A Study of QoS aware Energy level location based data accuracy estimation in Wireless Communication

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Abstract

Sink nodes and wireless sensor nodes are the components that come together to form a wireless sensor network, sometimes known as WSN for short. A wireless network links all of the nodes, allowing them to communicate with one another and also with the sink. WSNs have the potential to be used in an extremely broad range of applications, some of which include, but are not limited to, assisted living, visual surveillance, intelligent transportation, and habitant monitoring, to mention just a few. It is a difficult problem to provide support for quality of service (QoS) on account of the fact that sensor nodes often have very restricted access to resources, inconsistent wireless connectivity, and severe operation settings. Our primary concentration in this investigation is on the QoS support at the MAC layer, which is the foundational component of the communication stack. The Media Access Control (MAC) layer is the foundation of the communication stack. We investigate the QoS issues and opportunities presented by wireless sensor networks, conduct a comprehensive analysis of the QoS methods, categories the most advanced QoS-aware MAC protocols, and debate the benefits and drawbacks of each of these protocols. Because of this survey, we learned that the vast majority of protocols use a service differentiation method. This strategy entails classifying data packets according to the kind of data that is included within them. When the relevant network settings at the MAC layer are tuned, it is possible for various classes of packets to be handled in a manner that is suitable for the requirements of those specific packets. This strategy is implemented rather than offering deterministic quality of service guarantees. The nodes are responsible for data collection, which is followed by transmission to the sink. In the event that the source node is not within direct range of the sink for communication, the data is reported in a manner that makes use of multiple hops. This research is being done with the intention of extending the lifetime of large-scale wireless sensor networks, and one of the goals of the study is to explain various forms of MAC protocols as well as routing protocols. Received-based medium access control protocols, or R-MAC for short, Cluster-based data accuracy estimation, or CDAE for short, Available bandwidth estimation, or ABWE, and Location aware sensor routing are the four subcategories of wireless sensor network networks (LASeR). In this research, we provide a literature review of the algorithms that explain the concepts of multi-hop MAC routing protocols that are used in wireless sensor networks (WSN). The authors have done research on a number of routing algorithms in order to extend the lifetime of the network, reduce the amount of time it takes for data to go from one end to the other, and improve the network's reliability.

Keywords:WSN, distributed clusters, data accuracy, energy consumption, MAC, bandwidth, QoS, QoS, Challenges, MAC layer, QoS Mechanisms.

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I. Introduction

Sink nodes and wireless sensor nodes are the components that come together to form a wireless sensor network (WSN). A wireless network links all of the nodes, allowing them to communicate with one another and also with the sink. WSNs have the potential to be utilised in a wide variety of applications, some of which include, but are not limited to, the following: assisted living [1], habitant monitoring [2], visual surveillance [3], and intelligent transportation [4], to name just a few. WSNs also have the capability of being put to use in a variety of other applications. The nodes are in charge of collecting the data, which is then sent down to the sink after it has been processed. In the event that the source node is not within direct range of the sink for communication, the data is reported in a manner that makes use of multiple hops. The performance of applications that are run over WSNs is significantly impacted by the state of the relaying nodes that are present along a data forwarding path in relation to various metrics because a routing protocol is responsible for transferring data from its source to its sink. This is the case because a routing protocol is responsible for transferring data from its source to its sink. These metrics include, amongst others, the amount of available bandwidth, the amount of congestion, and the amount of delay. A WSN can also generate real-time data, for example, real-time multimedia data. In addition to variable bandwidth guarantees, the multimedia data requires strict limits to be set on the amount of time the data takes to process. Because a routing protocol can only select the best route, it cannot generally guarantee that it will satisfy the requirements of a flow even if it selects the best route. This is true even if the best route is selected. On the other hand, a flow admission control mechanism might be used to fulfil the conditions by admitting just those flows. This would mean that only those flows would be permitted to enter. The requirements can be fulfilled in this manner, which is one of the possible ways.

MWSNs have a wide variety of applications, some of which include the monitoring of animals [5, 6], surveillance [6, 7], and the monitoring of air pollutants. These are only few of the numerous possibilities. When it comes to applications like these, the benefits of deploying mobile nodes include the fact that they make it possible for the entire network to move in tandem with a target, that they make it simple to redeploy them, and that they enlarge the territory that they are able to cover [8]. This line of work was inspired by the ever-increasing variety of applications, each of which would demand solutions that were specifically adapted to their own needs.

Generally speaking, the raw data that are obtained by the sensor nodes in the physical environment are spatially correlated [9] with the raw data that are gathered by other sensor nodes in the physical environment. The degree to which observations made by geographically proximate sensor nodes are tightly linked [10] in the sensor field grows as the number of sensor nodes in a given area increases. This is because more sensor nodes means more closely linked observations. The considerable degree of data correlation that exists between the sensor nodes causes the sensor nodes to have a tendency to gather together in dispersed clusters [11] inside the sensor field. This is due to the fact that the sensor nodes prefer to gravitate toward one another. The construction of decentralised clusters contributes to the maintenance of low costs associated with the collecting of data [12]. LEACH [13] outlines a clear theory for the formation of probabilistically organised clusters that are dynamically dispersed throughout the sensor field. There is a node within each dynamically dispersed cluster that is referred to as the cluster head (CH) [14, 16]. This node is in charge of gathering the data that has been seen and transmitting it to the sink node. In a manner analogous to that

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which is carried out by LEACH, SEP [15] likewise constructs dispersed clusters inside the heterogeneous networks.

The proliferation of bandwidth-intensive multimedia applications is the key factor that has led to the requirement for quality of service in traditional data networks [17]. In this context, reservation-based systems, such as Integrated Services or IntServ [18], are used extensively in order to provide guarantees of a high level of service quality. However, because to the unpredictability of wireless networks, the instability of the topology, and the severe resource restrictions that WSNs face, it is not possible to guarantee a particular level of service quality. This is a difficult problem to solve. It will be more difficult to implement the solutions that are already available in wired and other wireless networks as a result of these limitations. In addition to these constraints, another one that affects the provision of quality of service (QoS) in wireless sensor networks is energy efficiency. Examples of modern applications that require quality of service support include real-time apps, multimedia applications, and mission-critical applications.

The Quality of Service (QoS) support at the MAC layer is the primary emphasis of this work. Additionally, a survey of previously published protocols is carried out.

There are centralised media access control (MAC) techniques for other kinds of networks as well, such as the point coordination function (PCF) in IEEE 802.11; in this scheme, nodes ask a coordinator for permission to access a medium. However, because to the vast number of sensor nodes, the multihop nature of the networks, and scalability concerns, these approaches are only seldom deployed to wireless sensor networks (WSNs). As a direct consequence of this, we are emphasizing the provision of support for distributed quality of service at the MAC layer. Since the MAC layer is the foundation for all of the components that go into the higher layers, this is where our focus is going to be. As a consequence of this, the MAC layer is an essential component that plays a pivotal role in determining how efficiently the network as a whole will operate.

Our contribution is to provide an in-depth examination of the subject matter and to have a conversation about the unresolved problems that exist within this field. This is a topic that, in our opinion, will receive a great deal of attention in the years to come, so we feel it is important to have this conversation now. First, some background information is supplied in regard to the context of the provision of QoS in wired and wireless networks. This will be followed by the main body of the discussion. After providing an overview of the many types of QoS approaches, we investigate which ones are appropriate for usage with wireless sensor networks (WSNs). In addition, we investigate the requirements of a wide variety of applications and highlight the QoS perspectives that are taken into account, including application-specific QoS and network-specific QoS.

II. Related work

In a nutshell, the existing routing protocols for WSNs may be split up into two distinct groups, which are called reactive and proactive protocols. There are two further subcategories that can be applied to proactive protocols, and those are the opportunistic protocols and the cost-function-based protocols. The rest of this part is going to be devoted to a comprehensive review of the most advanced routing protocols that are now available in each of the categories that have been discussed up until this point.

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In [19-21], an author presented reactive routing algorithms. These protocols are able to establish on demand a data forwarding link that stretches all the way from the source to the sink by utilising a technique that is known as controlled flooding of a route request message. This technology was developed by Cisco Systems. The vast majority of reactive routing protocols for WSNs make use of any one of the following routing metrics: hop-count, reliability, energy, latency, and congestion. This is because each of these metrics has its own unique advantages and disadvantages. These routing metrics can also be used with one another to produce additional useful information. After the sink has been given the route request message, it will select a course of action the vast majority of the time. In the event that the sink receives multiple copies of the message through a variety of channels, it will select the one that is advantageous to it the most. Examples of reactive routing algorithms for wireless sensor networks include these routing strategies (WSNs). The length of time that is required to build the path is perhaps the most significant disadvantage that is associated with the reactive routing methods.

The author makes a suggestion in [22-25] that the opportunistic routing strategies should be a category that includes the routing methods that have been addressed. Prior to beginning the process of transmitting a data packet, opportunistic routing algorithms first determine whether downstream nodes are candidates to receive the packet. Nodes that give progression towards a sink node are considered to be candidates for downstream nodes. To put it another way, candidates are nodes that are located along the route that the data packet will take.

The author of [26] made the suggestion that MANET protocols are often divided into two categories: proactive and reactive. Proactive protocols, such as optimal link state routing (OLSR), make an effort to guarantee that every node can reach every other node via an operational connection by ensuring that there is at least one active channel between them. This is done by ensuring that there is at least one active channel between them.

The author of [27] presented mobility based clustering (MBC), which functions in a manner that is comparable to that of LEACH-M, with the exception that it makes use of a more difficult mechanism for the election of the cluster head. LEACH-M operates in a manner that is comparable to that of LEACH-M. This method takes into account a number of factors, including the projected connection time, the distance, the residual energy, and the degree of the cluster head node. These measurements are used to develop an appropriateness metric, which helps nodes to make an informed decision regarding which cluster head to connect with, and this is performed by supplying them with as much information as is possibly available to them.

III. QoS support at MAC layer

In spite of the fact that the provision of quality of service is dependent on concerted efforts, the MAC layer is particularly important among them due to the fact that it governs the sharing of the medium and all of the other protocols that are used on higher layers are dependent on this. Despite the fact that the provision of quality of service is dependent on concerted efforts, the MAC layer possesses a particular importance among them. It is not possible to provide quality-of-service support in the network or transport layers unless it is assumed that the media access control (MAC) protocol would address the difficulties of medium sharing and make it possible to have reliable communication. In addition, it is the duty of the MAC layer to address any new problems that may arise as a result of the presence of WSNs. These obstacles include severe energy limits, which can be overcome with techniques like duty cycling, and unexpected environmental circumstances, which can be overcome with strategies like retransmissions and transmission power regulation. As a consequence of this, the Media Access Control (MAC) layer is of utmost significance for the delivery of quality of service and has a sizeable influence on the effectiveness of quality of service support performance. The reader can look to [28–33] for information on QoS support at the network layer, [34–37] for information about the transport layer, and [38] for information about the different layers of the protocol stack.

IV. QoS Challenges in WSNs

WSNs are to blame for the majority of the well-known quality of service challenges that are associated with traditional wireless networks [39], such as time-varying channels and unreliable links. These issues may be traced back to traditional wireless networks. On the other hand, the qualities that are typical of WSNs, such as severe constraints on the resources that are available and extreme environmental conditions, create additional and one-of-a-kind challenges for the quality of service support. In the next section, we will discuss the issues that arise with regard to the level of service provided by WSNs:

Resource constraints: The limitations of wireless sensor networks (WSNs) in terms of resources such as bandwidth, memory, energy, and compute capacity are significant. However, limited energy is the most critical one since, in many cases, it is either impossible or excessively expensive to replace or recharge the batteries of the sensor nodes. This makes the issue of limited energy the most critical one. Because of this, the problem of limited energy becomes the one that is the most pertinent. As a result, the problem of few energy resources becomes the most pressing concern. Although solar energy collection [40, 41] appears to be a potential solution to the problem of scarce energy, the solar panels that are currently available are still much too large for small sensor devices. This is despite the fact that solar energy collection appears to be a potential solution to the problem of scarce energy. In the end, any quality of service support mechanisms will need to be lightweight and basic in order for them to be able to function on a sensor node that has an incredibly low amount of resources.

Node deployment: It is possible to utilise either a deterministic or a random strategy for the deployment of the sensor nodes. Both of these methods are described in the next paragraph. When using deterministic deployment, sensor nodes must be manually placed throughout a network. Routing, on the other hand, can be performed along patterns that have been pre-planned. A random deployment is one in which sensor nodes are dispersed at random and allowed to self-organize in an ad hoc fashion. This type of deployment is known as a random deployment. As a direct consequence of this, the issues that need to be resolved include clustering, neighbour finding, path discovery, geographical information on the nodes, and many other related issues.

Topology changes: Changes in topology can be brought about by a variety of events, including as the relocation of nodes, the failure of links or nodes, the depletion of available energy, or even natural disasters like floods or fires. To save even more power, the vast majority of link layer and MAC layer protocols implement sleep-listen schedules. In order to accomplish this, the radio on the sensor nodes will need to be turned off for a brief period of time. Alterations to the topology are also frequently generated as a consequence of utilising this type of power management. The topology of the WSN will necessarily create an extra challenge for the quality of service support due to the fluid nature of the topology.

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Data redundancy: Because WSNs are made up of a huge number of microscopic sensor nodes, it is possible for numerous sensor nodes to notice an event or phenomena that has been witnessed. This creates a level of redundancy in the data. In spite of the fact that this redundancy helps to ensure that data is delivered consistently, it also results in the dissemination of data that is not required throughout the network, which ultimately leads to congestion. The techniques of data aggregation and fusion [42, 43] have the ability to cut down on redundancy, but they also have the potential to create additional delay and complexity inside the system. In order to deal with the redundant data as a result of this, efficient QoS solutions are necessary.

Multiple traffic types: Sensor nodes that are outfitted with the capability to sense or observe a variety of events have the potential to create a wide variety of traffic types since they have the ability to notice or observe several sorts of occurrences. It is feasible to convey numerous pieces of information at the same time for a single application, such as streaming video. These pieces of information could include the location of a recognised target or the periodic temperature information of an area. Applications that require the existence of many traffic classes create extra obstacles to the provision of quality service due to the fact that the requirements of various traffic classes are diverse from one another.

Real-time traffic: The data that has been acquired is only valid for a predetermined amount of time and must be supplied before the deadline in certain extremely important applications, such as the monitoring of natural disasters or security surveillance. This means that the data must be provided in a timely manner. It is necessary to have quality of service procedures in place that are up to the challenge of managing this kind of vital real-time data.

Unbalanced traffic: Within a WSN, there is often a central entity (or numerous entities) that is referred to as the sink node that obtains the global perspective of the sensing environment. These sink nodes are in charge of data collection and transmission throughout the network. In addition to this, there may be entities at the middle layer known as cluster heads that are in charge of compressing and aggregating data. These entities are accountable for their actions.

As a common consequence of this phenomena in wireless sensor networks, there is an imbalance in the flow of traffic between sensor nodes and sink nodes or cluster heads. In other words, there is a bottleneck at the sensor nodes (WSNs). In addition, the detection of an event by an event-driven system almost always results in unforeseen adjustments in the flow of traffic. This is because event-driven systems are driven by events. Although clever routing algorithms may disperse the strain of the traffic across several pathways, the MAC protocol must still be able to withstand unbalanced and bursty traffic in order to function properly.

Scalability: The great majority of wireless sensor networks are built up of individual sensor nodes, which might number in the hundreds or even thousands. Scalability allows for networks to grow or shrink as needed. If the area of interest grows or if the criteria for the quality of the observations are raised to a higher level, it will be necessary to deploy additional sensor nodes. As a consequence of this, the Quality of Service mechanism that is developed needs to have the capacity to scale well with highly dense or large scale networks.

V. Cluster based Data Accuracy Estimation algorithm

Karjee, J., and Jamadagni, H. [44] explaining the objective of this method, which is to reduce the number of sensor nodes that are found in each cluster of the distributed network. They accomplish this by determining an optimal balance between the precision of the data and the quantity of energy required to carry out the probabilistic processing of the data.

The sensor nodes that make up the sensor field are first distributed across its surface in a haphazard manner. If we continue to place sensor nodes in the sensor field, the total number of sensor nodes will increase, which will lead to an increase in the spatial correlation of the data that is observed across the sensor nodes. If we continue to place sensor nodes in the sensor field, we will continue to observe an increase in the spatial correlation of the data. Because of the increased spatial correlation of data that takes place among the sensor nodes, we are able to collect more accurate observed data from the sensor nodes. This is because of the increased spatial correlation of data that takes place. However, the quantity of energy required to power the network and the cost of deploying new nodes both increase in direct proportion to the number of sensor nodes that are added to the system. As a result of this, we need to reduce the cost of node deployment by reducing the number of sensor nodes in such a way that we also acquire more precise observed data from the sensor nodes while at the same time lowering the amount of energy that is consumed by the network. This must be done while simultaneously lowering the amount of energy that is consumed by the network. All of this must be accomplished while also reducing the amount of energy that is used by the network. In this section of the article, we will investigate a mathematical basis for the spatial correlation of data across sensor nodes in order to build distributed clusters in the sensor field that do not overlap with one another. This will allow us to construct clusters that are independent of one another. The next thing that we do after the construction of non-overlapping distributed clusters in the sensor field is analyse the degree to which accurate data is extracted by sensor nodes in each distributed cluster that is a part of the sensor networks. This is done so that we can determine how well the sensor networks are working. Before the procedure is finished, the precise data that each dispersed cluster in the sensor network has acquired is then transmitted to the sink node.

5.1 Distributed Clustering algorithm

We organise the sensor nodes in the sensor field into clusters of erratic shapes and sizes, which do not overlap and are dispersed across the field with the use of a distributed clustering algorithm. The following are the steps that are used to construct the algorithm for distributed clustering:

The following is a list of the notations that are utilised by the algorithm:

M = the collection of sensor nodes that have been put into operation in the field.

C = Set of cluster where each element c € C is of the from c= (ac,bc) where a denotes the CH node of the cluster c and b denotes the associated nodes that are not CH nodes of the cluster c. C = Set of cluster where each element c = (ac,bc) where a denotes the CH node of the cluster c and b denotes the associated nodes that are

The radius of the range of the data correlation is equal to the value of R.

5.1.1 Algorithm:

1. Start
2. Set W=M
3. ∀i € W ,let G(i)-{j € W: d(i,j) ≤ R,i+j}
   Where d(i,j) is the Euclidean distance between i and j sensor nodes.
4. S-{j € M:G(j)},i € M , we define $d_{max}(i)$= max $d_{j€G(i)}(i,j)$
   where d(i,j) is the Euclidean distance between i and j sensor nodes.
5. Let K=arg $min_{i€S} d_{max}(i)$
6. ℂ= ℂ˅{K,G(K)}
7. W=W-{K}-G(K)
8. If W≠ {ϕ} go to step 3
9. Stop

In the end, scattered clusters grow inside the sensor field that do not overlap with one another. In the following part of this conversation, we are going to concentrate on the data accuracy estimation that we are going to carry out for each scattered cluster that is part of the sensor field.

5.2 Clustering algorithm based Data accuracy Estimation

We do data accuracy estimation on a per-cluster basis for each scattered cluster that is produced in the sensor field by utilising the clustering technique. This estimate is carried out for each cluster. These clusters don't overlap with one another and are spread out. Each dispersed cluster possesses the ability to measure a single tracing point that is connected with the same event in the sensor field. We perform the calculation that is necessary to calculate the data accuracy for the measured data at the CH node of the appropriate cluster in the sensor field. This allows us to determine how accurate the data are. It is necessary to evaluate the accuracy of the data in order to ensure that the estimated data that have been sent to the CH node from all of the sensor nodes in the cluster are accurate and do not include any information that is redundant. In order to achieve this, it is necessary to evaluate the accuracy of the data.

VI. Received based MAC Protocol

According to the presentation given by Karjee, J. and Jamadagni, H. [44], the objective of this method is to evaluate the multi-hop performance of RB-MAC and adaptive RB-MAC methods in the most recent version of the RPL routing protocol. This purpose was explained by the researchers. It is essential to keep in mind that RB-MAC can be utilised with any gradient-based routing protocols, including geographic routing approaches. It is also possible to use RB-MAC with any other gradient-based routing strategies. As a consequence of this, a cross-layer approach is formed, which results in the ability to make routing decisions in accordance with the features of the MAC layer.

6.1 The preamble of the MAC protocol for sampling (PS-MAC)

Every node, as part of the preamble sampling method, decides on its own, independently of the other nodes, the schedule that dictates how long it should sleep and when it should wake up. In order to preserve their battery life, sensor nodes spend the majority of their time operating in a state known as sleep mode. These nodes are programmed to wake up at certain intervals for what is known as clear-channel assessment (CCA), which is a very short amount of time during which they detect whether or not there is an active transmission going place in the channel. Before delivering the data frame, the transmitting node will first send a lengthy preamble that is the same length as the CI. This is done to ensure that all recipients will identify the prologue and subsequently get the data frame. The sending of the data packet will take place after this step has been completed. By adjusting the CI as well as the CCA, it is feasible to obtain average duty-cycles that are lower than 1% without the need for scheduling or synchronisation. This is made possible by the use of tweaking. The term "Preamble Sampling technique" is referred to by a variety of different names in a number of different pieces of research. For example, "cycled receiver" and "channel polling" are two of the terms that are commonly used.

On the basis of the forwarding mechanisms that are available in sensor nodes, we divide preamble-sampling MAC protocols into two classes: SB-MAC and RB-MAC. These classes are named after the two types of forwarding mechanisms. To begin, we will talk about how a typical sender-based protocol works and how it functions. After that, we will talk about RB-MACs, and then we will finish up by talking about adaptable RB-MACs. In this investigation, we proceed under the assumption that each sensor node is aware of their proximity to the sink, as measured by the hop-count distance. This is something that can be achieved during the process of initialising the network.

6.2 Sender based MAC (SB-MAC)

In the SB-MAC protocol, a sensor node that has a message to send will first select a receiver from its neighbour table, then insert the address of the selected receiver into the header of the message, and then send the message. This sequence is repeated until the message is successfully sent. This step is carried out in a loop until the packet has been successfully transmitted. This strategy calls for the creation and upkeep of the neighbour table in each and every sensor node, which is not an efficient use of resources in lossy networks due to the dynamic nature of those networks. Because of the dynamic nature of the network, there is also the possibility of a large number of retransmissions (up to seven times in IEEE 802.15.4), each of which uses a significant amount of energy and results in a delay. In addition, each retransmission causes a delay in the transmission of the data.

6.3 MAC based on the receiver (RB-MAC)

When using an RB-MAC network, a sender node will transport its data without first selecting a particular node in the network to act as a receiver before doing so. The data packet is sent to all of the nodes that are located in close proximity to the sending node and are also within the node's communication range. Based on the information that it obtains from the micro-frame in the preamble, every individual node makes a determination as to whether or not it is "eligible" (meaning that it is closer than the sender node to the sink or that it has higher energy than a threshold) to take part in the process of forwarding the data. This determination is made based on the proximity of the individual node to the sink in comparison to the sender node. The sequence number of the data, the number of microframes that are left until the actual data arrive, and the distance between the sender and the sink are all included in this information. Receivers compete against one another in a "election" process to transmit the message to the subsequent node, and the recipient that emerges victorious is the one responsible for transmitting the data to the subsequent hop on the path towards the sink. This continues until all of the data has been transmitted. Figure 1 provides a visual representation of the chronological development of the RB-MAC procedure. The sender node, shown by the letter S in this figure, is making an effort to relay its data to the nodes that are adjacent to it. The first thing that it does is check to see whether there is already a transmission happening on the channel by performing a scan (performs CCA). It will first begin transmitting the preamble, and then it will begin sending the data, but only if there is room available on the channel. Each of the other nodes that are within communication range of node S will detect and sample a few microframes of the preamble as it is transmitted. Only three of the nodes that are adjacent to node S and are qualified to transmit data towards the node that serves as the sink are displayed here. Each of them extracts the information from the microframe (hop-count distance travelled by the data, sequence number of the data, and most significantly, it functions as a countdown). This node serves as the sink for the network (e.g. they are closer to the sink than node S). They recommence their journey in order to retrieve the information from the sender S. If it is found that the data packet that was received contains errors, it is swiftly discarded after the problem has been identified.

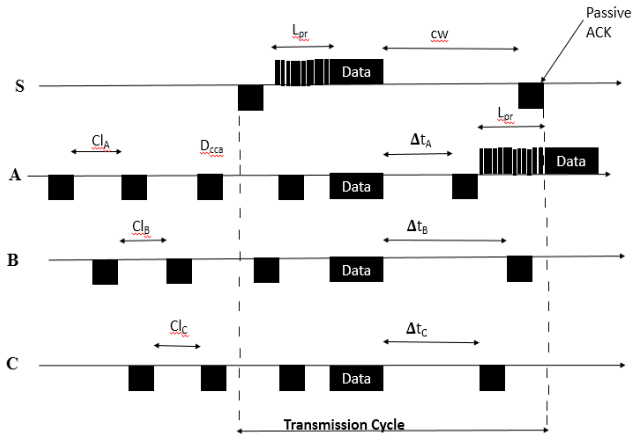

Fig. 1. Timeline of RB-MAC

The nodes in the network that have been successful in receiving data will not issue an acknowledgment message (ACK), but rather they will set a timer (t) before passing the data on to the node that will act as the next hop in the network. For instance, the amount of time that is provided to the receivers is proportional to the distance that separates them from the sink. The information will be transmitted in the direction of the sink by the node in the network that possesses a timer that is programmed to run out in the least period of time possible. As soon as the timer has reached its maximum value, the CCA operation is performed by each relay node (such as B and C in Fig. 1) in the network. It then conducts a comparison between the sequence number of the detected micro-frame and the one that it possesses; if it is found that the channel is being used, the process moves on to the next stage. It is an indication that the same data is being broadcast by a different node when the sequence numbers match one another and there is no difference between them. This results in the data packet being discarded as an unnecessary item. In the event that this is not the case, the existence of a free channel is proof that the current node has prevailed and can now start transmitting preamble frames (A in Fig. 1). The scenario proceeds in the same manner as it was described previously, and node A makes an effort to transmit data toward the sink node by utilising the same election method as before. In the event that none of the competing nodes in the contention window (CW) period are able to successfully forward the data packet, the sender node (S) can become aware of this fact by conducting CCA just a short while before the CW period comes to an end. This allows the sender node to make appropriate preparations. This makes it possible for the sending node to conduct the necessary actions (passive ACK). This specific scenario is the only one in which the sender node will attempt to convey the data once more. According to RB-MAC, an average sender-based MAC protocol underperforms in comparison to other sender-based MAC protocols in terms of the amount of energy it consumes and the amount of delay it causes. This is due to the fact that sender-based protocols incorporate a greater number of retransmissions. In order to circumvent the hidden terminal problem and prevent the receiver nodes from sending out multiple copies of the data packet after they have successfully received it, we make the assumption that the channel detection range of sensors is greater than their transmission range. This assumption is based on the fact that we want to avoid the hidden terminal problem. If this turns out to be the case, then the preamble will be detectable by all of the reception nodes that are within the sender node's range of transmission and are in close proximity to that node. Because of this, the other neighbours are able to identify the forwarding preamble if a winner neighbour distributes the packet to each and every one of the other neighbours (during passive ACK). As a direct result of this, we would only collaborate with a single freight forwarder, and the shipment would follow a single path all the way from its point of origin to its ultimate destination.

6.4 Adaptive preamble MAC (ap-MAC)

The ap-MAC protocol is a modification of the RB-MAC, and as such, it makes use of the same kinds of processes as that modification does. Every node in an ap-MAC network has a CI value that is held constant, and it samples the channel at regular intervals that are the same length of time each and every time. In contrast to RB-MAC, a sender node has the ability to adjust the length of the preamble to a smaller value based on one or more of a number of parameters (e.g. energy level of the sender node, data delivery delay, density of network and so on). The primary goal of shortening the length of the preamble is to cut down on (filter) the number of neighbouring nodes that are within communication range of the sending node and have the capability to detect the preamble. This is accomplished by decreasing the amount of time that the preamble is broadcast. There is a potential that the number of nodes that get the data packet will be fewer than that of RB-MAC if the size of the preamble is decreased. This is because smaller preambles take up less space. As a result, a smaller preamble size can contribute to an increase in the sender node's ability to save energy and can contribute to a decrease in the amount of time it takes for data to be transmitted to the subsequent hop in the chain. In addition, the adaptive preamble scheme can be utilised in a scenario where there is a deadline or an energy budget, in which the end-to-end latency or the energy should not exceed a predetermined period of time. This is possible because the adaptive preamble scheme can be tailored to meet the requirements of the scenario. In this approach, the length of the preamble can be customised by each sender node to match the time and energy resources that are still at their disposal. As part of the research that we are now conducting, we will look into this topic more.

6.5 Adaptive sampling MAC(as-MAC)

An example of an RB-MAC protocol is the adaptive sampling medium access control protocol, more commonly referred to as as-MAC. In this particular protocol, sensor nodes are given the ability to actively participate in the process of packet forwarding based on the specific measurements that they have taken themselves. It is the responsibility of every sensor node in as-MAC to autonomously change its own CI in accordance with its amount of residual energy, the rate at which it collects energy, or any combination of a number of other parameters. The size of the preamble is assumed to be fixed in as-MAC. In this design, it is to be anticipated that nodes that have a higher (lower) harvesting rate or a larger (lower) residual energy will sample the channel more frequently than nodes that do not have either of those characteristics (less frequently). In this circumstance, there is a good possibility that the sender's preamble will be identified, and the individual will be able to participate in the competition for high (low) power nodes if this happens (less). When there are numerous hops involved in the scenario, the sensor node that is immediately adjacent to the sink will broadcast the data packet instantly and without a preamble because it is expected that the sink is always active.

VII. Metrics and parameters of the QoS

In the previous section, we discussed the Quality of Service requirements of WSNs from the perspective of applications that use data gathering methodologies that are comparable to one another (section IV). In this section of the essay, we will talk about the metrics that may be used to measure the requirements for QoS, and we will look at some examples. When viewed from the perspective of networking, the general metrics include things like maximising throughput and goodput, reducing latency as much as possible, increasing dependability as much as possible, reducing delay jitter as much as possible, and increasing energy efficiency as much as possible. In order to obtain good performance in relation to these metrics and still support quality of service, it is essential to take into account the overall impact of the complete protocol stack. This will allow for better performance. Despite this, we are paying close attention to the performance standards that can be met at the MAC layer because we are focusing on that particular layer. The following are the measures in question:

Minimizing medium access delay: It is a given that one must also take into account the performance of the routing layer in order to minimise the amount of time it takes for data to be transmitted from the sensor sources to the sink node. This is necessary in order to cut down on the amount of time it takes for data to be transmitted. When it comes to delay, one of the things that can be done at the MAC layer is to ensure that the packet latency is optimised in such a way that it satisfies the requirements for end-to-end delay. It is not impossible to accomplish this objective if the length of time that it takes for the sensor devices to reach the medium is cut down as much as is reasonably possible.

Minimizing collisions: Collisions and the retransmissions that follow from them have an immediate and direct affect on the overall networking metrics such as throughput, latency, and energy efficiency. Therefore, it is important to keep the number of collisions as low as possible. The Media Access Control (MAC) layer is in charge of decreasing the number of collisions that take place. This is due to the fact that the MAC layer is responsible for managing the sharing of the wireless medium. Collisions can be prevented by making use of careful carrier sensing methods, such as modifying the contention window in accordance with the requirements of the traffic and taking into mind the utilisation of contention-based protocols. In a similar vein, in the case of contention-free protocols, it is possible to prevent collisions by altering the quantity of time slots and frequencies in accordance with the requirements of the network. This can be done in a manner that is analogous to the previous example.

Maximizing reliability: Increasing the network's dependability while also lowering the amount of collisions that occur. The medium access control (MAC) layer may also contribute to increasing the network's dependability. It is feasible to employ acknowledgment techniques in order to detect which packets were lost. Based on this information, it is then possible to carry out retransmissions in a timely manner in order to rectify any problems that may have occurred.

Minimizing energy consumption: Keeping power use to a minimum: energy efficiency is still the most important factor to consider when designing wireless sensor networks. This is because sensor devices must perform within the constraints of their limited battery power (WSNs). It is possible for the MAC layer to make a contribution to energy efficiency by decreasing the number of collisions and retransmissions. Additionally, and perhaps more importantly, it is possible for this layer to optimise the duty cycle of the sensor devices in accordance with the dynamics of the network. Due to the fact that wireless operations consume the vast majority of the available energy, duty cycling is a crucial component of WSN operations. Since wireless operations use the vast majority of energy, the radio should be turned off anytime it is not necessary to use it. The quantity of energy that is used up at the MAC layer can also be decreased by adjusting the transmission strength of the sensor radios in accordance with the parameters of the network. This is done in order to save power.

Minimizing interference and maximizing concurrency (parallel transmissions): Because the wireless medium is a shared medium, any unwanted transmissions that occur within the same network or transmissions that occur from other networks that utilise the same areas of the spectrum can cause interference with the transmissions that are meant to occur. To minimise interference and maximise concurrency (parallel transmissions), the following steps should be taken. Due to the fact that interference results in lost packets, the throughput, latency, and energy efficiency of the network are all significantly impacted when interference is present. Contributions to these measures can be made by maximising concurrency while simultaneously minimising the impact of interference on parallel transmissions. This will allow for the greatest possible number of concurrent transmissions. The MAC layer is able to achieve both the largest level of concurrency and the least amount of interference by altering the essential parameters, such as contention windowing, timing, transmission power, and operating channel. This allows for the best possible utilisation of available bandwidth.

Maximizing adaptivity to changes:WSNs are distinguished by their dynamic behaviour, which includes the following characteristics: links between nodes may change over time as a result of environmental conditions or topological changes; traffic conditions may change according to the phenomena that are being monitored; nodes' batteries may run out and cause them to become disconnected from the network; new nodes may be added to the network. As a consequence of this, media access control (MAC) protocols should exhibit adaptive behaviour in response to the dynamic nature of the network. In a network, for example, if the majority of the data flow is high-rate and real-time, the nodes should have a high duty cycle when they are working. On the other hand, if the traffic rate in the network is relatively low, then it is possible to keep the majority of the nodes in an inactive state in order to conserve energy.

Conclusion

WSNs of today are put to use not only for the traditional low-data-rate applications but also for the more intricate activities that demand the efficient, reliable, and timely collection of vast volumes of data. These applications require WSNs to be able to collect data in a timely manner. In addition, they do not simply consist of sensor devices that deliver scalar data; rather, they are increasingly employing video and microphone sensors in addition to the

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scalar data-producing sensors they already possess. This is due to the fact that the implementation of these sensors is gaining more and more traction. As the capacity of the sensor nodes in wireless sensor networks (WSNs) continue to increase, as well as the variety of application fields, and as multimodal use of sensors becomes more prevalent, it is imperative that WSNs have efficient QoS provisioning mechanisms. In light of these standards, the primary concerns of this research were the points of view, difficulties, metrics, parameters, and requirements of QoS-aware MAC protocols for WSNs. In addition to that, we have included a survey of the several protocols that are now in use, along with comparisons and categorizations of each. This survey led us to the discovery that the vast majority of protocols use a service differentiation strategy, which involves the classification of data packets based on the type of data contained within them. At the MAC layer, the associated network parameters are tuned in order to treat different types of packets in a manner that is appropriate for the requirements of those packets. Because of this, the protocols are able to circumvent the requirement of providing deterministic quality of service guarantees.

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