

COMPREHENSIVE STUDY ON ENERGY EFFICIENT ROUTING IN ZIGBEE WIRELESS SENSOR NETWORK

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Abstract:

As we recognize, the data correspondence in the wireless networks is more deceitful than it is in the wired network condition. Despite the fact that the virtual transporter detecting plan can be utilized as a part of the wireless unicast transmission, the multicast communicate still not abuse the affirmation instrument for solid transmission. This is because of the affirmation parcels of communicate program will cause much advanced correspondence activity and overhead. Since dependable data communicate is basic and mandatory in numerous applications in the wireless sensor networks, our examination centers around the ZigBee network which is another mechanical standard for sensor networks. Some past related papers enhanced the communicate unwavering quality by presenting repetitive transmission and expanding scope proportion of each recipient hub, yet there still exists likelihood of bundle misfortune and additional correspondence cost because of excess communicate. Wireless sensor networks are working in a few applications, including military, medicinal, natural and local. In every one of these applications, energy use is the deciding variable in the execution of wireless sensor networks. Accordingly, techniques for ZigBee based data routing and exchanging to the base station are vital in light of the fact that the sensor hubs keep running on battery control and the energy accessible for sensors is restricted. This Paper surveys every one of the viewpoints and imperatives identified with data routing inside ZigBee wireless sensor network.

Keywords: Zigbee Specifications, wireless sensor network, cluster-based routing, energy efficiency, IEEE 802.15.4.

I. INTRODUCTION

Wireless sensor networks, a developing innovation are comprised of sensor hubs which are dispersed and self-ruling in nature. These sensor hubs can change in number from a couple to thousands contingent upon the circumstance in which they are being utilized. These sensor networks are utilized as a part of military, checking applications and so on they are additionally utilized as a part of threatening situations, for example, debacle struck zones. Contingent upon the application or the zone in which such a network is utilized the energy usage of the individual hubs can shift.

Wireless Sensor Network (WSN) is normally sent with an extraordinary number of sensor hubs to cover a huge scope of territory to screen occasions, gather data from condition, and so on.

The data gathered by sensor hubs is normally transmitted to sink hubs, which are portals to outside world, for additionally handling by a multi-bounce network. Hub disappointments and migrations ought not thwart the effective transmission of data to the sinks. Thusly, WSN should be equipped for adjusting to changes in network topology caused by hub disappointments, migrations thus on. Initially, look into intrigue is centered around single sink WSN [1] and [2]. In any case, versatility of single sink WSN isn't sufficient to fulfill the request of transmitting

data from a substantial number of hubs to a solitary sink. As the quantity of hubs expands, network blockage because of problem area marvel will be severe to the point that transmission can't proceed. As of late, intrigue is changed toward to multi-sink WSN [3]-[5]. In a multi-sink WSN, the mean number of bounces amongst hubs and sinks can be diminished amazingly; network blockage can be mitigated by utilizing suitable routing strategy to adjust movement stack among the sinks equally.

ZigBee is a determination of abnormal state correspondence conventions based over IEEE 802.15.4 standard. In light of its minimal effort low power utilization properties and capacity to help work network topology, zigbee is a perfect innovation for execution of WSN.

ZigBee [6] is a wireless "standard" of ZigBee organization together based on IEEE 802.15.4 standard [7] for Personal Area Networks. It characterizes the network and application layers on the highest point of physical and data connect layers standardized in IEEE 802.15.4. ZigBee stack offers a wireless correspondence arrangement combined with ease, low energy utilization qualities. It can be utilized as a part of customer hardware, modern controls, PC peripherals, toys and recreations, and so on. Notwithstanding, one of the potential uses of this standard is in Wireless Sensor Networks (WSN). Indeed, IEEE 802.15.4 is intended to accomplish a low power utilization through a few improvements in Physical layer and Medium Access Control (MAC) sub-layer like the utilization of low obligation cycles. The network layer utilizes an altered AODV (Ad Hoc on Demand Distance Vector) of course and Hierarchical Tree Routing (HTR) as keep going resort. WSN have concentrated on Quality of Service (QoS) support to enhance the dependability and execution under extreme energy imperatives. The change of QoS can be handled in any layer. For example a few research work has been done on enhancing ongoing help in MAC sub-layer utilizing GTS (Guaranteed Time Slot) instrument of IEEE 802.15.4 [8]. This enhances just continuous QoS in single bounce networks. In network layer, which gives end to end continuous QoS in multi bounce networks, this is finished by including and enhancing the QoS support to the routing calculation. In any case, before doing that we have to dissect the execution of the current routing calculations. Obviously our point in long haul is to give ongoing help in ZigBee Routing Protocol (ZRP).

A. Foundation of ZigBee

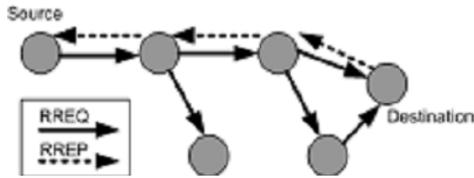
The ZigBee particular recognizes three sorts of gadgets that consolidate ZigBee radios, with every one of the three found in a regular ZigBee network:

? An organizer, which sorts out the network and keeps up routing table.

? Switches, which can likewise have the routing limit with respect to keeping up courses and converse with a wide range of gadgets.

? End gadgets, which can converse with switches and the organizer, however not to each other.

The ZigBee work routing receives the very much concentrated open space calculation AODV [9]. As AODV is an unadulterated on request convention, course revelation is based on a course demand and course answer question cycle. Course revelation starts when a source hub wants to send data to some goal.



As appeared in Figure 1, the source hub first communicates a course ask for (RREQ) bundle to its neighbors. At the point when a hub gets the RREQ, it at that point checks whether it has an unexpired course to the goal hub. If not, it makes a course passage and a course revelation section. The data put away in the course passage incorporates goal address, status, and next-bounce address. Next, the course revelation section contains Route Request ID, Source Address, Sender Address, Forward Cost, Residual Cost, and Expiration Time. The Route Request ID is increased for each RREQ the hub starts, and together with the source address, interestingly distinguishes a RREQ.

Figure 1: Basic routing disclosure Along with its own particular arrangement number and the Route Request ID, the source hub incorporates into the RREQ the latest succession number it has for the goal. Keeping in mind the end goal to react to the RREQ, the hub must be simply the goal. In the event that neither of this condition is met, the hub rebroadcasts the RREQ. The most recent ZigBee detail, formally named ZigBee 2012, offers full wireless work networking prepared to do

Supporting in excess of 64,000 gadgets on a solitary network.

It's intended to associate the vastest scope of gadgets, in any industry, into a solitary control network. ZigBee bolsters the biggest number of interoperable measures including ZigBee Building Automation, ZigBee Health Care, ZigBee Home Automation, ZigBee Light Link, ZigBee Smart Energy, ZigBee Telecom Services, and the expected ZigBee Retail Services.

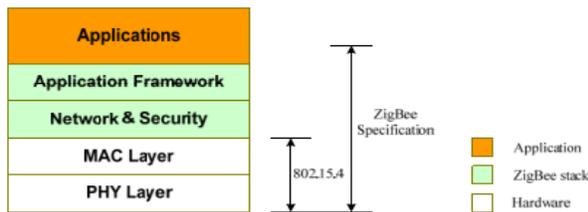


Figure 2. The ZigBee/IEEE 802.15.4 protocol stack.

II. ROUTING IN WIRELESS NETWORK

Routing is the demonstration of moving data over an internetwork from a source to a goal. En route, no less than one middle of the road hub normally is experienced. It's likewise alluded to as the way toward picking a way finished which to send the bundles. Routing is regularly appeared differently in relation to crossing over, which may appear to achieve correctly a similar thing to the easygoing eyewitness. The essential distinction between the two is that crossing over happens at Layer 2 (the

Data interface layer) of the OSI reference display, though routing happens at Layer 3 (the network layer). This qualification furnishes routing and crossing over with various data to use during the time spent moving data from source to goal, so the two capacities achieve their assignments in various ways. The routing calculation is the piece

of the network layer programming in charge of choosing which yield line an incoming bundle ought to be transmitted on, i.e. what ought to be the following moderate hub for the parcel. Routing conventions utilize measurements to assess what

Way will be the best for a parcel to movement. A metric is a standard of estimation; for example, way transfer speed, unwavering quality, and delay, current load on that way and so forth; that is utilized by routing calculations to decide the ideal way to a goal. To help the procedure of way assurance, routing calculations introduce and keep up routing tables, which contain course data. Course data differs relying upon the routing calculation utilized.

Figure 3: Typical router -based campus network Desirable properties of a router are as follows:

- Correctness and simplicity
- Robustness
- Stability
- Fairness and optimality
- Efficiency

III. CLASSIFICATION OF WIRELESS SENSOR NETWORKS

As indicated by another report from look into firm ON World "The home market for Wireless Sensor Networks (WSN) will achieve US\$6 billion a year by 2012". The expectation incorporates the two items and administrations fixated on in-home energy administration and wellbeing observing. In the mean time, ON World predicts the market for "Home Area Network" (HAN) energy administration answers for achieve 20 million homes worldwide by 2013. Wireless Sensor Networks may comprise of a wide range of sorts of sensors, for example, seismic, low testing rate attractive, warm, visual, infrared, acoustic and radar.

They can screen a wide assortment of surrounding conditions that incorporate temperature, dampness, vehicular development, lightning condition, weight, soil cosmetics, commotion levels, the nearness or absence of certain sorts of items, mechanical feelings of anxiety on joined articles, and the present attributes, for example, speed, heading and size of a protest. WSN applications can be grouped into two classes [10] as appeared in Figure 3:

? Observing

? Following

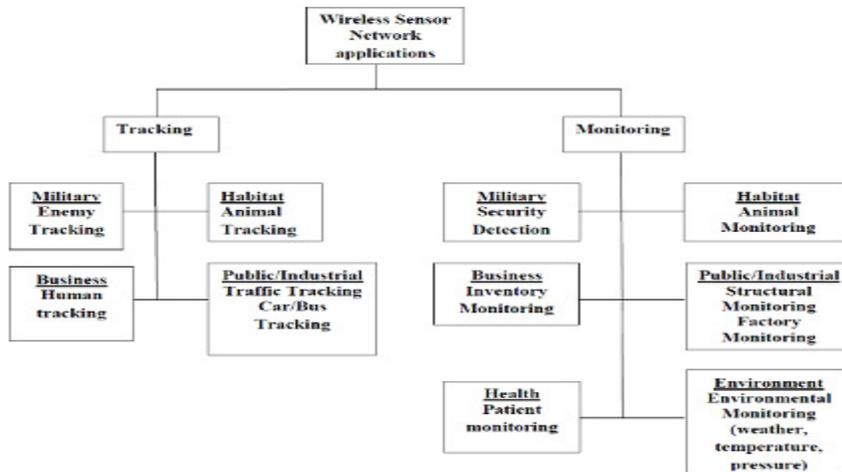


Figure 4: Overview of Wireless Sensor Network applications [10]

Monitoring applications include indoor/outdoor environmental monitoring, health and wellness monitoring, power monitoring, inventory location monitoring, factory and process automation, and seismic and structural monitoring. Tracking applications include tracking objects, animals, humans, and vehicles and categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief. In this subdivision a simple classification of the sensor networks based on their mode of the functioning & the type of target application is obtainable and are proactive, reactive, and hybrid networks.

IV. REVIEW OF LITERATURE

In 1981, Baker and Ephremides proposed clustering calculations called? Linked cluster calculation (LCA) [20] for wireless networks. To upgrade network reasonability, channel efficiency and energy economy of MANETS, Clustering calculations have been examined previously. Lin and Gela explored successful procedures to help media applications in the general multi-jump versatile specially appointed networks utilizing CDMA based medium mediation in [21]. Irregular rivalry based clustering (RCC) [22] is pertinent both to portable specially appointed networks and WSN.

RCC mostly centers at cluster solidness keeping in mind the end goal to help versatile hubs. The RCC calculation applies the First Declaration Wins control, in which any hub can "oversee" whatever is left of the hubs in its radio scope in the event that it is the first to guarantee being a CH. Some of understood clustering calculations for portable impromptu networks introduced in the writing are Cluster Gateway Switch Routing Protocol (CGSR) [23], Cluster-Based Routing Protocol (CBRP) [24], Weighted Clustering Algorithm (WCA) [25]. A study of clustering calculations for versatile impromptu networks has been talked about in [26].

As of late, creepy crawly sensory frameworks have been persuasive to new correspondences and registering models like bio propelled routing. It is because of their capacity to help highlights like self-sufficient, and self-sorted out versatile correspondence frameworks for inescapable conditions like WSN and portable specially appointed networks. Organic synchronization marvels can possibly empower disseminated and versatile synchronization calculations for WSN [27]. The primary MANET routing calculation in the writing to take inspiration n from ants are Ant-Colony Based Routing Algorithm (ARA) [28], Ant Net [29], AntHocNet [30] and so forth.

In [31], an energy proficient and delay-mindful routing calculation is proposed based on insect state based calculations. In [32], a bio-propelled versatile network synchronization convention for huge scale sensor networks is proposed, which is roused by the straightforward synchronization techniques in organic marvels, for example, blazing fireflies and spiking of neurons. A naturally propelled circulated synchronization calculation presented in [33] is based on a numerical model. It clarifies how neurons and fireflies immediately synchronize. In [34], the standards of hereditary qualities and development are embraced to empower benefit arranged, self-ruling, and self-versatile correspondence frameworks for inescapable situations, for example, WSN and portable impromptu networks. In [35], proficient bio-enlivened correspondence worldview for WSN is proposed based on the input circle component created by motivation from the standards of cell science. In [36], a clustering calculation based on organic majority detecting instrument is specified. It encourages the sensor hubs to shape clusters as indicated by spatial qualities of the watched occasion flag.

Quos is the capacity of a network component (e.g. an application, host or switch) to have some level of confirmation that its movement and administration prerequisites can be fulfilled. Quos oversees data transmission as indicated by

application requests and network administration settings. QoS has been broadly examined in wireless LANs and wired PC networks. IP and Asynchronous Transfer Mode (ATM) give broad QoS bolster going from best-exertion administration to ensured benefit.

A thorough outline of the condition of the field of QoS in networking was given by Chen in his proposal in 1999 [37]. Chakrabarti and Mishra [38] abridged the essential QoS-related issues in MANETs and the future work that required further consideration is given in [39]. In 2004, Al-Karaki and Kamal [40] displayed a point by point diagram about the condition of and the advancement slants in the field of QoS. It classified routing into the accompanying kinds of methodologies: level (all hubs assume an equivalent part), various leveled (a few hubs are nearby cluster sets out toward illustration), position based (use area data), and power-mindful (take battery utilization and remaining dash into thought) QoS routing. At long last, a point by point review of the all the more generally acknowledged MAC and routing answers for giving better QoS was exhibited in [41,42].

When all is said in done, routing in WSNs can be isolated into level based routing, various leveled based routing, and area based routing relying upon the network structure. In level based routing, all hubs are ordinarily relegated measure up to parts or usefulness. In various leveled based routing, in any case, hubs will assume diverse parts in the network. In area based routing, sensor hubs' positions are misused to course data in the network.

A routing convention is viewed as versatile if certain framework parameters can be controlled with a specific end goal to adjust to the present network conditions and accessible energy levels. Moreover, these conventions can be ordered into multipath-based, inquiry based, arrangement based, QoSbased, or routing methods relying upon the convention task. Notwithstanding the above, routing conventions can be grouped into three classes, specifically, proactive, receptive, and half and half conventions relying upon how the source sends a course to the goal. In proactive conventions, all courses are registered before they are extremely required, while in receptive conventions, courses are processed on request. Half and half conventions utilize a blend of these two thoughts. At the point when sensor hubs are static, it is desirable over have table driven routing conventions instead of utilizing receptive conventions. A lot of energy is utilized as a part of course disclosure and setup of receptive conventions. Another class of routing conventions is known as the helpful routing conventions. In agreeable routing, hubs send data to a focal hub where data can be accumulated and might be liable to additionally preparing, henceforth decreasing course cost regarding energy utilization.

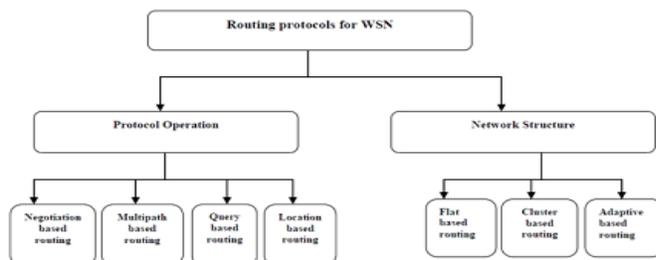


Figure 5: Taxonomy of routing protocols for WSN

V. THE ROUTING PROTOCOLS FOR PROTOCOL OPERATION

Transaction based routing: These conventions utilize abnormal state data descriptors called 'meta-data' keeping in mind the end goal to wipe out excess data transmission through arrangements. The important choices are based on accessible assets and neighborhood associations.

Sensor Protocols for Information by means of Negotiation (SPIN) [43] is one of surely understood Negotiation based routing convention for WSN. The SPIN conventions are intended to scatter the data of one sensor to every single other sensor accepting these sensors are potential base-stations. Henceforth, the fundamental thought of transaction based routing in WSN is to smother copy data and keep excess data from being sent to the following sensor or the base-station by directing a progression of arrangement messages before the genuine data transmission starts.

Multipath based routing: These conventions offer adaptation to internal failure by having no less than one substitute way (from source to sink) and along these lines, expanding energy utilization and movement age. These ways are kept alive by sending occasional messages.

Greatest Lifetime Routing in Wireless Sensor Networks [44] is a convention that courses data through a way whose hubs have the biggest remaining energy. The way is exchanged at whatever point a superior way is found. The essential way will be utilized until the point that its energy is underneath the energy of the reinforcement way. By methods for this approach, the hubs in the essential way won't drain their energy assets through persistent utilization of a similar course, therefore accomplishing longer lifetime. A detriment for applications that require versatility on the hubs, is that the convention is situated to take care of routing issue in static wireless networks.

Question based routing: In these conventions, the goal hubs proliferate an inquiry for data (detecting undertaking or enthusiasm) from the hub through the network. The hubs containing this data send it back to the hub that has started the inquiry.

Talk routing convention [45] is one of the routing convention utilized as a part of the setting of occasion warning. The approach does not surge the network with data around an occasion event however just introduces couple of ways in the network by conveying one or a few specialists. The specialists proliferate through the network introducing routing data about the occasion in every hub that is gone to. At the point when the operators run over shorter ways or more productive ways, they improve the ways in the routing tables as needs be. Every hub can likewise produce a specialist in a probabilistic fashion. Location based routing: In the conventions, the hubs are tended to by their area. Separations to next neighboring hubs can be evaluated by flag qualities or by GPS recipients. Area based routing conventions are: .Small Minimum Energy Communication Network (SMECN) [46] convention sets up and keeps up a base energy network for wireless networks by using low power GPS. In spite of the fact that, the convention expect a portable network, it is best pertinent to sensor networks, which are not versatile.

Geographic Adaptive Fidelity (GAF) [47] convention is energy-mindful area based routing outlined basically for portable specially appointed networks and can be material to sensor networks too. GAF keeps energy by killing pointless hubs in the network without influencing the level of routing loyalty. It frames a virtual matrix for the secured zone. Every hub utilizes its GPS-demonstrated area to connect itself with a point in the virtual matrix. Hubs related with a similar point on the network are viewed as identical as far as the cost of bundle routing. Such equality is misused in keeping a few hubs situated in a specific framework region in dozing state with a specific end goal to spare energy. Along these lines, GAF can considerably build the network lifetime as the quantity of hubs increment. GAF convention has both for non-portability (GAFbasic) and for versatility (GAF-versatility adjustment) of hubs.

Geographic and Energy Aware Routing (GEAR) [48] is the convention which utilizes geographic data while scattering the questions to the territories of enthusiasm since data inquiries regularly incorporates geographic properties. The convention utilizes energy mindful and topographically educated neighbor choice to highway a bundle towards the objective zone. Rigging can supplement coordinated dissemination by confining the quantity of

interests sent, and just considering a specific region as opposed to sending the interests to the entire network. In GEAR, every hub keeps an expected cost and a learning expense of achieving the goal through its neighbours. A virtual relative position based routing convention for sensor networks that gives techniques to data administration is Virtual Cord Protocol (VCP) [49]. VCP is a Distributed Hash Table like convention that offers an effective routing instrument, other than standard DHT capacities. The key attributes of VCP are the topographical region of virtual neighbors, which reduces the correspondence stack.

VI. ROUTING IN ZIGBEE TOPOLOGY

In a tree network, the ZigBee facilitator and switches can transmit reference points. Sending reference points encourages gadgets to synchronize with their folks and accordingly can bolster gadgets to rest and spare energy. Review that subsequent to shaping a network, the network organizer will decide the reference point arrange (BO) and super frame arrange (SO). At the point when BO is bigger than SO, gadgets can rest amid the inert parts of super frames. In the ZigBee network detail rendition 1.0, a super frame can be isolated into 2BO-SO non-covering schedule openings. A switch can pick a space to declare its reference point. The begin time of its guides is additionally the begin time of super frames of that switch. Along these lines, switches' super frames will be moved far from those of the coordinators by products of SD.

To maintain a strategic distance from crashes, a gadget ought not discretionarily pick an opening to transmit its guides. A gadget ought to abstain from utilizing a similar signal transmit openings as its neighbors' what's more, its parents; generally, its youngsters may lose signals because of crashes. Reference point crashes may happen in two ways: coordinate guide struggle between two neighbors and roundabout signal clash between non-neighbors. Since An and B are not neighbors, the contention is more hard to identify. The ZigBee network determination adaptation 1.0 does not give an unequivocal answer for this issue. In the present determination, a gadget should keep the signal transmission calendars of its neighbors and its neighbor's guardians. As such, signal transmission timetables of hubs inside two bounces ought to be kept up. Similar spaces ought to be maintained a strategic distance from. When sending guides, a gadget will include the time counterbalance between its reference point transmission time and its parents in the signal payload. This will enable a gadget to pick a contention to free space.

In a tree network, a gadget chooses its reference point transmission time when joining the network. Amid the joining method, a gadget tunes in to the reference points from its parent and its neighbors for a timeframe. At that point the gadget ascertains a void space as its reference point transmission opening. On the off chance that there is no accessible opening, this gadget will join this network as an end gadget. In the wake of choosing reference point transmission time, the network layer will advise the MAC layer the time contrast between its guide transmission time and its related parents signal transmission time.

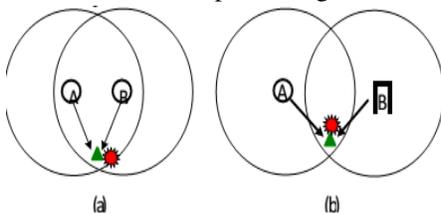


Figure 6: Beacon conflicts in a ZigBee tree network: (a) direct beacon conflict and (b) indirect beacon conflict. The ZigBee network specification version 1.0 defines the broadcast procedure in mesh networks. The network layer informs the MAC layer to broadcast network-layer packets. In ZigBee, the broadcast initiator can specify the scope of this broadcast. A device that receives a broadcast packet will check whether the radius field in the broadcast packet is larger than zero. If so, the device will rebroadcast the packet; otherwise, this packet will not

be further broadcast. ZigBee defines a passive acknowledgement mechanism to ensure the reliability of broadcasting. After broadcasting, the ZigBee device records the sent broadcast packet in its broadcast transaction table (BTT). The BTT will be combined with its neighbor table. This allows devices to track whether their broadcast packets have been properly rebroadcast or not. If a device finds that a neighbor does not rebroadcast, it will rebroadcast to guarantee reliability.

In ZigBee, devices use different strategies to broadcast packets according to the parameter *naxRxOoWhfoIemf* in the MAC layer. *naxRxOoWhfoIemf* controls whether a device can receive data when idle. By the nature of wireless communication, devices can detect radio signals when idle. However, they will refuse to process the received signals if *naxRxOoWhfoIemf* is False. When broadcasting is needed, a device with *naxRxOoWhfoIemf* = True will do so immediately. This device will also unicast the broadcast packet to those neighbors with *nadRxOoWhfoIemf* set to False. On the other hand, a device with *nadRxOoWhfoIemf* set to False can only unicast the broadcast packet to its neighbors. This is because that the device may miss passive acknowledgements from neighbors.

can ensure reliability. Fig. x. 12 shows an example that router A sets *nadRxOoWhfoIemf* to False. After receiving the broadcast packet from S, A will relay the packet to B and C by uncasing. However, broadcasting in ZigBee network may cause redundant transmissions. Reference (Ding et al., 2006) introduces a tree-based broadcast scheme to relieve this problem. The authors utilize the properties of ZigBee address assignment to find a set of forwarding nodes in the network. The proposed algorithm incurs low computation cost. Unicasting After receiving the broadcast packet from S, A will relay the packet to B and C by unicasting. However, broadcasting in ZigBee network may cause redundant transmissions. Reference (Ding et al., 2006) introduces a tree-based broadcast scheme to relieve this problem. The authors utilize the properties of ZigBee address assignment to find a set of forwarding nodes in the network. The proposed algorithm incurs low computation cost.

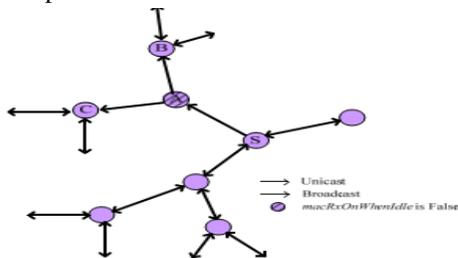


Figure 7: A broadcast example in a ZigBee Network.

Toward the start of a course revelation, the source communicates a course ask for parcel. A ZigBee switch that gets a course ask for parcel initially figures the connection cost. On the off chance that this gadget has routing limit, it will rebroadcast this demand in the event that it doesn't get this demand previously or the connection cost recorded in course ask for in addition to the cost it just figured is lower than the previous got ask. Else, it will dispose of this demand. For the case that a ZigBee switch that isn't routing skilled gets a course ask for, it likewise decides if to resend this demand based on a similar examination. On the off chance that this gadget decides to resend this course ask for, it will check the goal address and unicast this course demand to its parent or to one of its youngsters (in the tree network). Gadget S communicates a course ask for goal T and gadgets An and D get this bundle. Since gadget A has no routing limit, it will check the address of goal T and unicast this demand to gadget C. Since gadget D has routing limit, it will rebroadcast this demand. A gadget that has loathe are outer ask for bundle will record the demand sender in its course revelation table. This data will be disposed of if this gadget does not get a course answer inside a period interim.

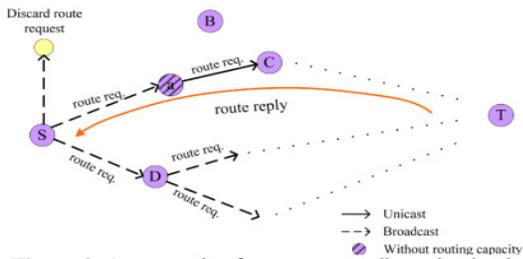


Figure 8. A case of course ask for dispersal in a ZigBee network. When the goal gets course ask for bundles from various ways, it will pick the routing way with the most minimal cost and send a course answer parcel to the source. The course answer bundle will be sent by uncast. A halfway hub that gets the course answer bundle checks its course disclosure table and sends the course answer to the demand sender. After the source hub effectively gets the course answer, it can send data bundles to the goal hub along the found course.

The ZigBee network layer additionally indicates course support systems for work and tree networks. In a work network, course disappointment is distinguished by a disappointment counter. On the off chance that the counter of a ZigBee switch surpasses a limit, the switch can begin the course upkeep method. For those switches that have routing limit, they can surge course ask for bundles to discover goals. For switches that don't have routing limit, they will unicast course ask for bundles to their folks or kids as per the goal addresses. Notwithstanding, in a tree network, a switch does not communicate course ask for bundles when it loses its parent. Rather, it disassociates with its parent and tries to re-connect with another parent. After reassociation, it will get another short 16-bit network address and can transmit parcels to its new parent.

CONCLUSION

In this paper, we have introduced the design of IEEE 802.15.4 and ZigBee network layer protocols. A lot of research stitutes and industrial companies have developed their sensor platforms based on ZigBee/IEEE 802.15.4 solutions. ZigBee and IEEE 802.15.4 are designed for lightweight sensor platforms. We have also addressed some applications such as medical care and fire emergency applications and some prototyping systems. For further readings, (Intanagonwiwat et al., 2003; Schurgers and Srivastava, 2001) address routing protocols and (Dam and Langendoen, 2003; Gandham et al., 2005; Ye et al., 2002) discuss energy efficient MAC protocols in WSN.

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