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ZigBee Based Network Architecture for Animal Health Monitoring

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***Abstract*—Wireless Sensor Network is collection of sensor nodes which consist of sensing device, storage device, processing unit and antenna. These nodes may be placed in difficult physical environment for sensing an event, collecting data, processing data and forwarding it using wireless network to the sink, where data can be stored, processed and analyzed. Animal monitoring, Building monitoring and other are some application area of WSN. The sensor node requires enough battery power to collect and communicate data with other network device/s. WSN has several constrains, one of them is low battery power. It thus becomes important to conserve energy of a node in WSN. Due to hardware limitation for efficient energy consumption, researchers are required to work on mechanisms to reduce the energy consumption by sensor nodes. One of the ways to increase the battery life of sensor node is to implement energy efficient network architecture and communication protocol. In this paper we have proposed ZigBee based network architecture for Animal Health Monitoring.**

Keywords: Wireless Sensor Network (WSN), ZigBee, MAC, Sensor, Health Monitoring, Personal Area Network (PAN)

I. INTRODUCTION

Wireless Sensor Network is a collection of low-cost, low-power and multifunctional wireless sensor nodes installed in distributed geographical area for monitoring specific scenario. WSNs create significant impact on a wide range of monitoring area by the coordinated effort of the wireless sensor nodes. The wireless sensor node works on battery power to communicate with other network sensor node. Wireless Sensor Network consists of several sensor nodes with sensing, computing and wireless communication capabilities. To perform a task, sensor node should be self organized into a multi hop wireless sensor network. The paper is divided in six sections. Section 2, discusses the related work. Section 3 discusses the use of ZigBee for animal health monitoring. In section 4 the proposed ZigBee based network architecture for animal health monitoring is described. Section 5 shows the data transmission model for WSN based.

Animal Health Monitoring followed by the conclusion in section 6

II. RELATED WORK

The ZigBee has been used in several applications of Wireless Sensor Networks. In this section we have discussed some of the ZigBee based application for Wireless Sensor Networks [1][12][9][20]. Nausheen Belin et al. proposed an automation system that allows us to ON/OFF a home appliance using the ZigBee wireless technology [15]. This system allows modernization of home integration system. Mukesh Kumar et al. proposed wireless fingerprint security system based on ZigBee technology [11]. This system is based on taking fingerprint of a user with the help of a fingerprint sensor module and matching it with the database and display result on screen. The proposed approach uses the technique which combines unique biometrics and the concept of wireless communication. K NirmalKumar et al. studied the impact of ZigBee wireless sensor network technology for paddy crop field monitoring [7]. The idea here was to monitor the crop without man power. They have analyzed the battery life of the sensor deployed in the water and have also evaluated the reliability of communications and measurements. Y.Bala Krishna et al. proposed design of Wireless home automation systems (WHAS) [19]. The automation centered on recognition of voice commands uses low power RF ZigBee wireless communication modules to control all lights and electrical appliances in a home or office. Nisha Ashok Somani et al. proposed to use the ZigBee technology in the industrial application as low power wireless technology [14]. They have discussed the ZigBee reference model and network topologies for industrial applications.

III. ZIGBEE BASED ANIMAL HEALTH MONITORING

In [3], we have proposed a Distributed Data Storage Model for Animal Health Monitoring Using WSNs for Rural Area of Gujarat and have also defined structure for them. The model was divided into two levels, namely local level model and central level model. The main aim of doing so was to get quick response for any query raised. The wireless network consists of heterogeneous wireless sensor devices with capability of sensing and transferring data. At local level wireless sensor network would be capable of collecting and processing data on occurrence of different event at regular interval.

In the WSN based Animal Health Monitoring, the cattle body sensor sends data like heart beats, respiration, body temperature while Environment sensor sends data like water pollution level, soil infection level, dust level in air and humidity data. All these sensory data should be generated on regular interval and needs to be small in the size. The WSNs would be deployed in rural areas of Gujarat. The geographical area of village is limited; hence the range of network should be restricted. The WSN based Animal Health Monitoring setup of village terminates at Gram Panchhayat office's local server. The Gram Panchhayat's local server is connected with central server via internet. Periodically the local server forwards its

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TABLE I. DEVICE TYPE FOR ANIMAL HEALTH MONITORING

Logical Device Type	Physical Device Type
PAN Coordinator	Full Functional Device (FFD)
Router	Full Functional Device (FFD)
End Device	Reduce Functional Device (RFD)

data to central server for further processing.

In the proposed architecture, each wireless sensor devices work on battery power. Depending on usability of sensor device it is required to change battery after a regular interval. At the time of data transmission battery power consumption is significant. In the setup data transmission between network devices is usually achieved by a unique channel. Hence we required to establish an efficient transmission technology and network topology among the sensor nodes. After comparing all wireless transmission technologies and circumstances of WSN based Animal Health Monitoring [8][4][13][18][10][6][5] [2], we proposed to implement the ZigBee based WSN Animal Health Monitoring. The ZigBee supports low data rate up to 250 Kbps with the range up to 20 meters which is perfect for cattle sheds [8][2][16][17][14][21][22]. Due to less data rate and effective management of medium by the ZigBee, the battery life of sensor node can be extended to years.

IV. PROPOSED ZIGBEE BASED NETWROK ARCHITECTURE FOR ANIMAL HEALTH MONITORING

Network device arrangement and communication path structure plays vital role in efficient energy management. The WSN based animal health monitoring is being designed for rural area of Gujarat. The network devices will be placed in rural village and sensory data will be transferred to nearest Gram Panchayat office at first level, while in the second level it should be transferred to the central data sever located at urban city of Gujarat. For implementing WSN based Animal Health monitoring scenario, we propose to implement network topology at two different levels. In general the Animal lives in the animal sheds located near to animal owner's home. In connection to this we propose to implement star topology based wireless Personal Area network (PAN) within the range of each animal shed. Three types of devices as mentioned in table I will be utilized in the star topology of PAN.

Logical Device Type Physical Device Type PAN Coordinator Full Functional Device (FFD) Router Full Functional Device (FFD) End Device Reduce Functional Device (RFD)

The animal shed is surrounded by one PAN coordinator. The PAN coordinator is FFD and responsible for PAN network establishment and controlling. It is responsible to start the network, generate beacon frame and allocate address to each network device. The end device is RFD with minimum functionality. The end devices are responsible for communicating with its PAN coordinator only. In the WSN based animal health monitoring scenario, end devices sense and transmit the data like Animal Id, Animal Body parameter (Heart Rate, Body Temperature and Blood Pressure), soil Infection parameter and dust level parameter. Each PAN works within the range up to 20 meters. Figure 1 shows the ZigBee based architecture

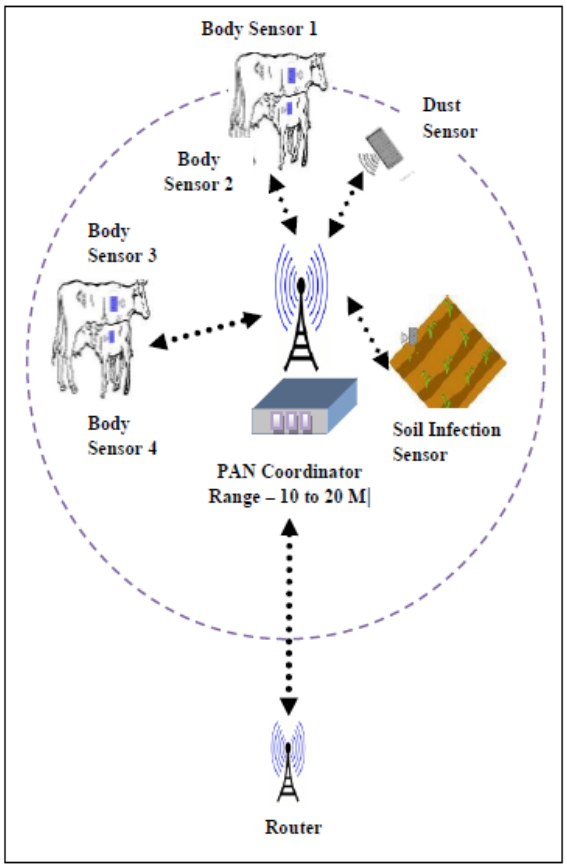

Fig. 1. Star topology implemented at Animal shade for WSN based AHM

framework of star topology for animal sheds in WSN based animal health monitoring scenario. The figure shows that the PAN coordinator will receive a data from end device and transmit it to the nearest network router which further transmits the data to the server located in Gram Panchayat office.

All the Personal Area Networks of animal health monitoring scenario follow Peer-to-Peer topology. Each animal shed works as PAN network hence the village has several such PAN networks. Each PAN coordinator transmits data frame to nearest routers, the last destination of this data frame is the local database server located in Gram Panchayat office. The network router can communicate with each other and the PAN coordinators can communicate directly or via router to each other.

Figure 2 shows the architecture of the ZigBee based Peer-to-Peer network topology for WSN based Animal Health Monitoring in rural area of Gujarat.

V. DATA TRANSMISSION MODEL FOR WSN BASED ANIMAL HEALTH MONITORING

In the ZigBee based network architecture, we need to transmit the data frame to the destination network device. In the proposed architecture, the data transfer model follows the Beacon mode of operations. All the devices that have data to transfer will use the slotted CSMA/CA mechanism. In the Beacon mode operation network devices synchronize their action and coordinate communication based on beacon. The

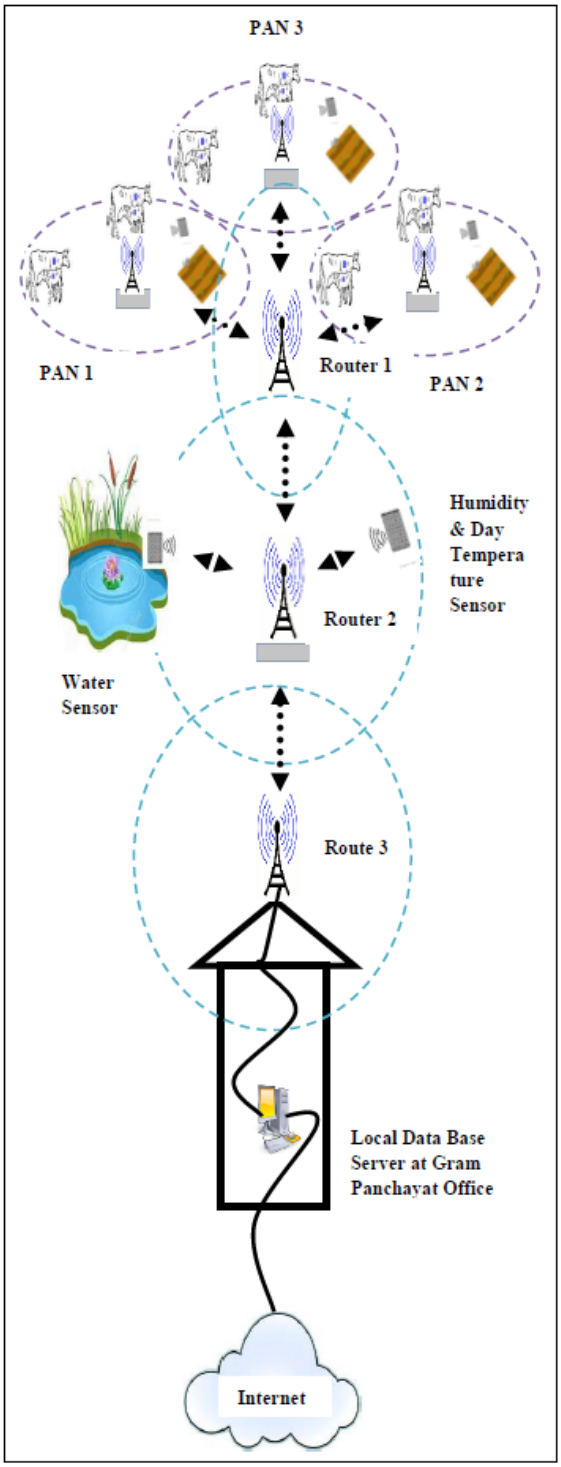

Fig. 2. Peer-to-Peer topology implemented at village for WSN based AHM

WSN based animal health monitoring architecture has three type of devices in the transmission network.These devices are End Devices used as a RFD, PAN Network coordinator used as a FFD and network router used as a FFD.

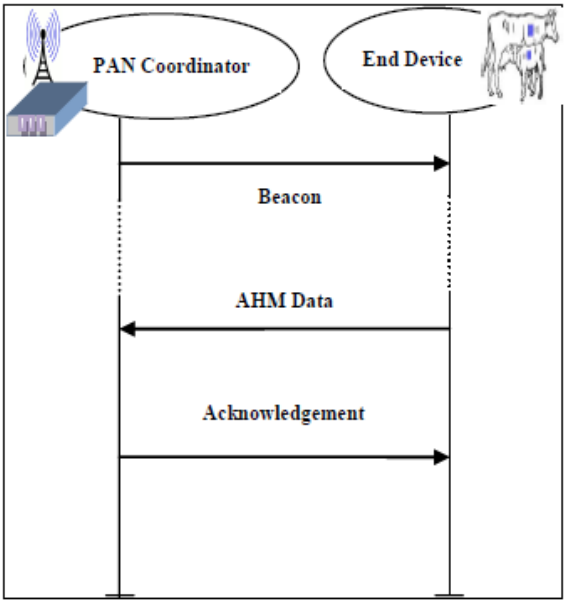

Fig. 3. Communication sequence from End Device to PAN Coordinator in AHM

A. *Data transfer from End Device to PAN Coordinator*

The animal shed works as a Personal Area Network with one PAN Coordinator and rest of the devices work as End Devices. It follows the star topology. Figure 3 shows the communication sequence from End device to PAN Coordinator.

This transfer happens within Star topology from one of the end device to the PAN Coordinator. When the End Device has a data to transfer to PAN Coordinator, it first listens for the Network Beacon. After receiving Beacon, at the appropriate time the End device transmits a Animal Health Monitoring (AHM) data frame to PAN Coordinator. As soon as PAN Coordinator receives a AHM data frame, it transmits acknowledgement frame indicating successful reception of data to the End Device.

B. *Data transfer from PAN Coordinator to End Device*

Figure 4 shows the communication sequence from PAN Coordinator to End Device. If PAN coordinator wants to transfer data to one of the End Devices within its PAN network, first of all it needs to intimate the network beacon that a message is pending. The end devices of PAN regularly listen to the network beacon. If the message is pending for a specific End Device, it transmits MAC command requesting data. As soon as the PAN Coordinator receives AHM data request, it will transmit acknowledgment frame and after that PAN Coordinator transmits the data frame to End Device. After receiving the data frame, the End Device transmits acknowledgement frame to PAN Coordinator. Finally the message is removed from the list of pending messages in the beacon.

C. *Association and Disassociation of Devices*

In the WSN based animal health monitoring architecture, a connection needs to be established between the End Device and PAN coordinator for transferring the data. Once the

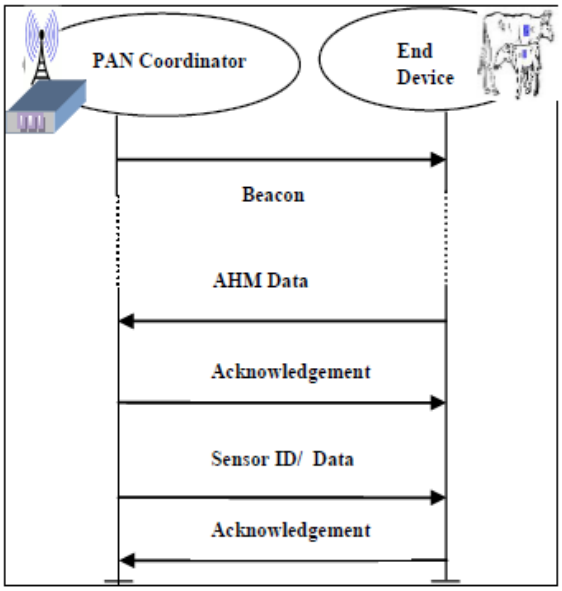

Fig. 4. Communication sequence from PAN Coordinator to End Device in AHM

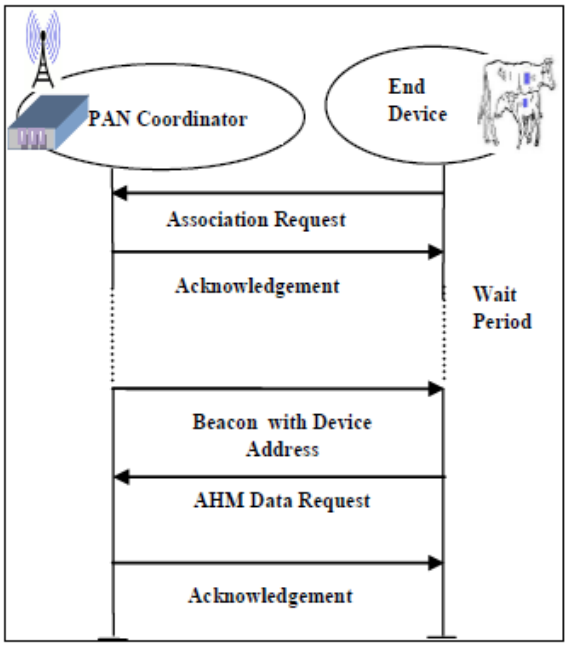

Fig. 5. Association sequence between PAN Coordinator and End Device in AHM

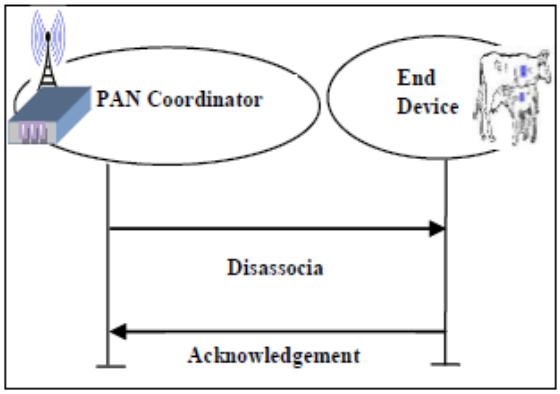

Fig. 6. Disassociation sequence between PAN Coordinator and End Device in AHM

transaction is over, the peer device is required to disconnect the connection. If the end device wants to become a member of Personal Area Network, it should scan the channel for potential PAN Coordinator. After finding PAN Coordinator, the end device waits for its beacon and transmits an association request command to the PAN Coordinator. As soon as the association request is received by PAN Coordinator, it will transmit acknowledgement frame. After receiving acknowledgement frame the end device should wait for association decision to be taken by the PAN Coordinator. After making decision on association request, the PAN Coordinator transmits the beacon frame with the End Device address ID. It indicates that the association request's result is now available. If the End Device finds its address in beacon, it sends the data request to the PAN Coordinator to acquire the association result. Figure 5 shows the association sequence between PAN Coordinator and End Device. If the PAN Coordinator wants to release an associated device from its PAN, it will send the disassociation command request to the End Device. As soon as the End Device receives the disassociation command, it will reply with an acknowledgement frame. If the end device wants to leave the PAN, the said procedure will be followed in reverse order. Figure 6 shows the disassociation sequence between PAN Coordinator and end device.

VI. CONCLUSION

In this paper we have proposed the ZigBee based network topology for the animal heath monitoring architecture. This topology works based on Personal Area Network. Each PAN consists of PAN coordinator and end devices.The topology shows interaction between different animal sheds. Each animal shed works as PAN and each PAN has coordinator to monitor and regulate the PAN network. Then we have proposed the data transmission model between end device and PAN coordinator. This data transmission model discusses various data transmission scenarios, association and disassociation between end devices and PAN coordinator. The proposed ZigBee based network architecture intends to enhance the exiting veterinary infrastructure. It allows of monitoring of animal health 24 * 7, 365 days. Thus making sure that timely action can be taken in case of eventualities.

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