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Simulation and evaluation of WSN Performancesusing True Time Tool Box

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Abstract—Routing is a functional important aspect in wireless ad - hoc that handles, discover, and maintain the paths between the nodes within a network. Ad hoc On-Demand Distance Vector (AODV) routing protocol was continues to be an active and successful research since its introduction Protocol in ad hoc wireless networks.

In this paper, we have emphasized mainly on the routing protocol implementation of AODV for ZigBee network based on IEEE 802.15.4 standard in the SIMULINK MATLAB TRUETIME database, which facilitates the task of controller co-simulation, running in real time kernels, network transmissions, thus has a comparison is made with other networks [802.11 (WLAN), NLM-WIRLESS.

This study includes analysis of indicators of performance such as Packet Delivery Ratio (PDR) and the Packet loss Ratio (PDR)with the change of emission power, the study of the variation of the parameters such as transmit power, under Receiver threshold, signal reach.

Keywords—ZigBee, true time,AODV, transmitting, PDR,PLR,WSNpower,MATLAB.

I. INTRODUCTION

The wireless sensor network consists initially in small or large knots, called sensor [1] nodes. These nodes are variable in size and dependent on the size of sensors, they work efficiently in different areas. Wireless sensor networks have nodes of sensors that are designedspecially so typical, they have a microcontroller, which controls monitoring and a radio transceiver to generate waves, different types of wireless radio communication devices and equipped with a source of energy as the battery.

The transmitter and receiver usedis for communications wireless with other nodes or the gateway. The gateway is responsible for transmitting sensor data to the remote base station that provides connectivity wireless Ad - Hoc Network (Wagner) and logging through a network of local transit. Finally, the data are available to researchers through a user interface. The wireless sensor network scenario we illustrated in figure1. ZigBee and wireless sensor network are under the IEEE 802.5.4 standard [2] [3]. For wireless networks the control area, which requires extremely low consumption and low flow (less than 250 Kbit/s), use of unlicensed radio bands, easy installation, good product and Flexible, built-in intelligence for network and routing, installation in order to improve the performance of the application. Protocols routing plays an important role in order to find and set up the path between the source node and destination. All the ZigBee network nodes are mobile and can connect dynamically in an arbitrary manner. All these network nodes have routers and take part in the discovery and maintenance of roads to other nodes of the network. This situation becomes more complicated if other nodes added within the network. Routing Protocol must be able to decide the best path between nodes to minimize the burden of bandwidth to enable the proper routing to reduce the time needed to converge after topology changes. Application networks ZigBee includes commercial, construction, security, home automation, Agriculture, environmental monitoringand monitoring medical health care, followed by vehicle. This paper includes the analysis of performance indicators such as rate ofpackages delivery and thepackage loss coefficient with the change in the emission power, the rest of this paper organized as follows: Section 2 gives brief idea about TRUETIME. Section 3 provides an overview on communication protocols. Section 4 describes the AODV Routing Protocol. Section 5 describes the Simulation implemented and results. Section 6 presents the conclusions of our study.

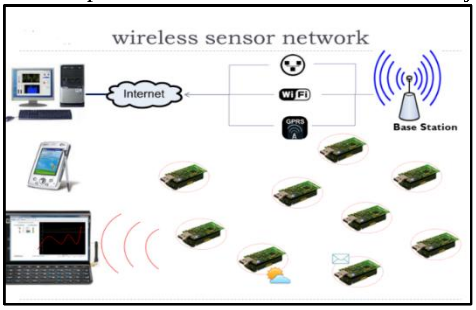


Figure.1Scenario of Wireless Sensor Network

II. TRUETIME

TRUETIME is a MATLAB/SIMULINK based simulator for real-time control systems [4]. TRUETIME facilitates co-simulation of controller task execution in real-time kernels, network transmissions, and Continuous plant dynamics. The kernel block simulates is a real-time kernel executing user-defined tasks and interrupt handlers. The various network blocks allow node (kernel blocks) communicate over simulated wired or wireless networks. TheTRUETIME network block simulates medium access and packet transmission in a local area network. Six simple models of networks are supported: CSMA/CD (e.g. Ethernet), CSMA/AMP (e.g. CAN), Round Robin (e.g. Token Bus), FDMA, TDMA (e.g. TTP), and Switched Ethernet.

The usage of the wireless network block is similarand works in the same way as the wired one. To also take the path-loss of the radio signals into account, it has x and y inputs to specify the true location of the nodes. Two network protocols supported are at this moment: IEEE 802.11b/g (WLAN) and IEEE 802.15.4 (ZigBee) [6]. The block library consists of the TRUETIME Kernel block that simulates a real-time kernel executing user defined tasks and interrupt handlers, the Network block that allows nodes to communicate over simulated network, a couple of standalone interface blocks and of the Battery block That allows modeling of battery driven operation.

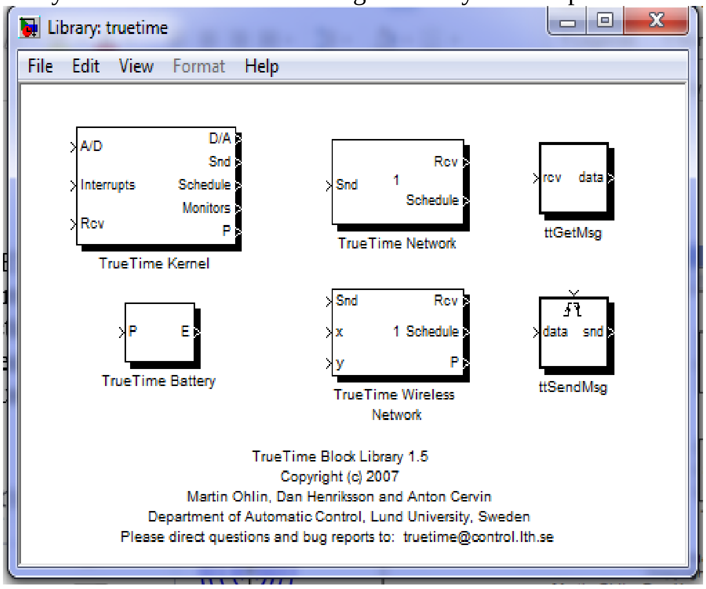


Figure. 2 The TRUETIME block library

III. WIRLESS NETWORK

A. Zig Bee(IEEE 802 .15.4)

ZigBee technology has recently become one of important and significant options for Wireless Sensor Network (WSN), since it possesses many advantages such as low power consumption, low data rate, low cost and short-time delay characteristic. ZigBee is the only standards-based wireless 802.15.4 technology. ZigBee protocol features include: support for multiple network topologies such as point to-point, point-to-multipoint and mesh networks, low duty cycle – provides long battery life, low latency, up to 65,000 nodes per network, encryption for secure data connections [5,6].Expected applications for the ZigBee are building automation, security systems, remote control, remote meter reading and computer peripherals [7].

B. WLAN (IEEE 802.11)

In 1997, IEEE 802.11 Working Group released the 802.11 protocol, which is the first internationally recognized agreement in the field of wireless LAN. With the development of 802.11, several different standards have emerged such as 802.11b/a/g standard. There exist the technical and performance differences between them. The former based on the CSMA / CA protocol, providing point to point against the other communication services; the latter controlled by the access point (AP), providing real-time communication services. IEEE 802.11 is a multiple access protocol in which stations in the network must “compete” for access to the shared communications medium to transmit data. Use IEEE 802.11 uses, as does Ethernet, a carrier sensing capability to determine if the communications medium is currently. If two or more stations in the network transmit at the same time (i.e., a collision occurs), stations retransmit their data after random periods as in Ethernet. Since IEEE 802.11 is a WLAN standard, its key intentions are to provide high throughput and a continuous network connection [8].

IV. AODV

A. Overview of AODV Routing Protocol

AODV stands for Ad-Hoc On-Demand Distance Vector [9,10] of a reactive type protocol, even though it still uses characteristics of a proactive protocol. AODV takes the interesting parts of DSR and DSDV [10], in the sense that it uses the concept of route discovery and route maintenance of DSR [11] and the concept of sequence numbers and sending of periodic hello messages from DSDV.Routes in AODV are discovered and established and maintained only when and as long as needed. To ensure loop freedom sequence numbers, which are created and updated by each node itself, are used. These allow also the nodes to select the most recent route to a given destination node.AODV takes advantage of route tables. In these, it stores routing information as destination and next hop addresses as well as the sequence number of a destination. Next to that a node also keeps a list of the precursor nodes, which route through it, to make route maintenance easier after linkbreakage. To prevent storing information and maintenance of routes that are not used anymore each route table entryhas a lifetime. If during this time the route has not be used, the entry is discarded [12]. This measurement and others are deliberate, using Overview of AODV Routing.

B. Simulation of Classical AODV using TRUETIME

The simulation model provides in TRUETIME for AODV routing protocol is shown in Figure 3.The simulation model creates the topology of the network consist of 7 nodes communicate with eachother using wireless connections shown in Figure 4.The Simulink model of AODV is shown in Figure 3. contains blocks for 7 nodes with their respective source and receiver blocks. The network block consists of information of TRUETIME wireless network block [12]. The information regarding number of nodes, transmission power, threshold acknowledgement timeout, frame size and Pathloss are supplied to the system through this block. Thenode 1 is the source or transmitter and node is destination or the receiver of the system. Thecommunication performed is between node number 1 and 7. The intermediate nodes are node number 2,3, 4, 5 and 6. The route for communication is selected between node 1 and node 7 depending upontransmission power and threshold. The maximum signal reach is calculated and route for communications selected.

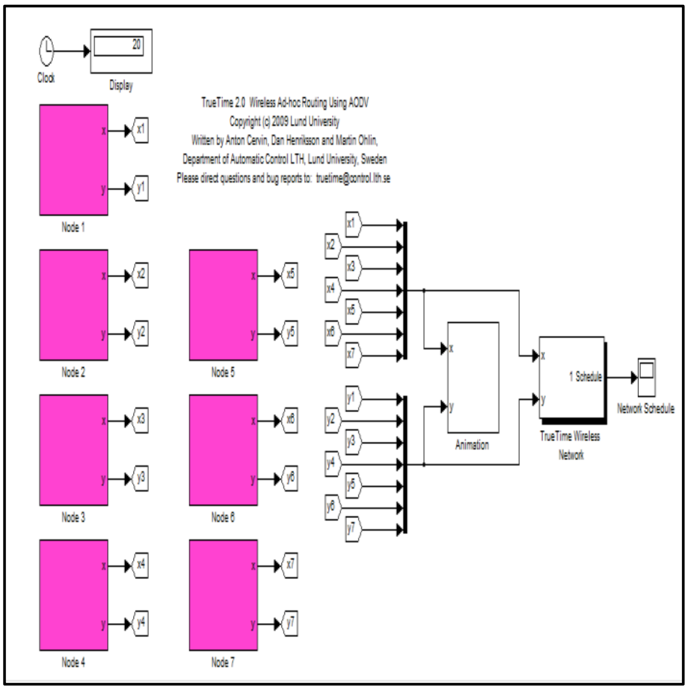


Figure.3Simulink model in TRUETIME

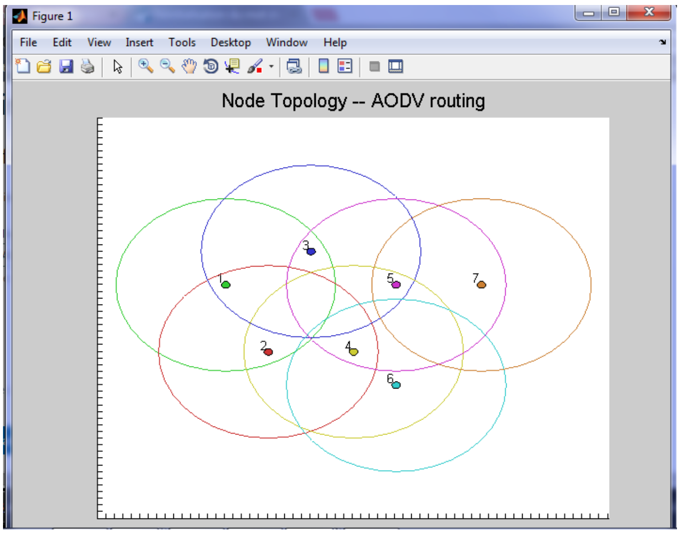


Figure.4 Topology created by Simulink model in TRUETIME

In the simulation scenario, the left-most node (node 1) sends data periodically to node 7 withperiod 0.5. The initial route that is established is 1 → 3 → 5 → 7.

At time t=3, node 5 starts to movewhich eventually leads to the route breaking. At time t=10, node 6 repairs the route by moving in betweennode 4 and 7. Various routes are available for communication, those routes are 1-3-5-7, 1-2-4-6-7, 1-5-7 etc. With increase in power and threshold the range or signal reach increase and number of hop countdecreases. At certain time, the node 5 moves out of range of communication performed through route 1-3-5-7. After node 5 moves away, the node 6 moves towards node 5 and comes in route of 1-3-5-7. Thenode topology is as shown in Figure 4. The circle with different colors shows various nodes used forcommunication.

V. SIMULATION AND RESULTS

There are many routing protocols available for ZigBee network. It is difficult to decide the preferable routing protocol for the network. Performance measures decided the implementation of routing protocol based on the parameters requiring a performance optimization. Here, the AODV Routing Protocol was simulated under the ZigBee (IEEE 802.15.4) standard, WLAN (IEEE 802.11)standard and NLM-WIRELESS standard. The range of transmission, which plays a very important role in the AODV Routing Protocol, has be evaluated. To analyze the Protocol of AODV Routing under each standards and make a comparison between them. This paper considered the following performance indicators:

A. *Packet Delivery Ratio (PDR):*

The PDR (equation (1)) is ratio of data packets received on data packets transmitted, his mathematical formula as follows:

$$PDR = \frac{(\text{Number of packets Reiceved})}{(\text{Number of Packet Transmited Packets})} * 100 \qquad (1)$$

B. *Packet loss Ratio (PDR):*

The PDR (equation (1)) is ratio of data packets not received on data packets transmitted, his mathematical formula as follows:

$$PLR = \frac{(\text{Number of packets not Reiceved})}{(\text{Number of Packet Transmited Packets})} * 100 \qquad (2)$$

In this paper,AODV Routing Protocol used three types of networkIEEE 802.15.4 standard,WLAN (IEEE 802.11)standard and standard NLM-WIRLESS standard in the TRUETIME / MATLAB [12]. The number of sending packets is 40.

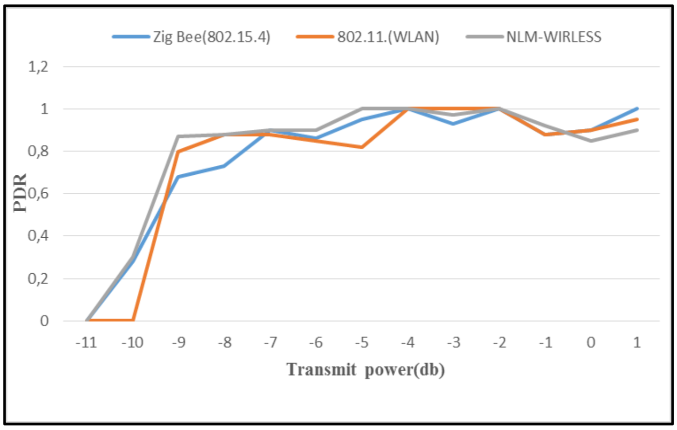


Figure.5Packet Delivery Ratio V/S Transmitting Power

In figure 5 and 6 :Seen while the transmission is using the NLM-WIRLESS standard gives us the best PDR and PLR better than other standards, but the standard Zig Bee (IEEE 802.15.4) has brought very important reaches up to 1.5 km, so we preferalwaysusing this standard.

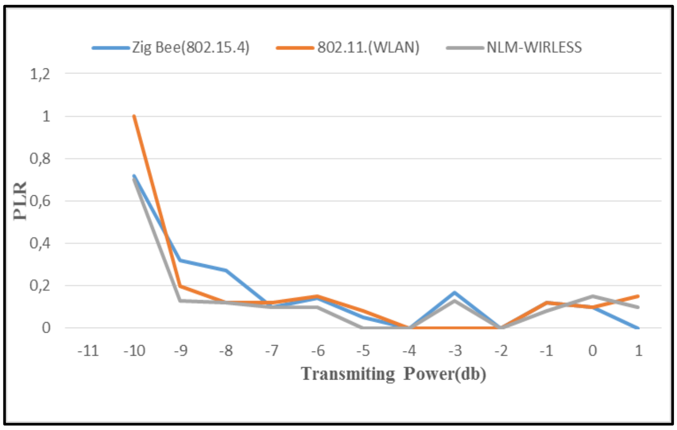


Figure.6 Packet Delivery Ratio V/S Transmitting Power

C. Receiver threshold V/S signal reach:

For three standards: Zig Bee (IEEE 802.15.4), WLAN (IEEE 802.11) and NLM-WIRLESS,theEffect of changes in Received threshold level and transmission power on Signal Reach explained in Figure 7 and 8 respectively. As the receiver threshold level, increases signal reach of the node decreases. It can observed from figure 8 that as transmission power increases signal reach of the nodes also increases. Standard WLAN (IEEE 802.11) gives us good results but has a scope is not large relative to the standard Zig Bee (IEEE 802.15.4), that is why we choose always work with the latter.

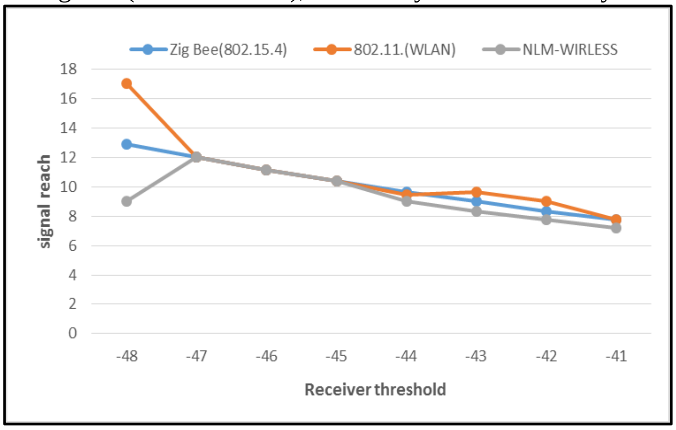


Figure.7Receiver threshold V/S signal reach

D. Transmit power V/S signal reach:

For the three standards: Zig Bee (IEEE 802.15.4) and WLAN (IEEE 802.11) and NLM-WIRLESS: We find the same results.

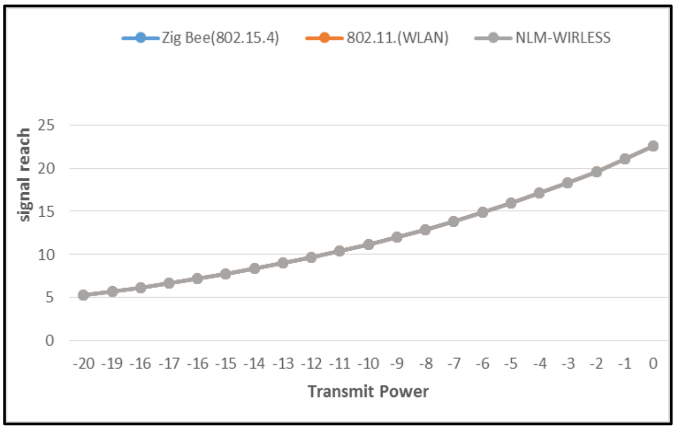
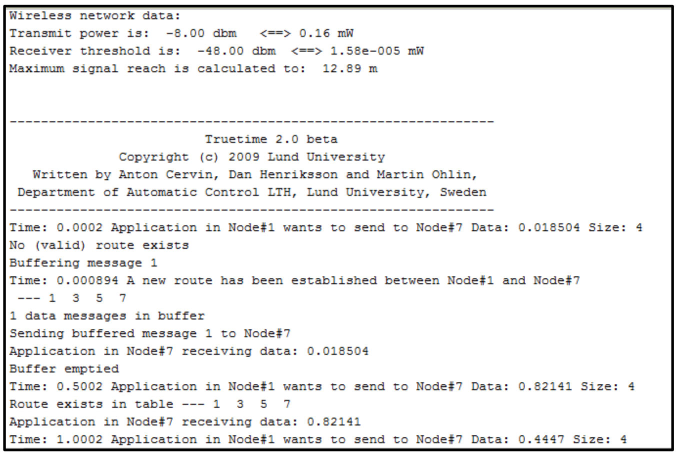


Figure.8 Transmit power V/S signal reach

The simulation of AODV ROUTING with TRUETIME give us the scenario of networks, so all the parameters, andknow the proper standard under which we will issue our information.



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Wireless network data:
Transmit power is:  -8.00 dbm   <==> 0.16 mW
Receiver threshold is:  -48.00 dbm  <==> 1.58e-005 mW
Maximum signal reach is calculated to:  12.89 m


--------------------------------------------------------------
                         Truetime 2.0 beta
              Copyright (c) 2009 Lund University
   Written by Anton Cervin, Dan Henriksson and Martin Ohlin,
 Department of Automatic Control LTH, Lund University, Sweden
--------------------------------------------------------------
Time: 0.0002 Application in Node#1 wants to send to Node#7 Data: 0.018504 Size: 4
No (valid) route exists
Buffering message 1
Time: 0.000894 A new route has been established between Node#1 and Node#7
 --- 1  3  5  7
1 data messages in buffer
Sending buffered message 1 to Node#7
Application in Node#7 receiving data: 0.018504
Buffer emptied
Time: 0.5002 Application in Node#1 wants to send to Node#7 Data: 0.82141 Size: 4
Route exists in table --- 1  3  5  7
Application in Node#7 receiving data: 0.82141
Time: 1.0002 Application in Node#1 wants to send to Node#7 Data: 0.4447 Size: 4
```

Figure.9Scenario of network using AODV rotting

VI. RELATED WORKS

It exists today, a number of general network simulators. One of the most WSN simulator is NS-2 [13], which is a discrete-event simulator for both wired and wireless networks withsupport for, e.g., TCP, UDP, routing, and multi-castprotocols. It also supports simple movement modelsfor mobile applications. The channel model in ns-2 is quite simple

[14]. NS-2assumes that messages isbe receivedwithout errors if the power level is above a certainthreshold. Packets with power levels below the sameThreshold dropped is simply. The packet with thelargest power level is be received if two-transmissionsuccor at the same time, and the difference in powerlevel between them is larger than 10 dB. Otherwiseboth packets are be dropped. Three different path-lossmodels are available, two of them are deterministicand form ideal circles where the messages are be receivedperfectly inside and dropped outside. The third modelis be called the shadowing model and adds some probabilistic changes to the path-loss by using a zero meanGaussian variable. Another discrete-event computer network simulator isOMNeT[15]. It contains detailed IP, TCP, and FDDI protocol models andseveral other simulation models (file system simulator, Ethernet, framework for simulation of mobility, etc.).It uses the same path-loss function as the TRUETIMEwireless block; errors are be however treated in a moredetailed manner. It distinguishes between header anddata part of packages and between different modulation techniques. Compared to these simulators, thenetwork simulation part in TRUETIME is in some casesmore simplistic. However, the strength of TRUETIMEis the co-simulation facilities that make it possibleto simulate the latency-related aspects of the networkcommunication in combination with the node computations and the dynamics of the physical environment. Rather than basing the co-simulation tool on a generalnetwork simulator and then try to extend this with additional co-simulation facilities, the approach has beento base the co-simulation tool on a powerful simulator for general dynamical systems, i.e., Simulink, andthen add support for simulation ofreal-time kernelsand the latency aspects of network communication tothis. An additional advantage of this approach is thepossibility to make use of the wide range of toolboxesthat are available for MATLAB/Simulink. For example, support for virtual reality animation. There are also some network simulators geared towards the sensor network domain. TOSSIM [16] compiles directly from TINYOS code andscales very well. Its radio and interference model ishowever very either simplistic, with perfect transmissions or predefined error rates, which can changedat runtime. COOJA [17] is similar toTOSSIM but simulates the CONTIKI OS instead. Network in a box (NAB) [18] is another simulator for large-scale sensor networks. Another example is J-SIM, a general compositional simulation environment that includes a generalized packet switchednetwork model that may use to simulate wirelessLANs and sensor network [19]. Again, thesetypes of simulators generally lack the possibility tosimulate continuous-time dynamics and to simulatethe inner workings of the nodes at the thread andinterrupt handler level, features that have been presentin TRUETIME since the early versions. A few other tools have be developed that support co-simulation of real-time computing systems and controlsystems. RTSIM [20] has a modulethat allows system dynamics to simulate in parallel with scheduling algorithms. XILO [21] supports the simulation of systemdynamics, CAN networks, and priority-preemptivescheduling. Ptolemy II is a general-purpose multidomain modeling and simulation environment that includes a continuous-time domain, and a simple RTOSdomain. Recently it has be extended in the sensornetwork direction [22]. In [23] a co-simulation environment based on ns-2 is be presented. The ns-2 simulator has be extendedwith an ODE-solver for dynamical simulations of thecontroller units and the environment. However, thistool lacks support for real-time kernel simulation.

VII. CONCLUSION

In this paper, we have emphasized mainly on the routing protocol implementation of AODV for ZigBee network based on IEEE 802.15.4 standard in the SIMULINK MATLAB TRUETIME database, which facilitates the task of controller co-simulation, running in real time kernels, network transmissions, thus has a comparison is made with other networks [802.11 (WLAN), NLM-WIRLESS. In addition, we have analysis of indicators of performance such as Packet Delivery Ratio (PDR) and the Packet loss Ratio (PDR) with the change of emission power, the study of the variation of the parameters such as transmit power, under Receiver threshold, signal reach. This paper help us to design a network of sensor wireless with better performance, good quality, appropriate topology and transmission standard that gives us the important scope, and quality at the level ofdata reception anddata emission and the long battery life time.

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