEDFA Algorithm

This algorithm is written for simulation purpose only. For future work we will design the algorithm with practical sensors.

Algorithm:

```
while(1)
{
b=0;   lcdcmd(0x89); lcdstring("NO");
        lcdcmd(0xcb); lcdstring("NO");
    if(vib==1)
    {
b=1;
lcdcmd(0x84);
lcdstring("Detected");
text();
txs('Sensor detected');
b=1;
while(act==0);
    }
```

```

}
if(act==0)
{
b=1;
lcdcmd(0xC9);
lcdstring("DETECTED");
text();
txs('Acuators detected'); txs(13); txs(10);
delay(60000);
b=1;
while(vib==0);}}
void text()
{
txs('Sensor detected');
txs(13); txs(10);
delay(60000); }

```

D. Flowchart for EDEDA

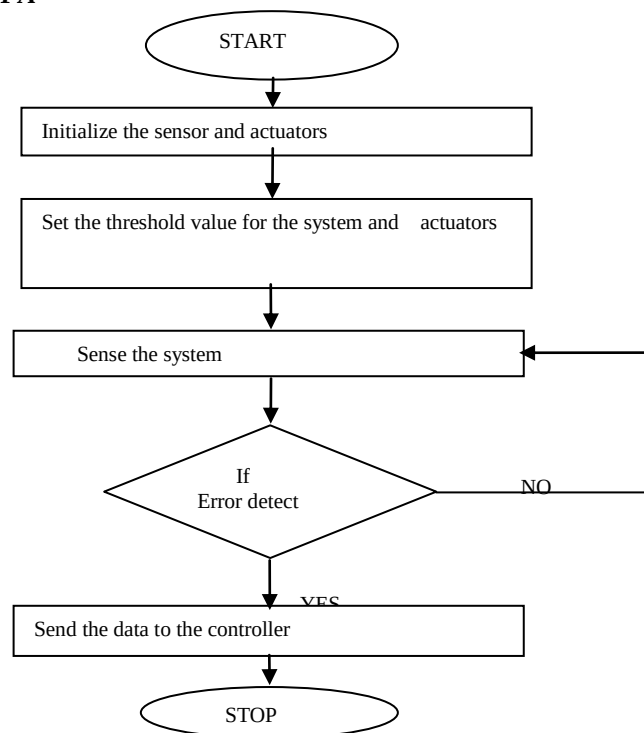


Fig. 3.1

E. Overview of Existing Architecture

The existing architecture of a WNCS where multiple plants are controlled over a wireless network, we assume that a sensor node is attached to each plant. The disadvantages of the existing block diagram is ever sensor node is connected the controller, and the each controller will connected through wireless medium to management controller, so the implementing the architecture need more controller for implement, then the cost of the implementation also will high, overcome these problem we go for the proposed model.

F. Proposed Architecture

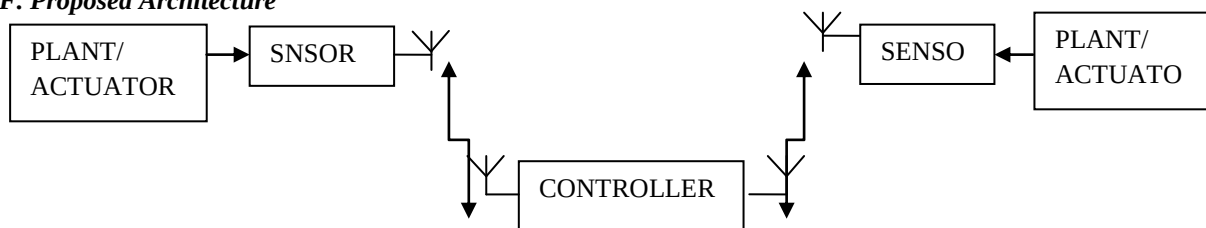


Fig.: 3.2

G. Overview of Architecture

Depicts the architecture of a WNCS where multiple plants are controlled over a wireless network. We assume that a sensor node is attached to each plant. Outputs of the plants are sampled at periodic intervals by the sensors and forwarded to the controller over a wireless network, which induces delays and packet errors. When the controller receives the measurements, a new control command is computed. The control command is forwarded to the actuator attached to the plant. We assume that the controller commands are successfully received by the actuator. Many practical NCSs have several sensing channels, whereas the controllers are collocated with the actuators, as in heat, ventilation and air conditioning control systems, because the control command is very critical. The time is partitioned into frames. Each frame is further divided into a beacon and time slots. The beacon is used by the network manager to provide time synchronization within the WNCS and broadcast updates on the scheduling decisions. The scheduling decisions include the time slot allocation and the values of the optimal node parameters including the transmission power, rate and sampling period corresponding to each sensor node. We assume that no concurrent transmissions are scheduled. The network manager continually monitors the received power and the packet error rate over each link. If the channel conditions do not change, the beacon only provides synchronization information. Otherwise, the beacon also includes the updates on the scheduling decisions.

H. Energy Consumption Mode

The nodes are assumed to operate their radio in sleep mode when they are not scheduled to transmit or receive a packet, and transient mode when they switch from sleep mode to active mode to transmit or receive a packet and vice versa. We consider only the energy consumption in the transmission of the packets in the optimization problem because it is much larger than that in the sleep and transient modes.

IV. Communication Unit

A. ZIG BEE Introduction

With the development of network and communication technology, the WSN has solved the inconvenience into people's life. WSN has good functions of data collection, transmission, and processing. It has many advantages compared to traditional wired network, for example, convenient organizing network, small influence to environment, low power dissipation, low cost, etc. At present, near field wireless communication technology has been used widely, especially Bluetooth, wireless local area network (WLAN), infrared, etc. But, they have a number of disadvantages, for example, complexity, large power dissipation, short distance, networking in small scale. In order to satisfy the demand of low power dissipation and low speed among Wireless communication devices, a new type of wireless net technology-Zigbee emerge as the times require. Outline, of the paper is, starts with description of ZigBee and IEEE802.15.4 specifications. Next describes ZigBee device types and protocol architecture and applications based on ZigBee in conclusion. ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios.

ZigBee is based on an IEEE 802.15.4 standard. Though its low power consumption limits transmission distances to 10–100 meters line-of-sight. ZigBee operates in the industrial, scientific and medical (ISM) radio bands: 2.4 GHz in most jurisdictions worldwide; 784 MHz in China, 868 MHz in Europe and 915 MHz in the USA and Australia. Data rates vary from 20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band).

B. ZIGBEE Logical Device Types

There are three categories of nodes in a ZigBee system. They are Coordinator, Router and End devices.

- 1) Coordinator: Forms the root of the network tree and might bridge to other networks. There is exactly one coordinator in each network. It is responsible for initiating the network and selecting the network parameters such as radio frequency channel, unique network identifier and setting other operational parameters. It can also store the information about network, security keys.
- 2) Router: Router acts as intermediate nodes, relaying data from other devices. Router can connect to an already existent network, also able to accept connections from other devices and be some kind of re-transmitters to the network. Network may be extended through the use of ZigBee routers.
- 3) End Devices: End Device can be low-power /battery-powered devices. They can collect various information from sensors and switches. They have sufficient functionality to talk to their parents (either the coordinator or a router) and cannot relay data from other devices. This reduced functionality allows for the potential to reduce their cost. They support better low power models. These devices do not have to stay awake the whole time, while the devices belonging to the other two categories have to. Each end device can have up to 240 end nodes which are separate applications sharing the same radio.

C. Access Modes

Two ways of multi-access in ZigBee protocol, are Beacon and Non-beacon. In non beacon enabled network, every node in the network can send the data when the channel is free. In beacon enabled network, nodes can only transmit in predetermined time slots. Here PAN coordinator allocates guaranteed time slots (GTS) for each

device; therefore devices will transmit their data during their own slot. All devices should be synchronized for this process. This will be sending beacon signal. The coordinator is responsible to transmit beacon signals to synchronize the devices attached to it, Network in which the coordinator does not transmit beacon signal is known as non-beacon network. It cannot have GTS and contention free periods, because the devices are not synchronized. Battery life is better than beacon enabled network, because the devices are wake up less often.

Advantages of ZIGBEE

Power saving, as a result of the short working period, low power consumption of communication, and standby mode.

- Reliability: Collision avoidance is adopted, with a special time slot allocated for those communications that need fixed bandwidth so that competition and conflict are avoided when transmitting data. The MAC layer adopts completely confirmed data transmission, that is, every data packet sent must wait for the confirmation from the receiver.
- Low cost of the modules, and the ZigBee protocol is patent fee free.
- Short time delay, typically 30 ms for device searching, 15 ms for standby to activation, and 15 ms for channel access of active devices.
- Large network capacity: One ZigBee network contains one master device and maximum 254 slave devices. There can be as many as 100 ZigBee networks within one area.
- Safety: ZigBee provides a data integrity check and authentication function. AES-128 is adopted and at the same time each application can flexibly determine its safety property.

D. Implementation

ECWNCS (Energy Consumption Wireless Network control System) was implemented through following methods,

- Serial communication between controller and Sensor unit
- Communication between controller and management controller
- Scheduling Algorithm with program

The interface with controller and the sensor with scheduling algorithm were implemented through the program.

E. Schematic diagram for simulation

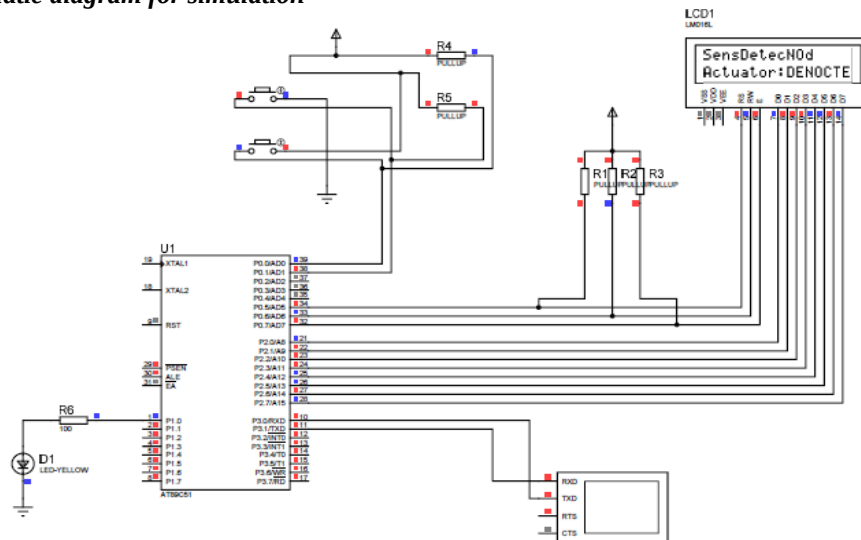


Fig.: 4.1

F. Simulation for Schematic Diagram

The simulation of the research paper was design through the proteus hardware design software; in the proteus we design the overview schematic diagram of the research. The results are obtained by simulating the research work through insert and run the program.

The above schematic figure 4.1 shows the how the connection are made from controller to other peripherals, in this diagram the peripherals are: (i) Transmission Unit, (ii) Input Sensor, and (iii) LCD

G. Discussion about Simulation

In the output discussion the sensor will detect the error the transmission unit will turn on and the data of the system will sent to the management controller. The management controller will analysis the error and sends the correct data to the system Actuators through communication model. In the simulation we use the controller with sensor switch and Actuators switch, if the system fail to response in the desired value the sensor will detect the

error then immediately transmission unit will send the data to the management controller. The virtual screen will denote sensor detection and transmission,

V. Conclusion and Future Work

A. Conclusion

The phase I of the research work conclude with the schematic diagram design, and program implementation. In this we design the single sensor and actuator device are interface with the controller. In this we could not include the threshold value for the sensor, because the simulation will not show the threshold value for sensor and we connect manual switch. Moreover, in hardware design we include the threshold value for particular sensor.

B. Future Work

- To design the sensor unit with transceiver without controller.
- Design the hardware of the above schematic diagram.
- Implement the automatic error detection and rectifying unit in the management controller, without human error rectifier.

References

- [1]. Yalcin sadi, sinem coleri ergen, pangun park "Minimum energy data transmission for wireless networked control system" IEEE Trans. Wireless communication ., vol. 13, no. 4, pp. 2163–2175, Apr 2014
- [2]. A. Aswani, N. Master, J. Taneja, D. Culler, and C. Tomlin, "Reducing transient and steady state electricity consumption in HVAC using learning-based model predictive control," Proc. IEEE, vol. 100, no. 1, pp. 240–253, Jan. 2012.
- [3]. A. Fu, E. Modiano, and J. N. Tsitsiklis, "Optimal transmission scheduling over a fading channel with energy and deadline constraints," IEEE Trans. Wireless Commun., vol. 5, no. 3, pp. 630–641, Mar. 2006.
- [4]. A. Willig, "Recent and emerging topics in wireless industrial communication," IEEE Trans. Industrial Inf., vol. 4, no. 2, pp. 102–124, May 2008.
- [5]. B. Demirel, Z. Zou, P. Soldati, and M. Johansson, "Modular co-design of controllers and transmission schedules in wireless harts," in Proc. 2011 IEEE Conf. Decision Control European Control, pp. 5951–5958.
- [6]. D. Carnevale, A. R. Teel, and D. Nesic, "A Lyapunov proof of an improved maximum allowable transfer interval for networked control systems," IEEE Trans. Automatic Control, vol. 52, no. 5, pp. 892–897, May 2007.
- [7]. E. Uysal-Biyikoglu, B. Prabhakar, and A. E. Gamal, "Energy-efficient packet transmission over a wireless link," IEEE/ACM Trans. Netw., vol. 10, no. 4, pp. 487–499, Aug. 2002.
- [8]. G. Walsh, H. Ye, and L. Bushnell, "Stability analysis of networked control systems," IEEE Trans. Control Syst. Technol., vol. 10, no. 3, pp. 438–446, May 2002.
- [9]. J. P. Hespanha, P. Naghshtabrizi, and Y. Xu, "A survey of recent results in networked control systems," Proc. IEEE, vol. 95, no. 1, pp. 138–162, Jan. 2007.
- [10]. O. Ozel, J. Yang, and S. Ulukus, "Optimal broadcast scheduling for an energy harvesting rechargeable transmitter with a finite capacity battery," IEEE Trans. Wireless Commun., vol. 11, no. 6, pp. 2193–2203, June 2012.
- [11]. P. Park, J. Araujo, and K. H. Johansson, "Wireless networked control system co design," in Proc. 2011 IEEE International Conf. Netw., Sensing and Control, pp. 486–491.
- [12]. P. Park, C. Fischione, A. Bonivento, K. Johansson, and A. Sangiovanni-Vincent, "Breath: an adaptive protocol for industrial control applications
- [13]. R. A. Gupta and M. Chow, "Networked control system: overview and research trends," IEEE Trans. Industrial Electron., vol. 57, no. 7, pp. 2527–2535, July 2010.
- [14]. T. Arampatzis, J. Lygeros, and S. Manesis, "A survey of applications of wireless sensors and wireless sensor networks," in Proc. 2005 IEEE International Symp. Mediterrean Conf. Control Automation, pp. 719–724.
- [15]. W. P. M. H. Heemels, A. R. Teel, N. van de Wouw, and D. Nesic, "Networked control systems with communication constraints: tradeoffs between transmission intervals, delays and performance," IEEE Trans. Automatic Control, vol. 55, no. 8, pp. 1781–1796, Aug. 2010.
- [16]. Y. Wu, G. Buttazzo, E. Bini, and A. Cervin, "Parameter selection for real-time controllers in resource-constrained systems," IEEE Trans. Industrial Inf., vol. 6, no. 4, pp. 610–620, Nov. 2010.