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MAC Protocol Analysis for Wireless Sensor Networks

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ABSTRACT

In wireless sensor networks, MAC protocol is used to achieve efficient, fair, and balanced allocation of wireless channel resources and access control of nodes in the network, and to control the communication process of nodes in the network. The energy consumption of wireless sensor nodes is mainly concentrated in the communication unit, including data transceiver, idle listening, protocol control overhead, etc. A good MAC protocol is beneficial to reduce unnecessary energy consumption and enhance node lifetime. At the same time, MAC protocol, as the bottom protocol of wireless sensor network, provides a stable and reliable communication foundation for the realization of the upper protocol. Therefore, a large number of scholars at home and abroad have carried out extensive and in-depth research on MAC layer protocol of network. In this paper, the research process and progress of MAC layer protocol in wireless sensor networks are analyzed, and the research progress of MAC layer protocol in multi-radio frequency and multi-channel wireless sensor networks is analyzed.

KEYWORDS

Energy Consumption, MAC Protocol, Wireless Sensor Networks

INTRODUCTION

The MAC protocol of wireless sensor network can be divided into many different ways from different angles. By channel access, it can be divided into non-scheduling (random/competitive)MAC protocol, scheduling (cooperative)MAC protocol and hybrid MAC protocol1. According to the number of radio frequency used by nodes in the network and the number of channels, it can be divided into single radio frequency single channel MAC protocol, single radio frequency multi-channel MAC protocol and multi-radio frequency multi-channel MAC protocol. According to the time synchronization characteristics of nodes in the network, it can be divided into synchronous MAC protocol and asynchronous MAC protocol (Liangrui Tang(2019)).

The same MAC protocol can also be classified into different classes according to different perspectives. For example, S-MAC, T-MAC, etc.. S-MAC protocol is designed based on IEEE 802.11 to save energy in sensor networks. S-MAC includes energy-saving methods from various energy consumption modes, such as idle interception, collision, crosstalk and control overhead. The T-MAC protocol dynamically adjusts the active time according to the traffic on the basis of keeping the period

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length unchanged, and sends messages in burst mode to reduce idle listening time. In this section, MAC protocols are divided into three types according to the anti-conflict mechanism adopted the protocol and the organization form of nodes in the network: non-scheduling MAC protocols, scheduling MAC protocols, hybrid MAC protocols and cross-layer MAC protocols (Karuna Babber(2017)).

In the non-scheduled MAC protocol network, the nodes do not exchange information with each other, but compete randomly using the wireless channel resources Carrier Sense Multiple Access(CSMA) (Joseph E. Mbowe(2014)). Because of its simple flexibility and good robustness, CSMA technology has become a common technology in non-scheduling MAC protocol. CSMA technology does not need complex basic technology and information to support: it does not need node time synchronization; No global network topology information is required.

It can adapt to the dynamic change of the number of nodes. However, such problems as high probability of channel conflict, high probability of data transmission failure, excessive data retransmission and long idle listening time will increase the energy consumption of nodes and shorten the network life time. In addition, CSMA technology can only listen to the node signal within the range of one hop, and it is easy to produce the problem of terminal disappearance in multi-hop communication. In order to reduce the energy consumption of nodes, the periodic activation/sleep mechanism is usually adopted, and the RTS/CTS handshaking mechanism is adopted to solve the problem of data collision during communication (Awatef Ben Fradj Guiloufi(2013)).

Scheduling MAC protocol manages the communication process between nodes in the network uniformly according to certain rules, and it widely uses Time Division Multiple Access (TDMA) technology to coordinate the access of nodes to channel resources in the network (Hemanta Kumar Kalita(2010)). The core idea of TDMA is to subdivide the timeline into several different time slots, each node occupies a different time slot, and the nodes wake up in the corresponding time slot and enjoy the exclusive wireless channel without conflict. In order to ensure the uniqueness of the time slot occupied by each node in the network and avoid channel conflict, the MAC protocol based on TDMA technology needs strict global time synchronization (Arun Kumar(2017)).

Hybrid MAC protocols combine the advantages of scheduling and non-scheduling MAC protocols. Due to the positive correlation between bit error rate, power consumption and data length, some hybrid MAC protocols divide the transmitted data into long data frames and short control frames in order to reduce node power consumption (Patrick Moriarty(2019)).

In the transmission of long data frames, scheduling protocol is adopted to reduce the channel conflicts between nodes, improve the transmission success rate, reduce the probability of retransmission and thus reduce the energy consumption of nodes. For periodic short control frames, the non-schedulingprotocol is used to improve the real-time performance of control frames. Some hybrid MAC protocols adaptively and dynamically adjust between CSMA and TDMA according to the intensity of channel competition in the network. The advantage of hybrid MAC protocol is that it can be switched quickly and adaptively according to the network traffic condition, thus saving a lot of energy consumption of nodes. The disadvantage is that this type of protocol is usually more complex, and the overhead of protocol control is high, which is not conducive to expansion.The non-scheduled MAC protocol allocates channel resources according to requirements, is easy to expand, and is more flexible to adapt to changes in network node density and topology. In addition, non-scheduled MAC protocol does not require time synchronization between nodes, which reduces the overhead of protocol control. For the same reason, non-scheduled MAC protocols usually have higher channel collision probability, which increases idle listening and crosstalk energy consumption. At the same time, compared with scheduling MAC protocol, the problem of balanced use of wireless channel in non-scheduling MAC protocol is more prominent. Non-scheduled MAC protocols generally fall into one of the following categories (Su Man Nam(2021)).

NON-SCHEDULING MAC PROTOCOL

MAC Protocol Application

Wireless sensor network is highly dependent on the characteristics of specific applications, so people can design specific MAC protocols according to the characteristics of specific application fields. For example, in a monitoring application, the data flow in the network is usually small most of the time, but once a trigger event occurs, a large amount of data will be generated in the network in a short period of time and need to be transmitted. Therefore, according to the characteristics of such applications, the MAC protocol with high efficiency burst transmission, ultra-low duty cycle and ultra-low power listening is particularly suitable (Khadije Rahimkhani(2017)).

The CC-MAC protocol that uses adjacent nodes to generate correlation measurements to meet application requirements and save node energy (Karuna Babber(2017)). CC-MAC filters highly correlated sensor node data to reduce the number of messages processed by the network, reduces the network load by minimizing the number of highly correlated messages, reduces the amount of data received and received by nodes and the occurrence of data collisions, which not only meets the data demand in the application, but also reduces the duty ratio of nodes and energy consumption of nodes. The CC-MAC consists of two parts: an event MAC (E-MAC) that filters sensor measurement data to reduce network traffic; Forward the filtered data to the network MAC (N-MAC) of the Sink node. Only the sensor nodes within the relevant radius of the monitoring area can generate the measurement data in E-MAC, and only the nodes in other areas can periodically sleep/wake up and forward the data, so as to reduce the amount of measurement data. N-MAC forward the measurement data to the Sink node. Since E-MAC reduces the redundant measurement data, the reliability of the data forwarded by N-MAC is particularly important (Mario Ruz(2019)).

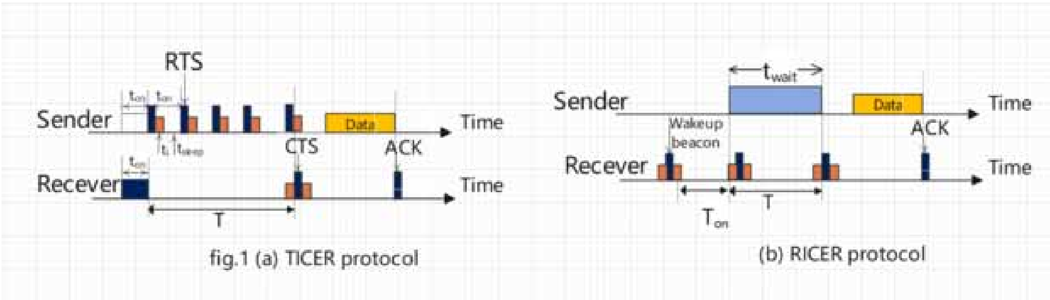
SIFT-MAC is a MAC protocol designed by Jamieson et al. for event-driven sensor network application environment. In this protocol, the non-uniform probability distribution function is used to select the time slot of data transmission in the slot competition window. When the channel is not used by any node in the first slot of the competing window, all nodes in the network assume that the number of competing nodes is small and exponentially increase the probability of data transmission in the next slot. Compared to the IEEE 802.11MAC protocol, SIFT-MAC can significantly reduce data latency when multiple nodes are transmitting event reports. The ALERT-MAC protocol is used to trigger emergency messages by collecting events that minimize latency in a set of sensor nodes. The protocol does not need any coordination and pre-scheduling between the receiving and receiving nodes during the execution, and uses multiple frequency channels by controlling the probability of the node to select the channel in the time slot. The alarm message minimizes the competition between nodes by using time and frequency multiplexing technology. The STEM protocol for sparse topology and energy management places all sensor nodes in a dormant state while monitoring the environment in order to save node energy. When there is data transmission, the source node wakes up the downstream neighbor node to forward the data through the control channel (Albert Sabban(2017)).

Convergence MAC Protocol

In order to realize inter-node communication, the source node and destination node must converge on the same channel at the same time. The most commonly used converging strategy is called cyclic receiving, in which the nodes periodically turn on and off power and send beacon frames to achieve the purpose of inter-node communication. Common cyclic receive strategies include: send open cyclic receive TICER protocol and receive open cyclic receive RICER protocol (Xuanxuan Tang(2019)).

As shown in fig.1 (a), the sending node in the TICER protocol periodically wakes/sleeps and sends RTS packets during the wake phase. The receiving node listens to the channel periodically and replies to the CTS packet if there is an RTS packet. The sending node starts sending data after receiving the CTS. Corresponding to TICER protocol is RICER protocol. As shown in fig.1 (b), the

Figure 1. (a) TICER protocol (b) RICER protocol



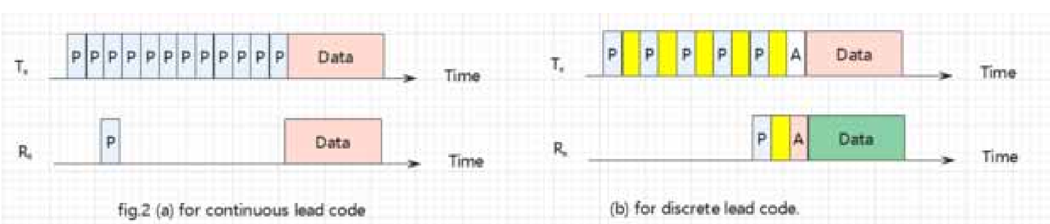
receiving node periodically wakes up and sends beacon frames in RICER protocol. The sending node periodically wakes up and listens for the beacon frame. After receiving the beacon frame sent by the destination node, if the data needs to be sent, it immediately sends the data to the destination node. In TICER protocol and RICER protocol, when the data is received successfully, it is confirmed by ACK message (Jin Wang(2019)).

Leading Code MAC Protocol

In wireless sensor network, the energy consumption of nodes is mainly concentrated in the stages of data sending, receiving and idle listening. When the network load is low, the energy consumption of idle listening is more significant and can not be ignored. In order to reduce the idle listening energy consumption of nodes, researchers designed an idle listening mode based on the precursor code. In MAC protocol based on lead code, the sending node before the first data insert a bunch of continuous flow of bits long enough as a lead code, its length to ensure destination node wakes up at least once and listen to the leading code, as shown in fig.2 lead code based MAC protocol data frame format, (a) for continuous lead code, (b) for discrete lead code (Yang Wang(2019)).

In the MAC protocol based on the leading code, the receiving node wakes up and carries out idle detection on the channel. If the channel is idle, it immediately goes to sleep; otherwise, it keeps waking state for the subsequent receiving of valid data. B-MAC protocol based on lead code using the exponential weighted moving average algorithm of RSSI of received signal to calculate the median number of background noise channel, when the receiving node aroused and detected when the channel is busy, the current channel of RSSI and calculate the average background noise, if the mean is greater than the background noise before deciding to effectively lead code, as the channel interference, conversely, the receiving node goes to sleep state. This mechanism effectively avoids the unnecessary idle listening of receiving nodes caused by channel noise and reduces the unnecessary energy consumption of receiving nodes. In the ENBMAC protocol, the leading code preorders the time when the source node starts to transmit data. Therefore, the destination node can sleep again

Figure 2. (a) For continuous lead code (b) for discrete lead code



until the time when the data starts to transmit wakes up to receive data again. This mechanism can further reduce the idle listening energy consumption of the destination node by using the leading code to reserve the time of data transmission (Shidi Yu(2018)).

In order to reduce the node energy consumption of sending leading codes, MH-MAC protocol, CSMA-MPS protocol, X-MAC protocol, Wise MAC protocol and so on improve the way of sending continuous leading codes, and adopt discrete leading codes. That is, the sending node reserves time between two adjacent leading codes for receiving ACK packets from the destination node to stop the sending of leading codes and start sending valid data, as shown in fig. 2 (b). This kind of MAC protocol reduces the energy consumption of sending node, but increases the difficulty of channel interception and idle interception energy consumption of destination node, and increases the delay of data transmission.

Multichannel MAC Protocol

The wide application of wireless sensor network, especially in the application field of time sensitive and large amount of data, puts forward higher requirements for real-time data and network throughput. At the same time, there are several non-overlapping and orthogonal channels in wireless sensor networks. Therefore, based on the design of multiple non-overlapping orthogonal channels existing in the network, a MAC protocol which can access multiple channels concurrently and transmit data in parallel is implemented to solve the increasing requirements of network performance in applications.

Swain et al. designed the MMAC protocol using channel hopping to use multiple channels within the network. In this protocol, nodes synchronously switch to the control channel to determine the wireless channel for data transceiver through negotiation, and the sending node switches to the data channel where the destination node is to send data in the time window of data transmission according to the negotiation result. In order to ensure the synchronization switch of control channel between nodes, the time synchronization of the whole network is required, which increases the overhead of control protocol. In order to alleviate the dependence of channel negotiation on control channel and the problem of terminal disappearance in frequency hopping, the authors propose RIM-MAC protocol and RB-MAC protocol initiated by receiver. RB-MAC protocol constantly updates the available receiving/transmitting channel, and the data channel is determined by negotiation in the currently available receiving/transmitting channel, which reduces the negotiation time delay and the collision probability of the data channel. The multi-channel MAC protocol TMCP based on the tree network topology divides the tree topology into several independent subtrees, and allocates different channels for each subtree to communicate with the nodes within the subtree. TMCP reduces the channel interference between subtrees and realizes the parallel data transmission between multiple subtrees. However, this protocol is only applicable to the tree network topology, and the flexibility and scalability of the protocol are poor. The researchers combine TDMA technology with multi-channel and propose MC-LMAC protocol and Much MAC protocol. According to the number of channels in the network, the MC-LMAC protocol divides the time into multiple time slots of the same amount. Each node determines its allocated time slot and corresponding channel through the control channel. In the same time slot, different nodes use different channels to avoid channel collision, and multi-channel parallel transmission can be realized among multi-nodes. Much MAC protocol also divides time into multiple time slots. According to node ID and time slots, nodes randomly wake up the wireless channel in the allocated time slot to send and receive data. Due to the random wake up mechanism of the channel, when there are multiple nodes in the communication range to wake up the same channel at the same time, channel collision will occur during node data transmission, resulting in data transmission failure and increasing data transmission delay (Mirsadeghi, F.(2020)).

Scheduling MAC Protocol

In the scheduling MAC protocol, each node in the network generates a scheduling table, which determines when the neighbor nodes use the wireless channel, so as to reduce or eliminate the channel collision, idle listening, and crosscast between nodes. During scheduling, the node goes into hibernation and is not awakened until data needs to be sent or received. In addition, nodes exchange network traffic and status information with each other to optimize their energy consumption. Scheduling MAC protocol requires control messages to maintain the consistency of node scheduling in the network, especially when nodes move, redeploy, die out of the network, and new nodes join.

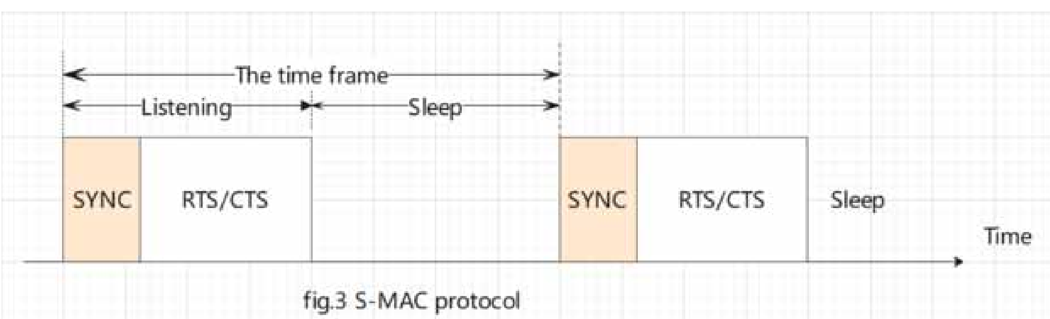
Timeslot-Based Scheduling MAC Protocol

Time-slot scheduling MAC protocol requires time synchronization of nodes in the network, so that the sleep/listening process of each node is synchronized. This protocol divides the time into multiple frames, and each time frame is subdivided into multiple time slots. When the node sends data, it wakes up at the beginning of each frame to compete using the wireless channel. This channel competition mechanism leads to a high probability of communication collision because all transmitting data nodes have synchronous wake up time. The RTS/CTS handshake mechanism is used in the improved time-slot competing MAC protocol to avoid communication collision problems.

S-MAC is a typical TIME-slot scheduling MAC protocol based on periodic sleep/listening and local synchronization management, as shown in fig.3. In the S-MAC protocol, the neighbor nodes form a virtual cluster, and there is a consistent sleep schedule among neighbors in the cluster. Nodes in the cluster continuously broadcast the time packet SYNC at a fixed frequency to implement time synchronization among neighbors in the cluster. CSMA carrier sense and RTS/CTS handshake mechanism are used to avoid data collision. In addition, in order to reduce the collision probability of long data transmission and improve the transmission success rate of long data frames, S-MAC divides the long data frame into several short data frames and transmits them in burst access mode, which is beneficial to reduce the protocol maintenance overhead and node energy consumption. Periodic hibernation can reduce unnecessary listening energy consumption of nodes, but it also brings large data communication delay, especially in the process of multi-hop communication, because nodes on multi-hop links are located in different clusters and have different hibernation cycles. Then Ye et al. proposed an adaptive listening algorithm to improve the communication delay caused by node sleep. The node obtains the end time of the neighbor's data transmission based on the RTS/CTS handshake data and wakes up for a small period of time before the data transmission ends to eavesdrop on the communication of its neighbor. If the node is the next hop node in the multi-hop transmission, the node does not go to sleep and receives data immediately. In the S-MAC protocol, even if the node sends no data, its fixed waking time wastes a lot of listening energy consumption, especially when the communication traffic of the node is small, this situation is more serious.

T-MAC still adopts the periodic sleep scheduling mechanism similar to S-MAC. However, the listening and sleep duration are adjusted according to the network load. RTS/CTS handshake mechanism is also used during data transmission. The adaptive adjustment time TA of the node must

Figure 3. S-MAC protocol



meet the following requirements: TA> C +R +T, where C is the channel race time, R is the time required for RTS packet transmission, and T is the interval between RTS sending completion and CTS receiving. If no event is activated within TA time, the node enters the hibernation state. The activation events are as follows: Timer timeout; Receiving data; Sense channel state, such as channel conflict; Send end or wait for ACK; Listens for RTS/CTS data frames after exchanging data with the neighbor node (Al-Qerem, A.(2020)).

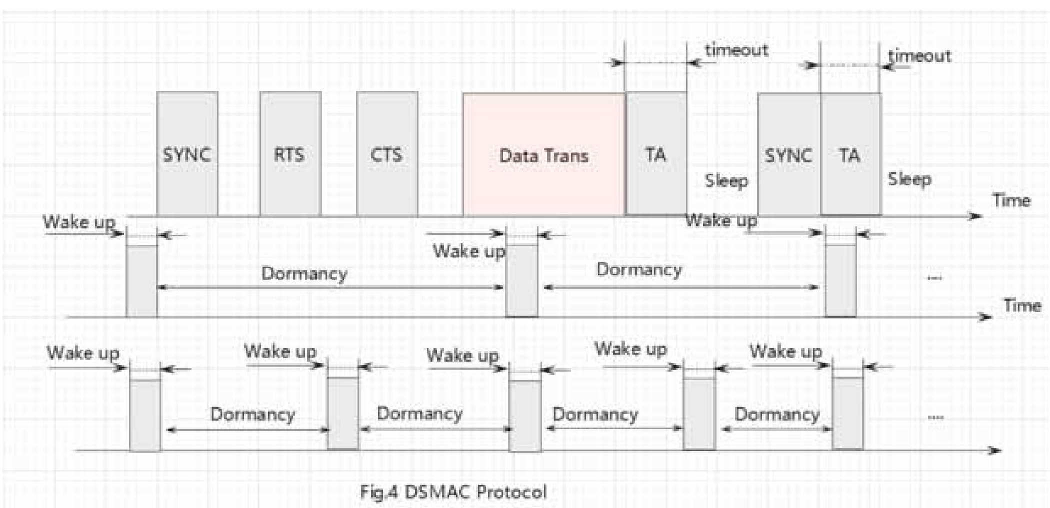
Although T-MAC protocol reduces the energy consumption of node listening by dynamically adjusting the listening time, the communication delay is still large. In order to solve the problem of nodes going to bed early in T-MAC protocol and improve data delay in the protocol, Future Request to Send (FRTS) packets are used. A node sends an FRTS packet to notify the next hop node of the time when it will send data. In addition, T-MAC protocol considers the size of node cache to solve the problem of node cache overflow. As show in Fig.4.

As mentioned above, regardless of S-MAC or T-MAC, data transmission can only be carried out hop by hop, and only one hop can be forwarded in each scheduling period. To solve this problem, Lu et al designed d-MAC protocol based on staggered wake-up scheduling.

D-MAC is mainly suitable for collection tree network, the agreement is still with S-MAC, T-MAC scheduling of periodic similar, the difference is that the nodes awakened state further subdivided into two stages: data sending and receiving, the duration of each phase is set to can meet the time needed for a complete data transmission, the rest of the time as a dormant state. Each node in the collection tree begins to receive data at d* u, where D represents the depth of the node in the collection tree. In ideal state, the receiving time of the parent node and the sending time of the child node on the multi-hop data forwarding link are staggered and coincide. Therefore, data is transferred from the source node to the destination node one by one, reducing the data delay caused by node sleep.

DSMAC protocol is designed to reduce communication delay by changing the fixed duty cycle in S-MAC protocol to dynamic duty cycle, which is mainly used in data delay sensitive application scenarios. In the DSMAC protocol, during the SYNC phase, all nodes exchange one-hop data latency (the time interval between data receiving and sending queue and data forwarding completion) to achieve the same duty cycle for all nodes. When the destination node detects that the latency of one-hop data is higher than the threshold, the destination node reduces its hibernation duration and declares it in the SYNC data frame. Then, when the sending node receives the SYNC statement, the sending node

Figure 4. DSMAC protocol



checks the data sending queue of the destination node. If such a sending queue exists and the power of the sending node is higher than the set threshold, the sending node doubles the duty cycle without affecting the schedule of the neighbor node. DSMAC is better than S-MAC in data delay and average power consumption during data transmission (Shivkumar S.(2017)).

In order to solve the change of cluster structure caused by node movement in S-MAC protocol, Peng et al designed a motion-aware MS-MAC protocol. In MS-MAC protocol, the node detects whether the node is moving according to the change of signal strength of the received SYNC data frame, and predicts the moving speed of the node. In MS-MAC, SYNC data frames include node scheduling information and node movement information or predicted node movement speed information. If more than one neighbor node moves, SYNC contains only the maximum movement speed information predicted for all moving neighbors. The movement information in SYNC is used by neighbor nodes to establish an active area around mobile nodes as they move from one cluster to another. The faster transmission frequency of SYNC data frames of mobile nodes in the active area enables them to quickly establish connections with new neighbor nodes. Although the energy consumption of nodes is higher at this time, this speeds up the establishment of network connections of mobile nodes.

MAC Protocol Based on TDMA

TDMA technology offers an attractive solution to reduce channel collisions and idle node listening power consumption. TDMA divides channel access time into multiple repeating frames, each of which is subdivided into N time slots, each of which allows only one node to transfer data. As show Fig.5.

Hoesel et al. designed LMAC protocol based on TDMA technology. LMAC protocol uses a distributed algorithm to divide the time into multiple time slots. In each time slot, nodes can access the channel without competition, which avoids the energy waste caused by communication collision. In the LMAC protocol, each message consists of a message control field and a data field. The message control field includes node ID, destination node address, data length and other information. Protocol control messages are used for time synchronization between nodes. As show Fig.6.

In MAC protocol based on TDMA technology, time slot allocation is one of the key problems to be solved, because it is difficult for sensor nodes to achieve a large range of coordinated allocation without introducing a large amount of protocol control overhead. In addition, an accurate time synchronization algorithm is needed to calibrate the time error between nodes.

The protocol based on TDMA technology usually needs to classify nodes into clusters. Nodes in clusters can only communicate with the cluster head first, but can not realize direct communication between clusters. In addition, the MAC protocol based on TDMA technology has limited scalability. The adaptability to the change of the number of nodes is poor. When the number of nodes in the cluster changes, the cluster head needs to readjust the time frame length and time slot allocation of each node in the cluster. Finally, the MAC protocol based on TDMA technology is implemented by distributed algorithm. Precise time synchronization is required to ensure that the boundaries of the slots are aligned.

Figure 5. TDMA divides N time slots

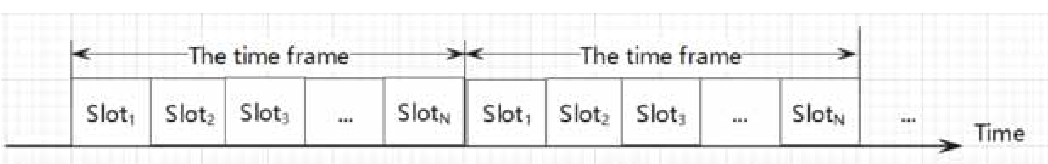
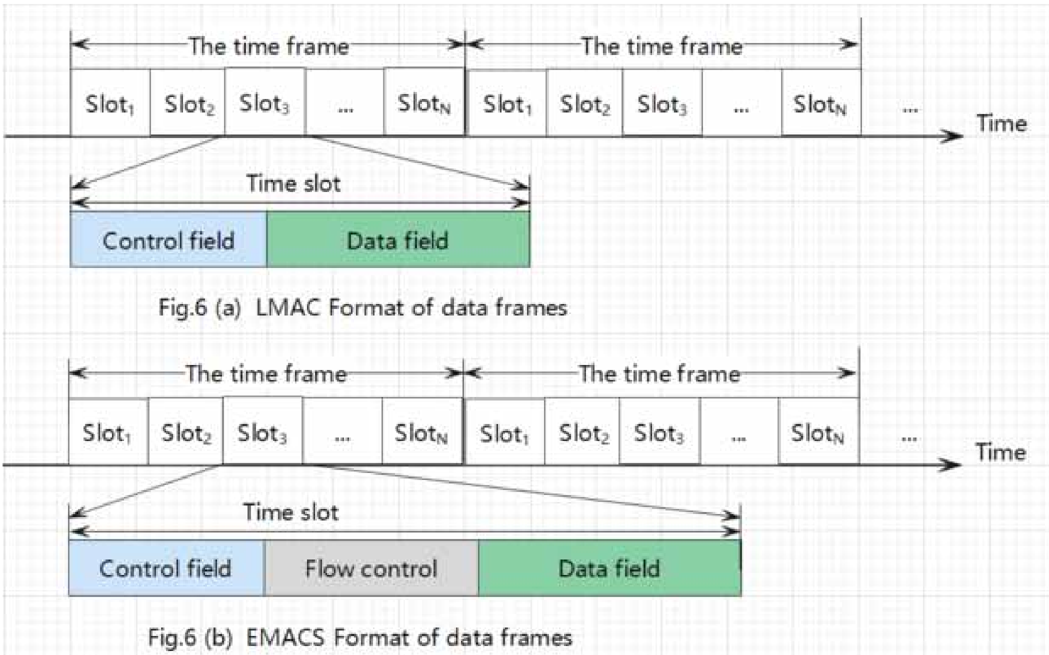


Fig.5 TDMA divides N time slots

Figure 6. (a) LMAC format of the data frames (b) EMACS format of the data frames



Priority - Based MAC Protocol

In the priority-based MAC protocol, the node ID and the number of allocated time slots are usually used as inputs to random functions to generate the priority of the node access channel. Nodes with high priority have priority access to the wireless channel. Bai et al. have designed NAMA protocol for nodal activation multiplexing, LAMA protocol for link-activation multiplexing, and PAMA protocol for paired link-activation multiplexing. The NAMA protocol activates only one node to send data in a time slot. In the NAMA protocol, each node calculates the priority between it and its neighbors to determine the access right of the wireless channel in the current time slot. LAMA activates the communication link and assigns priority to the transmitting node according to the direct sequence spread spectrum code assigned by the receiving node. According to the finite pseudo-random noise code assigned to nodes in the network, the node with the highest priority in the two-hop neighbor nodes in each communication slot has the active link access right to transmit data. Orthogonal coding can effectively avoid the same frequency interference and reduce the channel conflict of receiving nodes according to the network topology information. In the PAMA protocol, data transmission of each link is scheduled according to the link priority, that is, if the communication link (u,v) between the source node U and the destination node v has the highest priority among all links containing nodes u and v, the link (u,v) is activated.

In the MAC protocol based on priority scheduling, nodes need to dynamically calculate the priority of their neighbors, which increases the energy consumption of nodes and reduces the lifetime of the network. In addition, the nodes in LAMA and PAMA require pseudo-random coding, which increases the complexity of the protocols.

Cluster-Based MAC Protocol

The cluster communication of sensor nodes in the network enables nodes to distinguish between intra-cluster communication and inter-cluster communication, which is beneficial to saving energy consumption of nodes. Network cluster communication is beneficial to the extension of protocol, because each cluster in the network can be used as a separate complete network. Because of the dynamic nature of WIRELESS sensor networks (WSN), intra-cluster information sharing can greatly save network maintenance costs and energy consumption compared with global information sharing. However, the disadvantages of network cluster communication are also clear: first, network performance depends on efficient cluster head selection algorithm. Secondly, the cluster-head node is responsible for the maintenance of the cluster and the coordination of communication among nodes within the cluster, which leads to greater energy consumption. Finally, the dynamic change of nodes in the cluster leads to the dynamic change of cluster formation and cluster-head node allocation, which makes the cluster protocol more complex.

The LEACH protocol is one of the important representatives of MAC protocols based on clustering. It adopts random cluster head selection algorithm, which mainly includes the process of cluster establishment and data communication. In order to reduce the overhead of protocol maintenance, the duration of data communication process is much longer than that of cluster establishment process. During the establishment of cluster, a node randomly selects a number within (0,1). If the selected value is less than the threshold value, the node is selected as the cluster head. After the family head selection is complete, the cluster head node notifies other nodes that it has been selected as the new cluster head node. When other nodes in the network receive notifications from multiple cluster-head nodes, they decide to belong to the cluster according to the received signal strength, and inform the cluster-head nodes that they will join the cluster as intra-cluster nodes. After that, the cluster-head node assigns communication slots to each node in the cluster based on TDMA. At this point, network clustering is completed. Data communication process each cluster completes the corresponding data collection and transmission tasks. The cluster head fuses the data received in the cluster and sends it to the Sink node. In order to reduce the energy consumption of cluster-head nodes and prolong the network life time, new cluster-head nodes are selected after a period of time. The LEACH protocol consumes extra energy and time of nodes in the process of cluster formation and periodic cluster head selection. During this process, the network does not have communication capability, which increases data delay. In addition, nodes in a cluster can only communicate with cluster head, and cluster head is the backbone node in the network, whose high efficiency of communication directly affects the efficiency of data transmission among nodes in the whole cluster. To solve the problems in the LEACH protocol, researchers proposed an improved LEACH-C protocol. The biggest difference between this protocol and LEACH protocol is that the formation of clusters is centrally controlled by the Sink node. Each node in the network sends its position information and energy information to the Sink node. The cluster head selection algorithm with the optimal operating energy consumption of the Sink node generates a cluster head list and sends it to each node in the network.

The LEACH-C protocol can produce a cluster structure with global energy consumption optimal. However, this algorithm requires the location information of each node in the network, which increases the hardware cost of the node and the node power consumption when calculating the location estimation.

CONCLUSION

Wireless sensor network (WSN) is widely used, especially in the application field of time sensitive and large amount of data, which requires higher data real-time performance and network throughput. At the same time, there are several non-overlapping and orthogonal channels in wireless sensor networks. Therefore, based on the design of multiple non-overlapping and orthogonal channels existing in the network, a MAC protocol which can access multiple channels concurrently and transmit data in parallel is implemented to solve the requirements of network performance in applications.

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