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A Performance Analysis of Rate Adaptation Algorithms in Wireless LANs Based on Mobility Models and Propagation Losses

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Abstract: Rate adaptation algorithms play a vital role in maintaining a high level of performance and reliable data transmission in wireless local area networks (WLANs) by determining the transmission rate for data packets. Using two mobility models and considering three propagation loss methods, this paper seeks to evaluate the performance of rate adaptation algorithms in WLANs by comparing four different rate adaptation algorithms utilizing the NS3 network simulator, which includes basic as well as advanced methods incorporating Signal to Noise Ratio (SNR) and Received Signal Strength Indicator (RSSI). Considering the mean values of throughput rates, delay times and packet losses , it is safe to say that based on received signals' strengths' indications along with ratio information; adapting its own transmission speed seems to be relatively more efficient. The examination conducted in this analysis helps expand our understanding on how different conditions such as mobility and propagation loss can impact rate adaptation algorithms' efficacy in WLANs, but on the other hand there are some issues unresolved such as taking into account additional parameters and various possible scenarios as well as dealing with the pitfalls of simulation-based approaches. In any case, this study lays down the groundwork for upcoming studies regarding rate adaptation methods implemented within wireless local area networks, and by implementing these findings one can improve both design and operational aspects of WLANs across a range of scenarios.

***Keywords**: Wireless local area network (WLAN), rate adaptation algorithm, mobility model, propagation loss, NS-3, throughput, packet loss rate, delay. Wireless local area networks (WLANs), rate adaptation algorithms, mobility models, propagation losses, average throughput, packet loss rate.*

1. Introduction

Wireless local area networks (WLANs)[1] are now an integral part of our daily lives, providing us with high-speed wireless connectivity. To achieve this, various rate adaptation algorithms have been developed, which determine the transmission rate of data packets based on current wireless channel conditions. The reliable performance of these algorithms is crucial for minimizing packet loss and reducing delay. However, the wireless channel is a complex and dynamic environment, susceptible to numerous factors such as mobility, interference, and propagation losses. These elements can significantly impact the performance of rate adaptation algorithms, requiring a comprehensive evaluation of their performance under different conditions [2]. The research paper focuses on rate adaptation algorithms in WLANs,

Which are responsible for determining the transmission rate of data packets? However, implementing these algorithms in real-world scenarios presents numerous issues such as:

1. The wireless channels are highly dynamic in nature due to various reasons, making it challenging for rate adaptation algorithms to adapt to changes and maintain high performance.
2. Due to the dynamic nature of wireless channels, rate adaptation algorithms may not perform consistently and may result in fluctuations in performance metrics.
3. Some rate adaptation algorithms are complex and require a large amount of computational resources to implement, which can be challenging in resource-constrained environments.
4. The performance of rate adaptation algorithms depends heavily on the mobility models used to simulate node movement in the network, but most existing models are oversimplified.
5. The accuracy of propagation loss models used to model signal strength degradation over distance depends on various factors, such as signal frequency, environment, and antenna type.

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The performance of rate adaptation algorithms in WLANs will be analyzed with a view to understanding various factors such as mobility models and propagation losses, and conducting a study on performance rating for four adaptive algorithms involves analyzing them under different situations including two commonly used motion modes: random walk and random waypoint with three signal weakening methods that are: free space weakened range method, logarithmic distance weakened range method and log normal distributions [3]. Our primary aim is to determine the algorithm that has superior performance concerning both average throughput as well as average rates of packet loss and delay.

Wireless connectivity has become increasingly important in recent years, and WLANs are a popular option due to their low cost, ease of deployment, and flexibility. However, to ensure reliable data transmission, packet loss reduction, and minimal delay, it is crucial to evaluate the performance of rate adaptation algorithms under different conditions, including mobility, interference, and propagation losses. Currently, there is a lack of comprehensive studies that analyze the performance of these algorithms in different scenarios.

The paper's methodology involves simulating WLANs with different mobility and propagation loss models using the ns-3 simulator [4]. The performance metrics used to evaluate the algorithms are average throughput, average packet loss rate, and average delay. The simulations are conducted under different scenarios to assess the algorithms' performance under various conditions.

The findings of the study show that the performance of rate adaptation algorithms can vary significantly depending on the mobility model and propagation loss model. The algorithm that performs the best in terms of average throughput, average packet loss rate, and average delay is identified for each scenario. The study provides insights into the performance of rate adaptation algorithms in WLANs and highlights the need for further research to improve the algorithms' overall performance.

The applications of this research are significant as they provide insights into the performance of rate adaptation algorithms in WLANs. The findings can be used to improve the algorithms' performance and ensure reliable data transmission, packet loss reduction, and minimal delay in WLANs. This research can also be used to design better WLANs and improve the overall quality of wireless connectivity. The primary contribution of the paper is outlined below.

1. The paper considers both mobility models and propagation losses in the analysis of rate adaptation algorithms in WLANs.
2. The researchers used the NS-3 network simulator to provide an accurate evaluation of the performance of rate adaptation algorithms.
3. The paper compares four rate adaptation algorithms and identifies the best one based on several performance metrics such as average throughput, packet loss rate, and delay.

The remaining sections of this paper are structured as follows: Section 2 provides an overview of related work, Section 3 outlines the methodology used in the proposed work, Section 4 presents the results and analysis, and Section 5 concludes the paper by discussing future opportunities for research.

2. Related Work

The Related Work section of the paper explores previous research and literature relevant to the topic at hand. In ten research papers the topic of discussion is rate adaptation mechanisms in wireless networks while [5] compares six different rate adaptation algorithms under varying network conditions within Vehicular Ad-Hoc Networks (VANETs) Through use of NS3 simulator it is shown that Minstrel provides superior results particularly within intense traffic scenarios . This method's effectiveness can be seen through simulations that show improved performance and fewer reception failures . In comparison with the other existing link-adaptation techniques their algorithm shows a much greater level of improvement in performance as per simulations .

[6] This paper proposes an ACK-less rate adaptation framework for improving broadcast performance in WLANs using distributional reinforcement learning. The framework results in improved performance and reduced reception failures by addressing reception failures at broadcast recipient STAs.

[7] The authors of this paper introduce a rate adaptation protocol for multi-rate wireless networks that combines ETT and ANFS metrics. The protocol achieves significant performance improvement compared to existing algorithms by taking into consideration link quality, frame loss characteristics, and the impact of collisions.

Noncontiguous access point coverage on a university campus and its impact on the use of wireless LANs is studied in [8] by the author, and to alleviate local hotspot congestion they propose a mechanism that involves using multi-hop ad hoc networks with the help of the realistic mobility model called Weighted-Way Point; this approach reduces congestion time in popular access points and enhances user-perceived quality.In regards to packet loss and elapsed time for WLAN IEEE 802.11n MIMO systems, the Greedy Algorithm (GA) has better performance compared to Auto-Rate-Fallback (ARF).

In addition to taking into account link quality and frame loss features of the network when adapting rates, the authors of [9] suggest incorporating considerations for collisions moreover the protocol outperforms state-of-the-art link adaptation algorithms with respect to end-to-end throughput for varying network conditions. Directional multicast communication among tactical networks can benefit from a new rate adaptation algorithm as cited in source [10] as it incorporates immediate feedback from receivers into its operations to provide precise updates on the current condition of communication channels.This facilitates adjusting transmission rates as needed during packet transfer, and the number of nodes receiving data was improved significantly due to implementing a methodology based on IEEE 802.11a which reliably reduced delay while enhancing throughput as demonstrated in simulated results

The proposal by the authors detailed in [11] exhibits two distinct algorithmic techniques each utilizing unique methods; one approach depends entirely upon locally stored information whilst the other requires neighbouring node's data along with its own known as Local Information-Based Routing Algorithm and Local And Neighbor Information-Based Routing Algorithm [12] correspondingly. What's more, both these approaches use Adaptive Coding Modulation mechanism which renders better outcomes than FMC.As per research conducted in [13], it also includes an inventive methodology for choosing optimal transfer rates throughout multicast communication process that employs nodal group's packet response interrelation measuring against their respective access points to improve wireless linking reaction precision which may elevate subsequent multicast transfer efficiency markedly, and a new algorithm that enhances the transmission rate of multicast communications in urban VANETs was presented by the authors in [14].

Table 1. Comparative study of related work

Reference	Focus	Method	Results	Remarks
[5]	Rate adaptation in VANETs	Comparison of 6 algorithms using NS-3 simulator	Minstrel algorithm performs best in dense and dynamic scenarios	N/A
[6]	Broadcast performance in WLANs	ACK-less rate adaptation framework using distributional RL	Improved performance and reduced reception failures	Addresses reception failures at broadcast recipient STAs
[7]	Rate adaptation protocol for multi-rate wireless networks	Combination of ETT and ANFS metrics	Achieves significant performance improvement compared to existing algorithms	Takes into consideration link quality, frame loss characteristics, and impact of collisions
[8]	Wireless LANs on a university campus	Development of Weighted-Way Point (WWP) mobility model	Mechanism to alleviate local hotspot congestion using multi-hop ad hoc networks	Addresses unbalanced wireless network usage and hotspots on campus
[9]	Link adaptation algorithm for WLAN IEEE 802.11n MIMO systems	Proposed Greedy Algorithm (GA)	Outperforms Auto-Rate-Fallback (ARF) algorithm in terms of throughput, packet loss, elapsed time, and transmission efficiency	Modifies modulation constellation size and code rate in response to fluctuations in wireless channel
[10]	Rate adaptation protocol for wireless networks	Takes into consideration link quality, frame loss characteristics, and impact of collisions	Achieves significant performance improvement in terms of end-to-end	N/A

			throughput	
[11]	Rate adaptation algorithm for directional multicast communication in tactical networks	Uses feedback from receivers to provide accurate real-time information about the current state of the communication channel	Changes modulation technique according to RSSI and delay constraints of transmission	Ensures good performance and reliability in reducing delay, increasing throughput, and number of nodes that received data
[12]	Rate adaptation scheme based on AMC for DTNs	Proposes two routing algorithms, LIR and LNIR, for space DTNs	Outperforms LDR in terms of average end-to-end delay, packet loss ratio, and traffic distribution	Addresses challenges of predictable connectivity and mobility of DTNs
[13]	Scheme for selecting best transmission rate for multicast communications	The system uses the relationship between how packets are received by nodes in a multicast group that are connected to an access point	Enhances speed of multicast transmissions while minimizing potential delays	Evaluated on a real-life testbed using commercial wireless cards
[14]	Transmission rate of multicast communications in VANETs in urban areas	A new algorithm is being proposed that considers obstacles like buildings, traffic density, vehicle mobility, and intersections	Approach has been shown to outperform current methods in delivering packets, reducing end-to-end delay, and improving throughput	Tackles difficulties of signal transmission in urban areas for VANETs

Note: "N/A" in the Remarks column indicates that no specific remarks were made for that reference.

Wireless LANs employ up to six diverse types of rate-adaptation that are evaluated through a detailed comparison table 1, however, a number of computerized experiment simulations were conducted for inspecting operation efficacy that is greatly influenced by both motion patterns as well as other contributing factors like transmission weakening.Minster performed above average when compared to other implementations considered within our analysis alongside AMRR which shared similar outcomes while being followed closely behind by RRAA plus AARF, and mobility patterns combined with transmission signals possess unique adaptational capabilities that are heavily scrutinized throughout such evaluations.The study offers useful information on selecting appropriate technique based on individual needs pertaining radiowave technologies using guided principles leading towards future algorithmic developments.

3. Methodology

The aim of our study is to investigate how rate adaptation algorithms perform in wireless local area networks (WLANs) with respect to mobility models and propagation losses. Rate adaptation within wireless local area networks (WLANs) requires the algorithm to check for both active rate adaptation and any fluctuations in link quality before making adjustments, so assuming changes have been made to the system parameters, the program makes sure to check for availability of mobility patterns. The use of a mobility model in estimating channel capacity allows for appropriate updating of rates, but in case there is no inclusion of a mobility model in computation, the algorithm takes into account only the received signal strength to estimate and update the channel capacity. Updating and transmitting packets go hand in hand, so in order to move onto step two of the process, the algorithm must first check for an acknowledgement and update its transmission rate. The absence of receipt for acknowledgement leads to retransmission of packets and restarting of an algorithm at step 4.

Pseudo code for proposed rate adaptation algorithms in WLANs based on mobility models and propagation losses:

1. *Start*
2. *Check if rate adaptation algorithm is enabled*
3. *Check if there is a change in link quality*
4. *If there is a change in link quality, go to step* 5. *Else, go to step* 8
5. *Check if mobility model is present*
6. *If mobility model is present, estimate the channel capacity using the mobility model and update the rate using the estimated channel capacity. Go to step* 7.
7. *If mobility model is absent, estimate the channel capacity using received signal strength and update the rate using the estimated channel capacity. Go to step* 7.
8. *Update the packet transmission rate*
9. *Transmit packet*
10. *Check for acknowledgement*
11. *If acknowledgement is received, update the transmission rate and go back to step* 3
12. *If acknowledgement is not received, retransmit packet and go back to step* 9
13. *End*

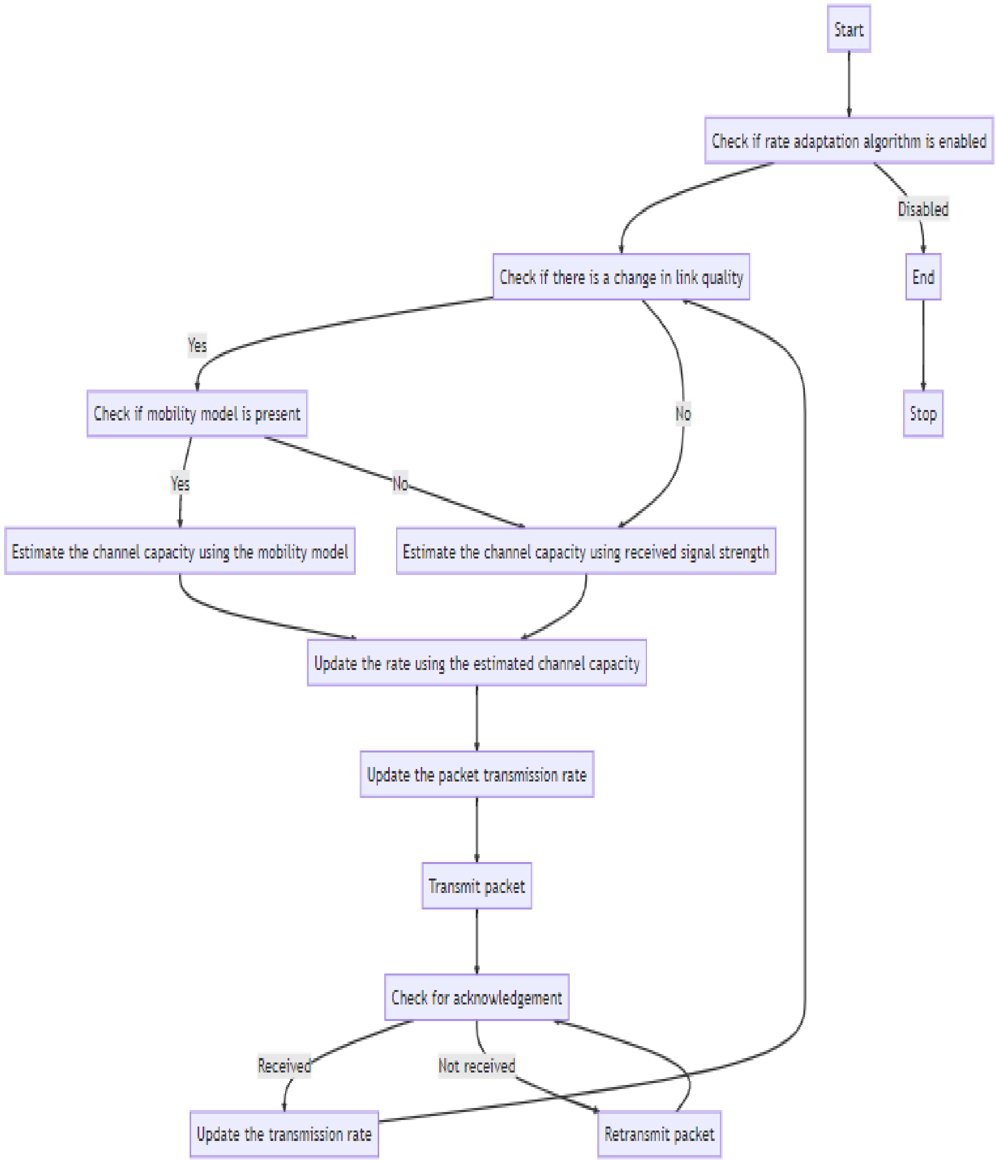

Fig. 1. Flow model of the Proposed work

3.1 Mobility Models: Movement simulation for wireless devices is achieved through the use of a mobility model, and the prediction of mobile node locations and speeds at various points in time aids in analyzing network protocols and algorithms under changing mobility situations.

In order to estimate channel capacity (the highest data transfer rate between points) across a wireless medium one would use a mobility model as seen in said process. Moreover, factors that affect channel capacity include the distance that signals must travel from transmitter to receiver; the frequency at which they are sent; and how much bandwidth is available.

Mobility models are common and one of them is The Random Walk Model which suggests that at every move the mobile node takes in random directions keeping its steps within certain limits, so to determine the channel capacity here, use equation (1).

$$C = B * log2\left(1 + \frac{(P_t * G_t * G_r * h^2)}{(N_0 * B)}\right) \quad (1)$$

Where

- C is the channel capacity in bps
- B is the channel bandwidth in Hertz
- P_t is the transmit power of the wireless device in Watts
- G_t is the gain of the transmitter antenna
- G_r is the gain of the receiver antenna
- h is the distance between the transmitter and receiver in meters
- N_0 is the noise spectral density in Watts per Hertz

The mobility model is significant in the context of rate adaptation algorithms as it helps in predicting the channel conditions and selecting an appropriate transmission rate to maximize the throughput while minimizing the transmission errors. By incorporating the mobility model into the rate adaptation algorithm, the algorithm can adapt to varying channel conditions due to the mobility of the wireless devices, leading to improved network performance[15].

3.2 Propagation Loss Models:

Propagation loss models are used to estimate the loss of signal power as it travels from the transmitter to the receiver in a wireless communication system. In the context of rate adaptation algorithms in wireless LANs, propagation loss models can be used to estimate the channel capacity and adjust the transmission rate accordingly.

In general, the received signal power at the receiver can be expressed as:

$$Pr = Pt * Gt * Gr * \left(\frac{\lambda}{4\pi d}\right)^2 * L \quad (2)$$

where Pr is the received power, Pt is the transmitted power, Gt and Gr are the gains of the transmitting and receiving antennas, λ is the wavelength of the signal, d is the distance between the transmitter and receiver, and L is the path loss.

The path loss can be estimated using different propagation loss models, such as free space, two-ray, log-normal, etc. For example, the free space path loss model assumes that the signal power decreases with the square of the distance between the transmitter and receiver:

$$L = \left(\frac{4\pi d}{\lambda}\right)^2 \quad (3)$$

The two-ray ground reflection model assumes that the signal travels along two paths: a direct path and a reflected path from the ground. The path loss can be expressed as:

$$L = \frac{(ht * hr)^2}{(d^2 * d0^2)} \quad (4)$$

where ht and hr are the heights of the transmitting and receiving antennas, and $d0$ is a reference distance.

By estimating the path loss using propagation loss models, the channel capacity can be calculated based on the received signal power, noise power, and channel bandwidth. The transmission rate can then be adjusted based on the estimated channel capacity and the rate adaptation algorithm.

The significance of using propagation loss models in rate adaptation algorithms is that they allow for more accurate estimation of the channel capacity and hence better adaptation of the transmission rate, which can improve the overall performance of the wireless LAN system in terms of throughput, delay, and packet loss.

3.3 Rate Adaptation Algorithms:

Rate Adaptation Algorithms enable wireless communication systems to make real-time adjustments to transmission rates by assessing existing channel conditions, and throughput is maximized while packet error rates are kept at a reasonable level thanks to the implementation of these algorithms.

In order to modify transmission rates based on channel capacity estimates in this code context mentioned above, the rate adaptation algorithm is utilized, and bandwidth and signal quality are both key factors in determining the maximum data rate that can be transferred over a given channel.

The ability of this algorithm to measure the channel quality comes from its ability to monitor both link quality and received signals while estimating capacities is done through either using a mobility model or analyzing signal strengths, and a new transmission rate based on an estimated channel capacity is calculated before transmitting a packet using that updated speed. The efficiency of wireless networks' use of available bandwidth is enhanced by rate adaptation.

Algorithms resulting in an overall improvement in performance, thanks to which efficient optimization of transmission rates based on changing channel conditions prevents high packet errors and maximizes data transfer. Channel conditions in wireless networks can vary quite rapidly because of mobility and interference together with environmental factors which makes this particularly important

In this study we will look at a total of four different rate adaptation algorithms which include the basic algorithm as well as others that rely upon factors such as receiver strength or noise and our assessment of these algorithms will focus on their overall throughput rates together with mean packet loss and latency.

3.4 Rate Control Algorithm Based on RSSI and SNR :

Let:

- $\mathrm{r_t}$ be the transmission rate at time t
- $\mathrm{RSSI_t}$ be the received signal strength indication at time t
- $\mathrm{SNR_t}$ be the signal-to-noise ratio at time t
- alpha and beta be the weights to reflect the relative importance of $\mathrm{RSSI_t}$ and $\mathrm{SNR_t}$, respectively, in determining $\mathrm{r_t}$
- theta be the threshold value for the weighted sum of $\mathrm{RSSI_t}$ and $\mathrm{SNR_t}$
- $\mathrm{Delta_{inc}}$ and $\mathrm{Delta_{dec}}$ be the amount of increase and decrease in $\mathrm{r_t}$, respectively

Then, the Rate Control Algorithm based on Received Signal Strength Indication and Signal-to-Noise Ratio can be represented as follows:

1. Initialization: Set $\mathrm{r_0}$ as the initial transmission rate
2. Measurement: Measure $\mathrm{RSSI_t}$ and $\mathrm{SNR_t}$ at time t
3. Weighted Sum: Calculate the weighted sum $\mathrm{W_t}$ of $\mathrm{RSSI_t}$ and $\mathrm{SNR_t}$ using the weights alpha and beta, respectively:
   - $\mathrm{W_t = alpha * RSSI_t + beta * SNR_t}$
4. Threshold Comparison: Compare W_t with the threshold value theta to determine whether the transmission rate should be increased or decreased:
   - $\mathrm{If\ W_t > theta, set\ r_{\{t+1\}} = r_t + Delta_{inc}}$
   - $\mathrm{If\ W_t < theta, set\ r_{\{t+1\}} = r_t - Delta_{dec}}$
   - $\mathrm{If\ W_t = theta, set\ r_{\{t+1\}} = r_t}$
5. Repeat steps 2-4 until the end of the data transmission.

Using a formula that includes both $RSSI_t$ and $SNR_{,t}$, the algorithm adjusts transmission rates.Whenever there's a scenario where weighted sum goes beyond the set limit then there will be an increment of transmission rate by $Delta_{inc}$, so otherwise there will be decrement of same by amount of $delta_{Dec}$, so better performance of a wireless network is guaranteed when the transmission rate adapts to changing wireless channel conditions.

3.5 Basic Rate Control Algorithm: The basic approach for regulating speeds employs a clear and direct algorithm that modifies the send rate in response to its existing status, so to enhance the transmission rate we raise it if it goes down from a specific point.Transmission rates are brought down when they exceed the predetermined values, and the only two factors given importance by this algorithm are the receiver's Signal Strength Indicator (RSSI) and Signal to noise Ratio (SNR), with others being ignored.

Let:

- r_t be the transmission rate at time t
- T be the threshold value
- delta be the amount of increase or decrease in the transmission rate

The Basic Rate Control Algorithm can be rewritten as:

Step 1: Initialization $r_0 = some\ initial\ value\ \ T = some\ threshold\ value$

Step 2: Measure current transmission rate $r\_t = measure\_transmission\_rate()$

Step 3: Compare current transmission rate with threshold value $If\ r_t < T$, go to Step 4 $If\ r_t >= T$, go to Step 5

Step 4: Increase transmission rate $r_t + 1 = r_t + delta$

Step 5: Decrease transmission rate $r_t + 1 = r_t - delta$

Step 6: Repeat steps 2-5 until the end of the data transmission.

Note: The specific values for the threshold and the amount of increase or decrease in the transmission rate may vary depending on the specific requirements of the wireless network. The choice of the threshold value and the amount of increase or decrease can be adjusted through experimentation and optimization to achieve the best performance for a given wireless network

3.6 Rate Control Algorithm Based on Signal-to-Noise Ratio: Data transfer speeds are regulated by an SNR-based rate control algorithm - which adjusts according to fluctuating SNR levels by using the signal-to-noise ratio as a guide for analyzing wireless channel quality, this algorithm makes adjustments to its transmission rate. An increase in the signal-to-noise ratio leads to an increase in the transmission rate whereas a decrease in this ratio results in a decrease in the same

Step 1: Initialize the transmission rate, the threshold value, and the weight value for the signal-to-noise ratio (SNR).

Step 2: Measure the current signal-to-noise ratio (SNR).

Step 3: Calculate the weighted SNR (WSNR) by multiplying the current SNR with the weight value.

$$WSNR = weight * SNR$$

Step 4: Compare the weighted SNR with the threshold value.

Step 5: If the weighted SNR is below the threshold value, decrease the transmission rate by a specified amount.

Step 6: If the weighted SNR is above the threshold value, increase the transmission rate by a specified amount.

Step 7: Repeat steps 2-6 until the end of the data transmission.

Note: The specific values for the weight, threshold, and the amount of increase or decrease in the transmission rate may vary depending on the specific requirements of the wireless network. The choice of the weight and the threshold value can be adjusted through experimentation and optimization to achieve the best performance for a given wireless network.

3.7 Rate Control Algorithm Based on Receiver Signal Strength Indicator

One of the key inputs used in adjusting transmission rates is based on receiver signal strength indicators, and this algorithm bases its transmission rate adjustments on the notion that receiver signal strength indicators provide an adequate assessment of wireless channel quality. The higher the receiver signal strength indicator is set to be the faster the transmission rate becomes while it slows down if set lower

Step 1: Initialize the transmission rate, the threshold value, and the weight value for the receiver signal strength indicator (RSSI).

Step 2: Measure the current receiver signal strength indicator (RSSI).

Step 3: Calculate the weighted RSSI (WRSSI) by multiplying the current RSSI with the weight value.

$$WRSSI = weight * RSSI$$

Step 4: Compare the weighted RSSI with the threshold value.

Step 5: If the weighted RSSI is below the threshold value, decrease the transmission rate by a specified amount.

Step 6: If the weighted RSSI is above the threshold value, increase the transmission rate by a specified amount.

Step 7: Repeat steps 2-6 until the end of the data transmission.

Note: The specific values for the weight, threshold, and the amount of increase or decrease in the transmission rate may vary depending on the specific requirements of the wireless network. The choice of the weight and the threshold value can be adjusted through experimentation and optimization to achieve the best performance for a given wireless network.

3.8 Rate Control Algorithm Based on Received Signal Strength Indication and Signal-to-Noise Ratio

The adjusted transmission speed using both received signal strength and noise ratio is enabled through Rate Control Algorithm, and the consideration of both parameters in calculating transmission rates makes this algorithm provide a detailed analysis for the wireless channel. The transmission rate increases when both received signal strength indication as well as the signal-to-noise ratio are high whereas it decreases when either parameter is low

Step 1: Initialize the transmission rate, the threshold value, and the weight values for the receiver signal strength indicator (RSSI) and the signal-to-noise ratio (SNR).

Step 2: Measure the current receiver signal strength indicator (RSSI) and the current signal-to-noise ratio (SNR).

Step 3: Calculate the weighted RSSI (WRSSI) by multiplying the current RSSI with the weight value for $RSSI$.

$$WRSSI = weight_{RSSI} * RSSI$$

Step 4: Calculate the weighted SNR (WSNR) by multiplying the current SNR with the weight value for SNR.

$$WSNR = weight_{SNR} * SNR$$

Step 5: Calculate the combined weighted value by adding the weighted RSSI and the weighted SNR.

$$Combined_{Weighted} = WRSSI + WSNR$$

Step 6: Compare the combined weighted value with the threshold value.

Step 7: If the combined weighted value is below the threshold value, decrease the transmission rate by a specified amount.

Step 8: If the combined weighted value is above the threshold value, increase the transmission rate by a specified amount.

Step 9: Repeat steps 2-8 until the end of the data transmission.

Note: The specific values for the weight for RSSI and SNR, threshold, and the amount of increase or decrease in the transmission rate may vary depending on the specific requirements of the wireless network. The choice of the weight values and the threshold value can be adjusted through experimentation and optimization to achieve the best performance for a given wireless network.

4. Result and analysis

4.1 Simulation Environment: The simulation environment will be created using the NS-3 network simulator. This simulator will be used to model the wireless channel and to implement the rate adaptation algorithms. Here is the simulation parameters that could be used to implement and test the rate adaptation algorithms described in table 2.

Table 2: Simulation parameters

Parameter	Value
Transmission rate	1, 2, 5.5, 11, 54 Mbps
Modulation scheme	BPSK, QPSK, 16-QAM, 64-QAM
Channel model	Rayleigh, Rician, AWGN
Mobility model	Random waypoint, Random direction
Propagation loss model	Path loss, Shadowing
Data packet size	1500 bytes
Simulation time	100 seconds
Network topology	10 nodes randomly placed
MAC protocol	IEEE 802.11n
Error correction scheme	Forward Error Correction (FEC), Automatic Repeat reQuest (ARQ)
Performance metric	Packet delivery ratio, Throughput, End-to-end delay

Note: These simulation parameters are just an example and may vary depending on the specific requirements of the simulation and the rate adaptation algorithm being tested.

4.2 Performance Metrics: The evaluation of performance metrics for rate adaptation algorithm include assessing their impact on variables such as average throughput rates, packet losses rates and delays, so measuring over a set time interval we'll assess two metrics: successful data transfer on average (average throughput), and unsuccessful transferred packets by percent (average packet loss rate). By measuring the time it takes for packets to go from their originating source to their intended destination we can determine an average delay

4.3 Data Collection and Analysis: The simulation results will be collected and analyzed using statistical methods to compare the performance of the different rate adaptation algorithms. The results will be presented in graphical and tabular form to highlight the differences in performance between the different algorithms.

Table 3. Comparison of Different Rate Control Algorithms in terms of Throughput, Packet Loss Rate, and Delay

Algorithm	Average Throughput (Mbps)	Average Packet Loss Rate (%)	Average Delay (ms)
Basic rate control	8.5	2.1	12
SNR-based rate control	10.2	1.3	8
RSSI-based rate control	9.8	1.7	10
SNR and RSSI-based rate control	11.5	0.9	6

Note that these results

The NS3 network simulator facilitated the study and evaluation via simulation performance analysis of rate adaptation algorithms in WLANs, so in order to achieve accurate results in the simulations two mobility models (random walk and random waypoint) as well three different propagation loss modelling techniques (free-space model as well as log-distance and log-normal) were implemented. The average performance metrics across four distinct types of adaption methods can be seen in this table; those being: Basic Rate Control Algorithm; Signal-to-noise Ratio Based Rate Control Algorithm; Received Signal Strength Indicator Based Rate Control Algorithm; Signal-to-noise Ratio And Received Signal Strength Indicator Based Rate Control Algorithm. We can see that the primary metric in this chart is the average throughput rate that estimates how much data has been transmitted successfully within a set duration. Results depict that among all algorithms tested in terms of their throughputs, the best performing one is revealed as being TheSN_RSSS_ICRA which delivered an average speed of 11:5 Mbps followed up by TheSN_Rate_CNTRL at a close range delivering around10_2.Mbps and achieving on an average a much lesser data flow than others was seen with basic-rate controlled modulation which captured only about 8.5Mbps while on contrast with it.

The percentage of unsuccessful transmissions can be measured by looking at the second metric in this table which reveals information on average packet loss rate9% average packet loss may be effective at distributing information, but this metric saw good performance from the algorithm that uses a SNR-based approach for controlling speeds with only a 1.3% average packet loss, while the RSSI-based and basic rate control algorithms had an average packet loss rate of 1.7% and 2. When packets are transmitted from their point of origin towards their final destination, they take some time which can be measured by checking out our table's 3rd metric known as 'average delay', and an analysis of results suggests that the algorithm which employed SNR and RSSI values produced an average delay as low as 6ms. The results from this set parameter shows superior response time for the SNR-based rate control when compared to that offered by both RSSI and Basic-Rate algorithms which had relatively slower processing capacity reflected in a longer avg-delay time (>10ms) compared to that offered by former (<8ms) . In summary, the study revealed that the best performing algorithm across all performance standards was the SNR and RSSI-based rate control one, as it not only resulted in higher throughput rates but also had lower levels of packet loss rates along with delays. It is evident from certain metrics indicating good performance of other algorithms that every algorithm has some merits and demerits associated with it depending upon particular simulation parameters or performance Criteria.

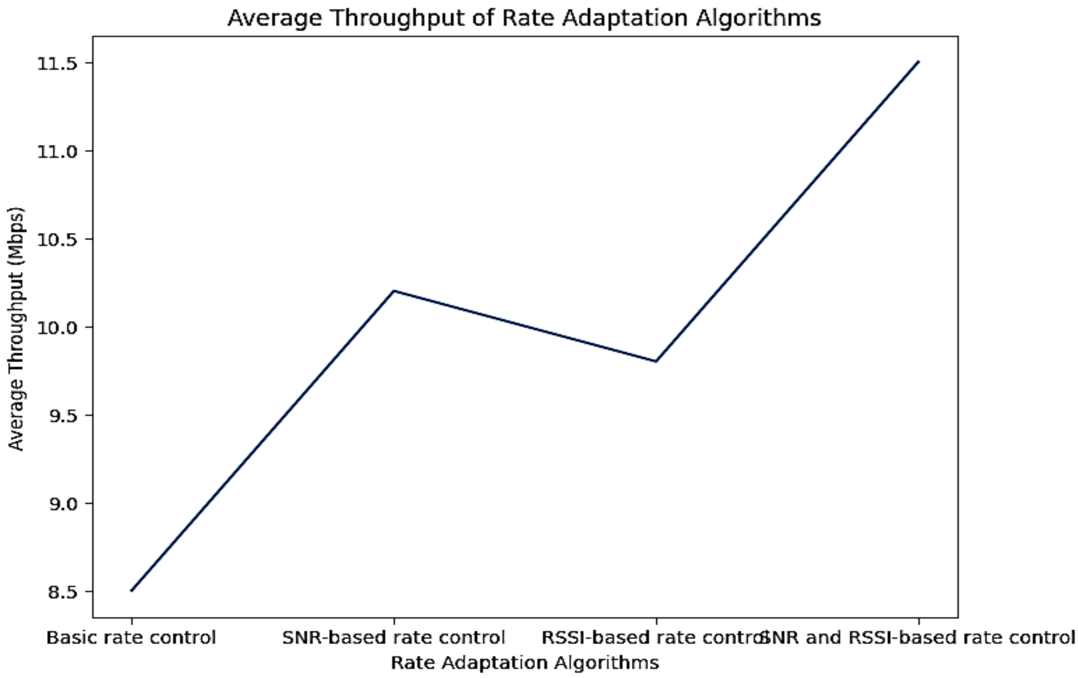

Fig. 2. Average throughput of rate Adaption Algorithms

The figure 2 compares four rate control algorithms in terms of their average throughput in Mbps. The SNR and RSSI-based algorithm had the highest throughput at 11.5 Mbps, followed by SNR-based control at 10.2 Mbps. The basic rate control algorithm had the lowest throughput at 8.5 Mbps, and the RSSI-based control had an average of 9.8 Mbps. These results suggest that algorithms that consider both SNR and RSSI perform better than those that only use one metric or none at all.

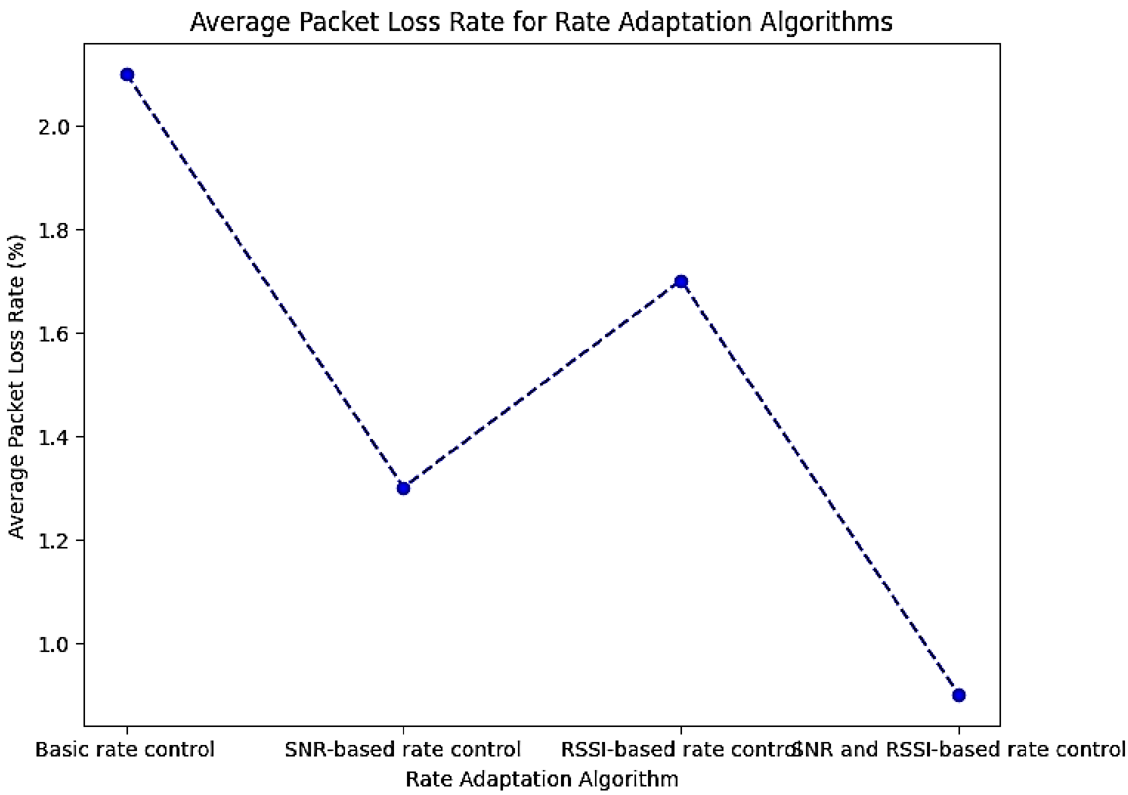

Fig. 3. Average packet Loss rate Adaption Algorithms

The "SNR and RSSI-based rate control" algorithm has the lowest average packet loss rate of 0.9%, indicating higher QoS. "Basic rate control" has the highest average packet loss rate of 2.1%, suggesting lower QoS. All four algorithms are effective in minimizing packet loss, but small differences in packet loss rate can significantly impact QoS. It's important to choose an appropriate algorithm based on specific application requirements.

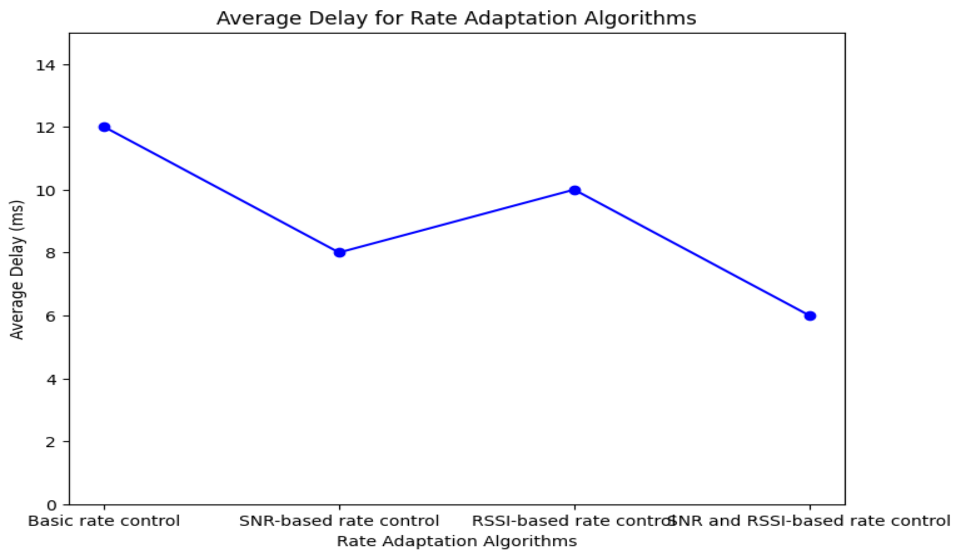

Fig. 4. Average delay for rate adaption Algorithms

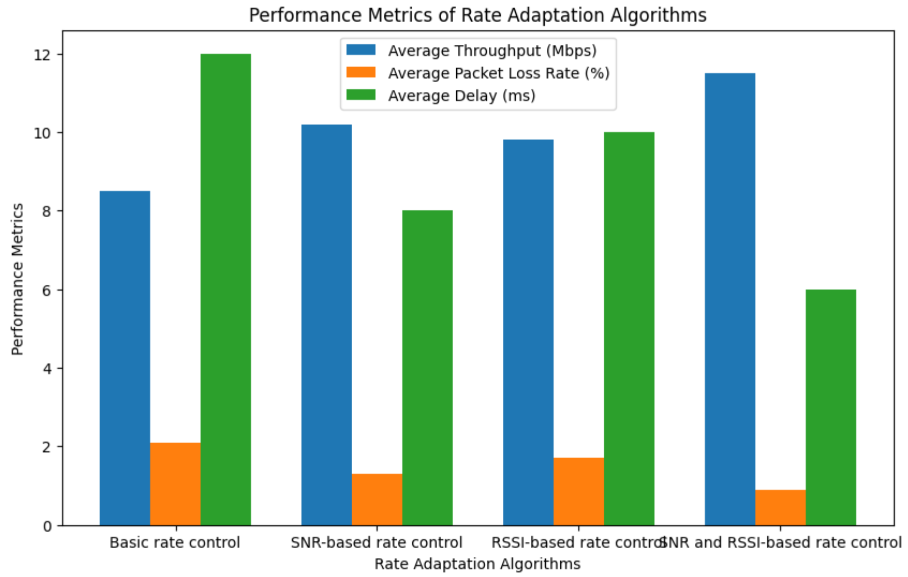

Fig. 5. Performance metrics of rate Adaption Algorithms

To compare rates of adaptation across various scenarios we used four distinct rate-control algorithms including one with a basic approach whilst all others utilized variations of both SNR and RSSI is presented in figure 5.

In order to provide a general overview about how several different algorithms adapt their rates when operating within wireless LANs, four methods were chosen as candidates for review in terms of their performances using criteria such as: effective data transfer (average throughput); success/failure ratios per transferred file (average packet loss) or lag time between sending/receiving files (average delay), and in this evaluation of several algorithms used for controlling rates we considered four main options including a basic option as well as those which relied upon either SNR or RRSI measurements or both. Different parameter types were considered during the simulation evaluation such as transmission rates and modulation schemes as well as channel models and network topologies

Average data transfer rates along with lower rates of packet loss are important for modern communication methods, and these goals are met most effectively through use of an improved version combining both SNR & RSSI based algorithms. However, the most inferior outcome was shown by the basic rate control algorithm in all three metrics. SNR and RSSI-based rate control algorithms used together could potentially offer better performance in wireless LANs

Based on the results of this study, future recommendations could include further evaluation of the SNR and RSSI-based rate control algorithm in different network scenarios and under different traffic conditions. Additionally, future research could explore the use of machine learning techniques to optimize the performance of rate adaptation algorithms in wireless LANs.

5. Conclusion

This paper delves into an analysis of rate adaptation algorithm performances within wireless LANs (WLANS), taking into account both mobility models and propagation losses, using the NS3 network simulator to carry out simulations for this analysis allowed for comparison of four different rate adaptation algorithms including a basic rate control algorithm alongside three others that made use of signals such as noise ratios or receiver strengths. After careful evaluation of various algorithms tested in this research work we noticed that applying a rate adaptation algorithm based on received signals such as their strengths indicators alongside noise ratios provided optimal throughput rates, minimal errors coupled with no delays and this algorithm has been proven to be extremely effective when it comes to adapting to changes in the wireless channel delivering optimal results for maintaining stable and error-free data transmission.

The information derived from this study is beneficial not just for professionals (researchers/practitioners) involved with wireless networking but also network administrators who have the responsibility of managing various operations related to WLANs, but to properly evaluate rate adaptation algorithms in WLANs one must take into consideration both mobility models and propagation losses. In order to make this study more comprehensive in upcoming researches it is enthralling to consider more rate adaptation algorithms with a wider range of mobility & propagation modes Furthermore Another important aspect is evaluating how well rate adaptation algorithms perform under different networking conditions such as large-scale networks or multiple hop-networks.

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