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Scheduled Throughput Intelligence of Multi-Data Lightweight Synchronization Strategy for Channel Allocation in Mobile Ad Hoc Network

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ABSTRACT:

The medium access control (MAC) protocol is critical because it addresses how to handle any contentions and collisions among wireless nodes and provide an equitable portion of channel capacity to them. However, because of the hidden/exposed terminal problem and partially connected network topology, the IEEE 802.11 standard, the de facto and widely accepted wireless MAC protocol, does not function well in mobile ad hoc networks (MANETs) because it causes intense collisions, unfair channel access, and rapidly degraded system throughput in multi-hop environments, especially when the entire system is dense and congested. One solution is to employ multichannel MAC protocol, which allows various nodes to access the wireless channel concurrently as long as they pick distinct channels to broadcast their packets.The suggested method addresses timely delivery; one ideal approach is to increase network throughput so that more real-time applications with tighter time limitations may be served in any given network.

Keywords: MAC, MANET and Topology

1. INTRODUCTION

Wireless networks are communication networks that employ radio waves as the channel for information transfer. Wireless networks may be split into infrastructure networks and infrastructure-free networks based on topology, which expands the area for cable network services. Wireless networks reduce time, place, and object constraints due to their low cost, short cycle, flexible structure, and several other advantages.

Mobile ad hoc network (MANET) is a fast-expanding sector of activity in wireless networks that has lately attracted a lot of attention due to its dynamic topology, improved targeting, and ease of use. A MANET is a self-configuring infrastructure-less wireless network that connects a cluster of mobile nodes without the need of cable lines. MANETs may be used in a variety of settings, including battlegrounds and natural catastrophes. Mobile nodes connect with one another using multi-hop wireless networks in a MANET, and there is no permanent infrastructure support, such as a base station.

Each node in a Mobile Ad-hoc Network is equipped with a radio transmitter and a receiver, allowing them to communicate with the system via wireless bidirectional communication. The following are the primary reasons why MANETs offer data transfer with comparable qualities while preserving their active approach: Surprisingly, the transmission scope of this transmission is more constrained than the previous transmission scope, making data swapping throughout the system impossible for any number of nodes. A key issue with Wi-Fi Ad-Hoc networks is that portable nodes rely on batteries, which are often weak in most settings and require a long time to recharge or replace.

One approach to alleviate this problem is to use multichannel MAC protocol because these nodes can access the wireless channel simultaneously as long as they choose the different channels to transmit their packets. Nowadays, the modern wireless MAC protocols usually support multiple channels, where mobile nodes adapt their channels based on their channel selection strategies to transmit their own packets. In adaptive channel allocation strategy for IEEE 802.11 based multi-channel MAC protocol in MANETs. An analytic model is also carried out to study the normalized saturation throughput of proposed scheme. In addition to theoretical analysis, simulations are conducted to evaluate the performance of the adoptive channel allocation scheme in congested multi-hop environments, and the results indicate that our adaptive channel allocation strategy did achieve far better performance than the legacy single channel IEEE 802.11 protocol without loss of simplicity.

2. LITERATURE SURVEY

Cognitive radio technology has been investigated in recent years as one of the spectrum sensing approaches for 5G (Fifth Generation) and beyond communication networks to reduce spectrum inefficiencies. According to several studies, licensed users do not always use the same spectrum. Certain regions of the spectrum are underutilized or inefficiently exploited. The usage of vacant channels has been allowed by OFDM-based cognitive radio technology designed to improve spectrum efficiency. Yilmazel, R et al [1] developed a method that combines artificial intelligence approaches with spectrum detection algorithms. By using this innovative approach to OFDM technology, the precision of the findings was noticed. The genetic algorithm (GA) is used to determine the optimal field channel allocation and maximum accuracy for spectrum utilisation.

Latif, S., et al. [2] demonstrated an improved hybrid approach for CRN channel assignment. A repair method is also added to increase spectrum usage for those SUs that access the same channel. To minimize interference, it pushes traffic immediately into vacant channels while avoiding busy ones. Cognitive Radio (CR) technology demonstrated the ability to address the spectrum shortage issue.

Zhou, X et al [3] introduced an energy-efficient channel allocation-based data aggregation mechanism for IT-WSNs. They first analysed the energy consumption conditions of the ITWSN with data collected from real systems and find the unbalanced energy consumption becomes the bottleneck for system lifespan. With this observation, author focused on mitigating the energy consumption of relay nodes by adopting an adaptive cycle period mechanism. Moreover, they allocated the channel properly with a constructive-interference-based mechanism to avoid packet collision. Large-scale simulation results reveal EDA can mitigate the unbalanced energy consumption among the network effectively.

Ebrahim, N.S et al [4] attempted to address the optimal k-barrier coverage problem (OKBCP) packet collision and interference difficulties. They presented two forwarding routing tree algorithms, VMF MCRT and AGLSBT, which established sink-connectivity of many convergent nodes. The first multi-pool algorithm, VMFMCRT, used van graph characteristics and the maximum flow minimum cost algorithm (MFMC) to achieve convergence node connectivity; the second algorithm, ALGSBT, established the multi-aggregation node relay routing tree with the sensor node's actual geographic location. Efficient Greedy multi-channel and time-slot scheduling (EGCSA) was designed and implemented in the relay routing tree to make better use of the channel's time slot amount while simultaneously reducing interference.

Humayun, M. et al. [5] addressed and concentrated on the design issues of intrusion detection systems (IDS) in wireless networks such as MANET, IoT, and VANET. Based on known research gaps, wireless network traffic headers (from 802.11 frames and data link layer) should be significantly weighted in network analysis. The author finishes with many recommendations and principles for IDS design that are mostly useful against wireless intrusions. Due to architectural challenges, deploying an intrusion detection system in a wireless environment is more difficult than in a wired network context.

M.A. Al-Shareeda et al [6] conducted a thorough analysis of the impact of MITM attackers on MANET. They investigated the impact of two forms of MITM attacks (delayed messages and dropped messages) in the MANET. MITM attack simulations were conducted out in OMNeT++ using the NETA and INET frameworks. Our findings indicate that these two forms of attacks have a significant impact on the network in terms of high E2ED, delayed messages, dropped messages, and PLR.

The safe optimization routing technique developed by Srilakshmi, U., et al [7] addresses both the energy issue and the communication delay between hops. Bacteria for Aging Optimization Algorithm (BFOA) was employed to create an efficient routing strategy. In the first step, the Fuzzy clustering technique is utilized to determine the CHs with the highest trust values for direct, indirect, and recent trust. The CHs with the highest trust values for direct, indirect, and recent trust are computed in the second step. The detection of intruded nodes is determined by the threshold value. The CHs are in responsibility of routing data packets to the drain, which must pass through several hops along the route. The most promising candidate for advanced routing in MANET, on the other hand, is discovered through the application of the Bacteria for Aging Optimization Algorithm optimization (BFOA). The proposed method offers a quicker convergence rate and optimizes storage, throughput, and route connection constraints.

Rajendran, A., et al [8] investigated various deep clustering algorithms in order to obtain a better understanding of the problem of enhancing DNNs with clustering algorithms in order to allow them to demonstrate unsupervised learning behaviour in order to detect and prevent misbehaving attacks.

Salameh, H.B., et al [9] studied the challenge of optimizing network throughput by offering distributed CR-aware MIMO-mode channel-assignment choices for numerous CR transmissions (batching technique) while adhering to a set of limitations. In general, the combined batch-based MIMO-mode and channel-assignment optimization is an NP-hard combinatorial integer non-linear problem. They presented a two-stage optimization approach to solve such a joint problem in polynomial time.

The suggested technique first determines the maximum amount of packets that each contesting CR user can send over each idle channel. The optimum channel-user assignment that can result in the greatest number of sent packets is then computed in the second step. We employ an admission control mechanism that allows CR users to publish the needed control information in order to implement the proposed batch-based method in a distributed way. When compared to existing MIMO-based CRN protocols, the findings reveal that the proposed protocol considerably improves overall network performance by up to 60% by conducting batch-based channel assignment and per-user MIMO-mode optimization simultaneously.

M.S. Shahryari et al. [10] investigated a high-throughput and energy-efficient method for performing clustering, routing, and channel assignment in a heterogeneous environment. Their technique divides the original issue into two phases, which are then solved using a genetic algorithm. The first phase involves building a spanning tree across super nodes and allocating appropriate channels to their radios. A unique multi-objective cost function is developed, which significantly increases network longevity when compared to existing tree construction methodologies. It also boosts performance by balancing perceived interference across the network. The suitable CH and channel per normal node are determined in the second step of the proposed technique. Extensive simulations show that the suggested approach achieves excellent throughput by utilizing several channels.

Parihar et al [11] modeled FANET as an application of dynamic graph by applying its properties and propose a token-based resource allocation algorithm in FANET to achieve DME. They began their discussion with the study that comprises together with the exposure of distributed mutual exclusion algorithms on various ad hoc networks along with the background knowledge of dynamic graphs till date. Author then provided few observations regarding resource allocation issues in FANET in terms of optimal message broadcasting and also presented FANET as an application of dynamic graphs. They have used and modelled FANET architecture through Neo4j graph database using cipher query languages.

Efficient spectrum utilization is a prominent issue in cognitive radio networks. Owing to this, power allocation policies are proposed by Chinnathampy et al [12] through which underlay cognitive radio networks together among all prime nodes, secondary nodes, eavesdropper and secondary sender powered by renewable energy that is harvested from primary sender to acquire improved energy efficiency to enhance transmission rate, throughput, and Spectrum Utilization (SU). The prime objective of their work was to intend a route control based multi-path Quality of Service (QoS) and to find substitute paths between Secondary User (SU) source and SU destination fulfilling QoS metrics, specifically providing maximal throughput and minimal delay.

Alam, M.M. et al [13] found that incorporating QL with position-based routing protocols significantly improves the routing performance in terms of energy consumption, end-to-end delay, local minimum avoidance, and routing loop avoidance. Additionally, the QL technique improves the PDR, minimizes the control overhead, and provides tolerance to localization error. The surveyed protocols were qualitatively compared in terms of their objectives, innovation features, and several important performance metrics. In addition, we discussed important performance improvement criteria such as precise SINR, delay calculation, multi-objective reward function, self-healing, and robustness. From our comparative discussion, it was inferred that researchers or engineers can make a choice of an appropriate routing protocol by taking not only their target applications but also their primary performance metrics.

Vigneshwaran, P et al [14] addressed various scenarios on dynamic sectorized routing in mobile ad hoc networks (MANET) and the behavioral change of dynamic sectorized routing when reconfigurable directional antenna is used. This approach was compared with traditional and sector-based MANET using omni-directional antenna. They evaluated the performance in various aspects such as average collision rate, resource efficiency, transmission speed, and signal power strength. First, author compared dynamic sectorized MANET against both traditional MANET and sector-based MANET in their work. Specifically, the dynamic sectorized MANET outperforms in the average collision rate, resource efficiency, and transmission speed, when compared it against to traditional and sector-based MANETs.

Tabassum, K et al [15] presented a mobile adhoc platform for patient monitoring and tracking in an emergency state which could be operated with a mobile application downloaded onto a mobile and offer suitable emergency services. Wireless medical sensor networks are gaining enormous attention to make patient monitoring and tracking significantly. Sensors are implanted in human body to record medical data from various points in the human body and this is referred to as Body area network.

Resource allocation in wireless networks, i.e., assigning time and frequency slots over specific terminals under spatiotemporal constraints, is a fundamental and challenging problem. Belief Propagation/message passing (inference) algorithms by Chatzigeorgiou, R [16] was done for constraint satisfaction problems (CSP), since they are inherently amenable to distributed implementation. They comparedtwo message passing algorithms for time and frequency allocation, satisfying signal-to-interference-and-noiseratio, half-duplex-radio operation and routing constraints. The first method periodically checks whether the constraints are satisfied locally and restarts specific messages, when the local constraints (encoded in corresponding factors) are not satisfied. The second method stochastically perturbs Belief Propagation, using Gibbs sampling.

Channel bonding is a concept considered by the IEEE 802.11ac amendment to improve WLAN performance [17-21]. Increasing the number of channels used provides a variety of advantages, as can increase transmission rates. discovered that bandwidth utilisation is particularly inefficient in congested, decentralised contexts such as apartment complexes. Another strategy is to better decentralise or centralise network coordination by using existing standards and protocols. Having 11 Wi-Fi channels with channel bonding had an influence on average throughput. There is a possibility that certain STA clusters may earn more money than others, raising concerns about equality. When A-MPDU is disabled, several independent broadcasts over narrow channels outperform one transmission across vast channels. Channel bonding may be used to produce 40, 80, and 160 MHz channel widths in 802.11n, or two, four, or eight in the latest versions (ac/ax).

The proposed approach is deal with timely delivery; one desirable approach is to improve network throughput so that more real-time applications with tighter time constraints can be satisfied in any given network. To deal with reliable delivery, the use of a carrier sense multiple data access with light weight synchronization (CHSLWS) strategy for data transmission is preferred, along with the use of a sharable data within which multiple nodes compete to send data. Thus, we present a method of using multiple-Data synchronization and a way to optimize the size of the sharable slot. The proposed cluster head selection and lightweight synchronization algorithm tries to optimize the size of a sharable data when multiple channels are used.

3. METHODOLOGY

Proposed Methodology consists of following Modules

1. Mobile Ad-Hoc Network Model Construction
2. Cluster Head Selection
3. Scheduled Throughput Intelligence of Multi Data Light-Weight Synchronization Strategy
4. Performance Evaluation

A. Mobile Ad-hoc Network Model Construction

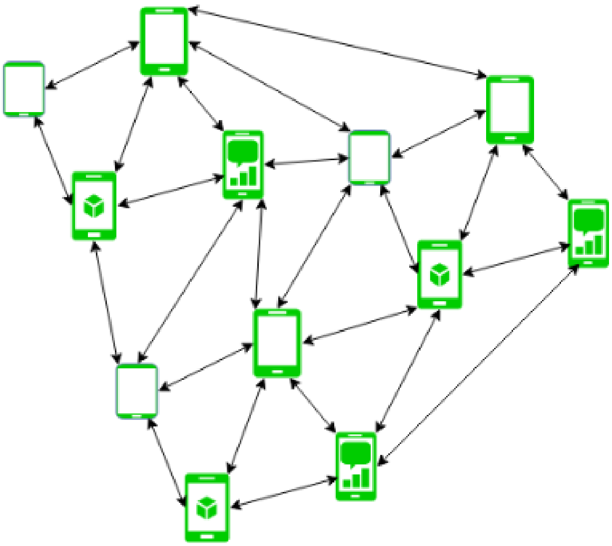

Fig 3.1 Mobile Ad-Hoc Network

On top of a Link Layer ad hoc network, a mobile ad hoc network-also known as a wireless ad hoc network or an ad hoc wireless network-typically has a routable networking environment. They don't have a permanent infrastructure; instead, they are made up of a number of mobile nodes that are wirelessly connected in a self-configured, self-healing network. Since the topology of the network is always changing, MANET nodes are free to relocate at will. Every node act as a router, sending traffic to other designated nodes within the network.

B. Cluster Head Selection

The process of dividing the network into interconnectedsubstructures is called clustering and the interconnectedsubstructures are called clusters. The cluster head (CH) ofeach cluster act as a coordinator within the substructure. EachCH acts as a temporary base station within its zone or cluster.It also communicates with other CHs. The Cluster basedrouting provides an answer to address nodes heterogeneity,and to limit the amount of routing information thatpropagates inside the network. The grouping of networknodes into a number of overlapping clusters is the main ideabehind clustering. A hierarchical routing is possible byclustering in which paths are recorded between clustersinstead of between nodes. It increases the routes lifetime,thus decreasing the amount of routing control overhead. Thecluster head coordinates the cluster activities inside thecluster.

Cluster Head selection Algorithm

The overall mechanism for selection of the Cluster Head. When a network is required to select the cluster head, then every node will check its routing table according to Algorithm.

Cluster Head Selection Algorithm

R.T as Routing Table
Step 1: Check R.T
Step 2: Check Sequence #
Step 3: Select highest Seq #
Step 4: If
Seq # > all other Nodes
Step 5: Then
Check Black List
If
Black List is un-check
Then
Elect as CH
Else
Reject
endif
Step 6: end if.

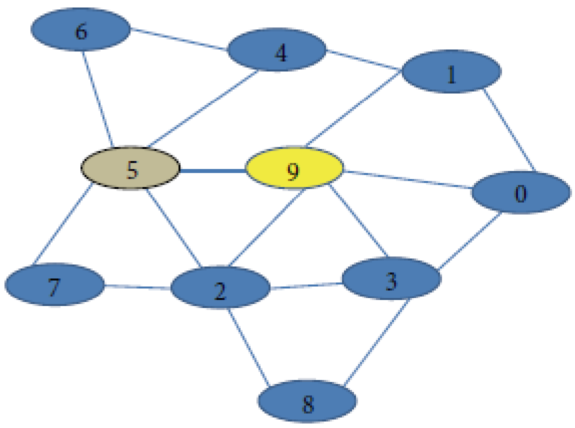

Fig 3.2 Cluster Head Selection

For instance, consider a multi-hop wireless ad hoc network with 6 nodes labelled by A–F in Fig. When node A initiates a connection and it selects channel 1, it will broadcast the RTS packet to its neighbours within its transmission range, i.e., nodes B, C, and E, and let them know the channel number it used. If we consider node C is the receiver, then node C will reply a CTS packet to node A. Hence, node C's neighbour, i.e., nodes A, B, and D, will know the channel number which chosen by node A. Consequently, node B, C, D, and E will try to select a different channel to transmit their packets later on. In addition, as mentioned earlier, note that RTS/CTS(request-to-send/clear-to-send) packets also include a field called NAV, which is used to inform neighbour nodes how long they should defer access to the used channel. Compare with the legacy single channel IEEE 802.11 MAC protocol, our scheme provides better performance in terms of lower packet collision probability, shorter average channel access delay, and fair channel access. The following pseudo-code describes the initialization of our algorithm.

C. Scheduled Throughput Intelligence of Multi Data Light-Weight Synchronization Strategy

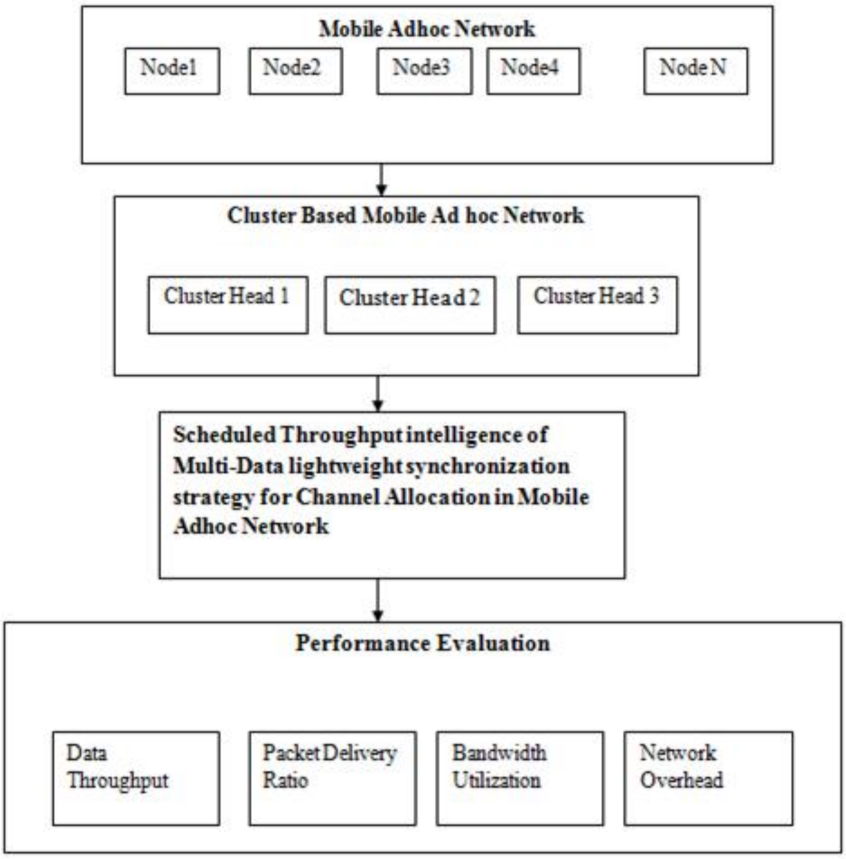

Fig 3.1 Proposed Methodology

Numerous wired and wireless systems require synchronization, and there are numerous time synchronization techniques available.

In order to increase network performance, we took use of the radios' multi-channel operation capacity. We also suggested an effective scheduling method to get rid of the effects of non-coordinated broadcasts, such as collision, idle listening, and overhearing. Our job consists of arranging the normal traffic that is transmitted on a periodic basis and modifying the schedule to accommodate any additional traffic that may be required in the future. We develop the whole communication process required for sensor nodes to talk with one another in order to establish a network and transmit the sensed data to the collecting point in order to implement the schedule-based multi-channel protocol on actual applications.

Channel Allocation

```
// considering each node that has two transceivers
// in which one is always on channel 0 for controlling packets
// while the other can change its channel for transmitting data.
Initialization
hopCount := 2
channelNum := 0
isNotSetChannel := true
// If the node broadcasts its channel number, then isNotSetChannel would be false
repeat
```

```
if the node receives a control frame (possibly from RTS or CTS) then
// Let recvHopCount denote the hopCount of the received packet
// Let recvChannelNum denote the channelNum of the received packet
if recvHopCount > 0 then
recvHopCount := recvHopCount −1
if isNotSetChannel is true or channelNum equals recvChannelNum then
record the channel number of the received packet
check whether there is any free channel from cluster head
if there exists some free channel then
channelNum := the number of the free channel
else
channelNum := rand() % (ξ − 1)
end
broadcast a RTS with hopCount and channelNum
and a CTS with recvHopCount and recvChannelNum
else
broadcast a CTS with recvHopCount and recvChannelNum
end
else
drop the received packet
end
end
until no more frame to transmit
```

In order to maximize the system performance, we proposed an adaptive channel allocation approach that is both straightforward and effective for IEEE 802.11 based multi-channel MAC protocols in multi-hop wireless ad hoc networks. In very crowded situations, the suggested multi-channel MAC technique may reduce intense node collisions and efficiently boost system performance. It can also resolve fairness issues in partially connected network topologies and hidden/exposed terminal issues. Our technique eliminates the requirement for clock synchronization across mobile nodes by assigning suitable channels and sending a few control messages. This allows for improved system performance over a greater range of network topologies.

4. PERFORMANCE EVALUATION

A. Packet Delivery Ratio

The ratio of total packets delivered to total packets sent from source node to destination node in the network is known as the packet delivery ratio, or PDR. The maximum amount of data packets that must arrive at the destination is what is intended. The network's performance rises in tandem with the PDR value.

TABLE I Comparison of Packet Delivery Ratio

Packet Delivery Ratio

algorithmname	Packet_Delivery_Ratio
Adaptive channel allocation strategy	26.0
Multi-Data lightweight synchronization Strategy	78.59999999999994

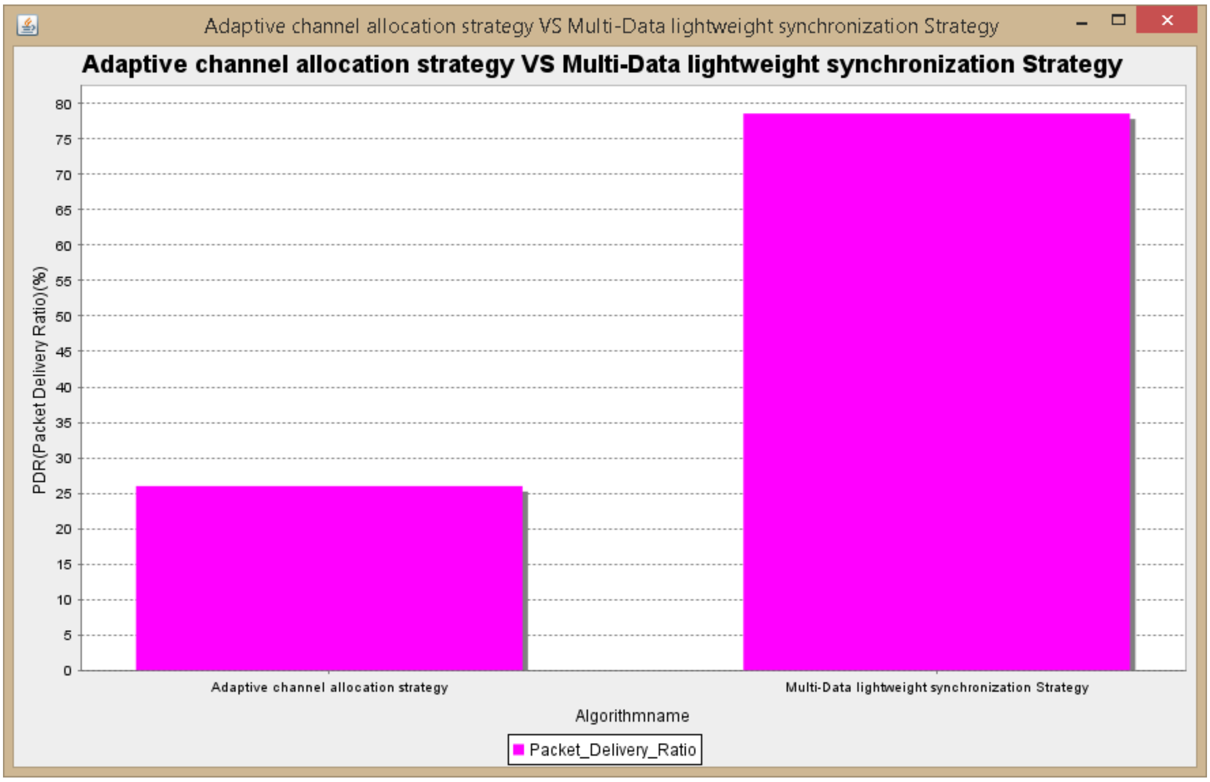

Fig 4.1 Packet Delivery Ratio of Adaptive channel allocation strategy and Multi-Data Synchronization Strategy

The above figure shows that efficient packet delivery ratio is obtained through multi-data synchronization strategy.

B. Throughput

Throughput in wireless sensor networks is defined as the quantity of packets that are successfully sent from the source to the destination in a second. A well-designed network should have a high throughput value; if it is attacked, the throughput value will drop significantly.

TABLE II Comparison of Throughput

Throughput

algorithmname	throughput
Adaptive channel allocation strategy	1.2
Multi-Data lightweight synchronization Strategy	2.5

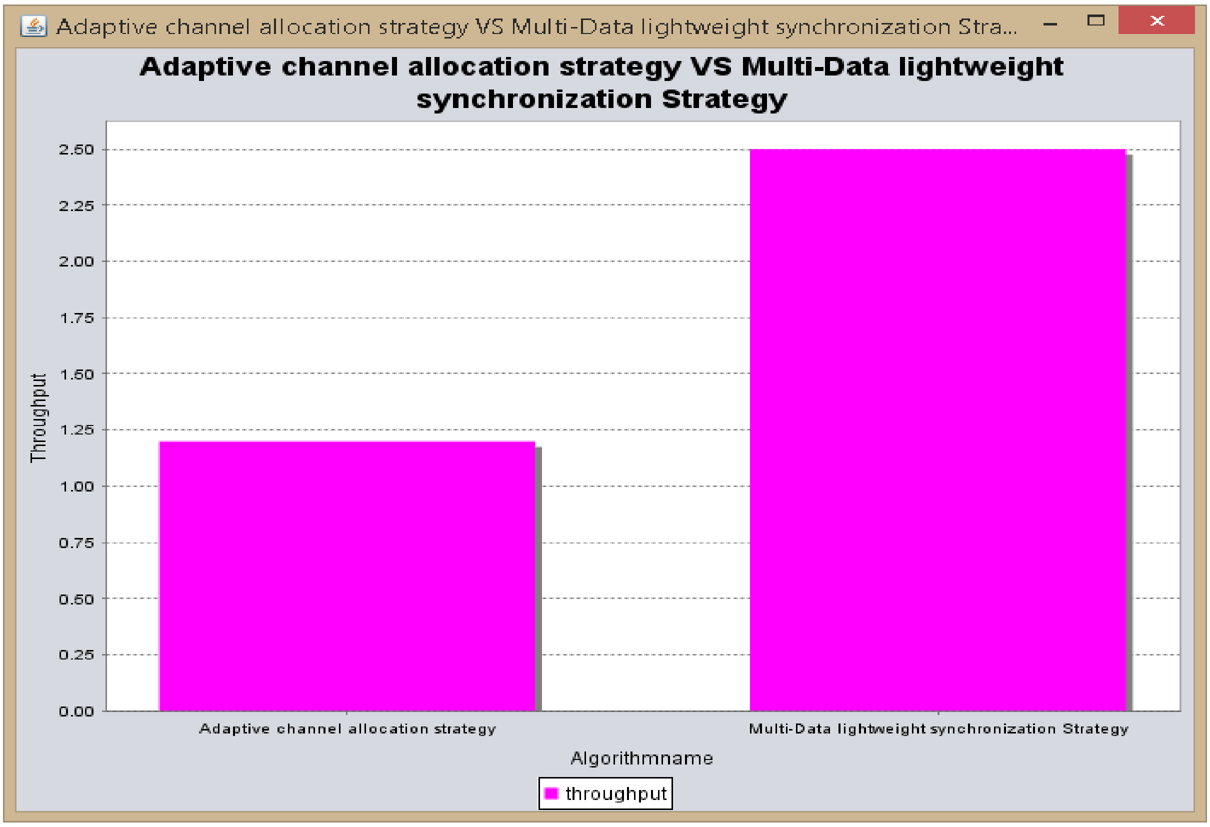

Fig 4.2 Throughput of Adaptive channel allocation strategy and Multi-Data Synchronization Strategy

The above figure shows that throughput obtained through multi-data synchronization strategy is better than compared with throughput obtained by adaptive channel allocation strategy.

C. Execution Time (ms)

TABLE III Comparison of Execution Time for two different Strategies

Execution Time(ms)

algorithmname	Executiontime
Adaptive channel allocation strategy	12226.0
Multi-Data lightweight synchronization Strategy	7925.0

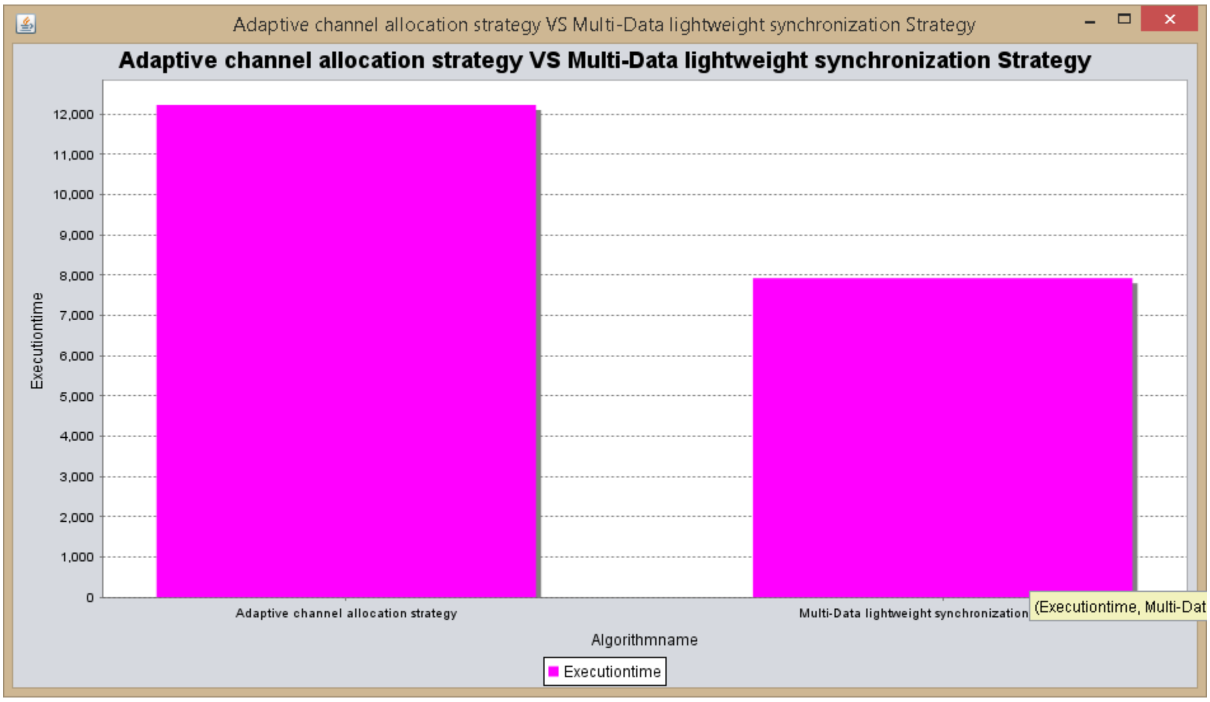

Fig 4.3 Execution Time of Adaptive channel allocation strategy and Multi-Data Synchronization Strategy

TABLE IV Comparison of Network Overhead of two different Strategies

Algorithmname	NetworkOverhead
Adaptive channel allocation strategy	60.0
Multi-Data lightweight synchronization Strategy	15.0

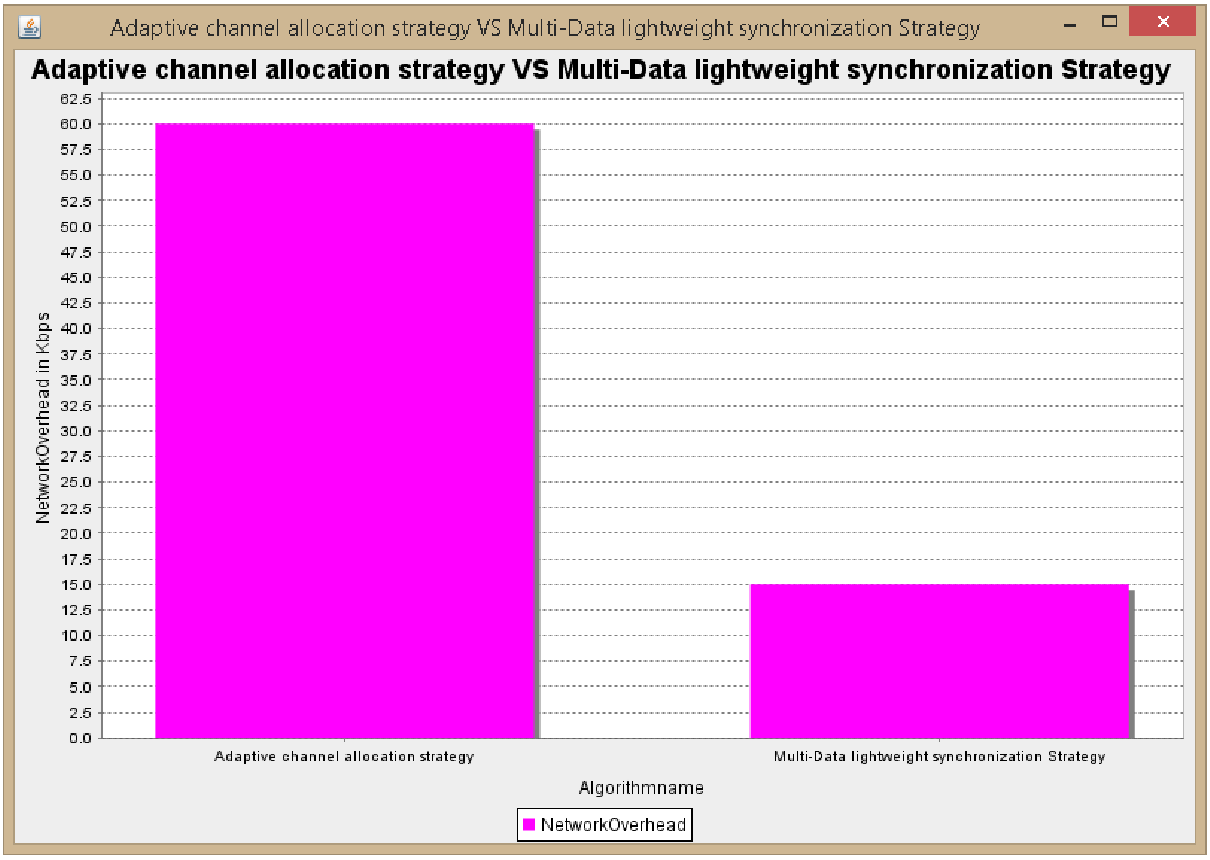

Fig 4.4 Network Overhead of Adaptive channel allocation strategy and Multi-Data Synchronization Strategy

Improving data transmission performance is one of the main objectives of MAC protocol design. Thus, we compared the two protocols here in terms of Packet Delivery Ratio, network throughput, or the number of channels to be used and the influence of network density, as well as the rate at which successful data packets (measured in bytes) are delivered per second, Network Overhead and in terms of Execution time.

5. CONCLUSION

We proposed optimized cluster head selection and lightweight synchronization (CHSLWS) that aims at optimizing the size of a sharable data with the use of multiple channels. It also handles general situations where a node can generate multiple data packets. Thanks to the improved throughput, the proposed algorithm enables a protocol to support more real-time applications with tighter time constraints for data gathering. According to extensive simulation results, our proposed approach outperforms the CHSLWS protocol in terms of packet reception ratio, network throughput, and energy efficiency. Therefore, it can be said that our proposed approach is highly suitable for real-time applications in industrial Mobile Ad-hoc networks.

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