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Performance Evaluation of MAC Protocol in Mobile Ad-Hoc Wireless Network

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ABSTRACT:

A Mobile Ad Hoc Network (MANET) is a collection of wireless hosts that may be quickly built as a multihop packet radio network without the need for any established infrastructure or centralized administration [1]. The coordination of access from active nodes is handled by the Medium Access Control (MAC) protocols. A set of protocols known as Carrier Sense Multiple Access (CSMA) is used by stations competing for access to a shared medium such as an Ethernet cable or a radio channel. MACA (Multiple Accesses with Collision Avoidance) is a Sender-Initiated Protocol that employs Contention. Request to send packet, clear to send packet, and data packet exchange are all examples of three-way handshaking. Avoid congestion with the use of the binary exponential back off Algorithm, which also helps to calculate the proper transmitting rate. If a node's packet is dropped, the node utilizes the back-off (BEB) technique to wait a random period of time. On the Ns-2 2.35 Version simulator, a comparison was made between CSMA and MACA. The CSMA& MACA performance will be evaluated using the DSR routing protocol. The goal of this study is to examine standardized MAC protocols on MANETs, with the goal of measuring performance under various node densities and MAC protocols. Dynamic Source Routing is one of the routing protocols evaluated in the analysis. Furthermore, because of the ubiquitous deployment of MAC protocols for MANETs, it is vital to evaluate them from the perspective of the transport layer, which benefits from the advantage of decisive data transmission over the Internet. As a result, determining the most appropriate and efficient MAC protocols that can operate under these unique conditions is critical.

1.0 INTRODUCTION

Wireless networks enable users to access computing and communication services while on the move, regardless of their physical location. The infrastructure-less networks known as Mobile Ad-Hoc Networks (MANET) [1] are one sort of wireless network. It's a self-configuring architecture with fewer wirelessly connected devices and networking capabilities. The migration of hosts in these networks is quite fast. Because all nodes can move and can be joined dynamically in any way, topology changes often. Because nodes in wireless Ad-Hoc Networks are self-contained and do not require fixed infrastructure, each node performs routing functions such as forwarding network traffic. Before creating an Ad-Hoc wireless network, we need think about things like the media access control protocol, routing protocol, transport layer protocol, quality of service, and security support. Different protocols in wireless Ad-Hoc Networks must deal with different challenges in order to function successfully, such as network noise, routing information error, transmission ranges, and so on. Only a portion of the information acquired by one protocol is sometimes sent to another protocol in a single node, resulting in protocol misunderstanding. To address this, we propose a change to the Media Access Control 802.11 protocol to avoid launching unnecessary DSR (Dynamic Source Routing) operations, resulting in improved network performance, such as less routing overload, fewer routing changes, fewer packet collisions, fewer route errors, fewer MAC errors, and higher throughput. When a neighboring node is still close, the DSR protocol sends out a route error because it interprets the information received from the MAC layer as a broken link. Interferences between radio ranges of nodes are usually the cause of this dispute. The suggested technique monitors each node's signal strength and informs the routing layer that the node has sufficient signal strength, bypassing DSR's route error. A MAC protocol is an important component of a Mobile Ad-Hoc Network because it regulates how nodes access the shared medium. It's crucial because a well-designed MAC protocol can improve the network's performance and adequacy. A tremendous deal of effort has gone into developing a MAC protocol with the best feasible performance [2].

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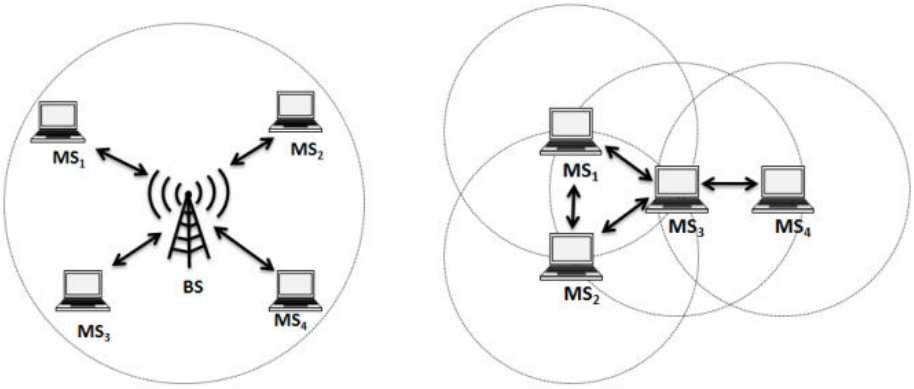

Fig. 1.1(a) Fig. 1.1(b)

Figure1.0 Mobile ad hoc network

1.1 Performance Parameters

- **Packet delivery fraction** The ratio between the numbers of received data packets at the intended destination node and the number of transmitting data packets at the source node. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the most complete and correct is the MAC protocol.

$$PDF = \frac{\Sigma \text{ Data packets Received}}{\Sigma \text{ Data packets send}} \quad \text{.....(1.1)}$$

- **Throughput** Through put is defined as the number of packets flowing through the channel at a particular instant of time. This performance metric signifies that the total number of packets that have been successfully delivered from source node to the destination node.

$$\text{Throughput} = \frac{\Sigma \text{ Packet Received}}{\text{Transmission time}} \quad \text{.....(1.2)}$$

- **Routing overhead** Routing Overhead is the ratio of overhead byte to the delivered data byte. The transmission at each hop along the route is counted as one transmission in the calculation of this metric.

2.0 ISSUES AND DESIGN GOALS

The most difficult problem at the MAC layer is allocating the channel among competing users. Before going over the primary MAC layer protocols, there are a few things to keep in mind [21].

• Assumption of a single channel: All stations share a single channel.

• Collision assumption: If two frames transmit at the same time, they will overlap in time, resulting in a distorted signal.

Time is divided into segments called slots in slotted time. Frame transmission always begins at the start of a slot. The users transmit one after the other in fast succession, each using their assigned time slot.

• No carrier sense: Stations are unable to detect the channel prior to its use. A station can only check whether or not a transmission was successful after it has been sent.

• Carrier sense: Stations can detect whether or not a channel is busy. If a channel is busy, a station will wait until it becomes available before attempting to utilize it.

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2.1 Operation

For channel allocation, traditional Local Area Networks (LANs) use Carrier Sense Multiple Access with Collision Detection (CSMA/CD) in the MAC layer [17]. If two stations try to access the channel at the same time using CSMA/CD, they will notice a collision and the transmission will be aborted. After a collision is detected, a station waits a random amount of time before attempting to obtain the channel again. Because the range of the nodes must be considered, this protocol cannot be utilized in wireless networks. Interferences in wireless networks might occur in the receiver, whereas CSMA/CD only considers interference in the transmitter. The hidden/exposed terminal problem will clarify this.

The hidden station problem occurs when packets collide at the receiving node, because nodes are not within transmission range of each other when sending, but they are within transmission range of the receiver [17]. In Figure 4.1, S1 is transmitting to R1, and S2 can potentially interfere with R1 but not with S1. If S2 detects the channel, it will be unable to hear S1 since it is out of range, and will therefore incorrectly believe it is able to transmit to

R1. If S1 begins to transmit at this time, it will collide with node S2, resulting in packet loss. The exposed node problem happens in wireless networks when a node is restricted from delivering packets to other nodes owing to surrounding nodes. When a node incorrectly thinks that it cannot broadcast because a nearby node is transmitting to another node, the exposed station problem occurs. Consider picture 4.1, where S1 is sending data to R1. If S3 detects the channel, it will hear a continuing transmission and incorrectly infer that it is unable to communicate with R2. Collisions could only occur in the zone between S1 and R1 in this situation.

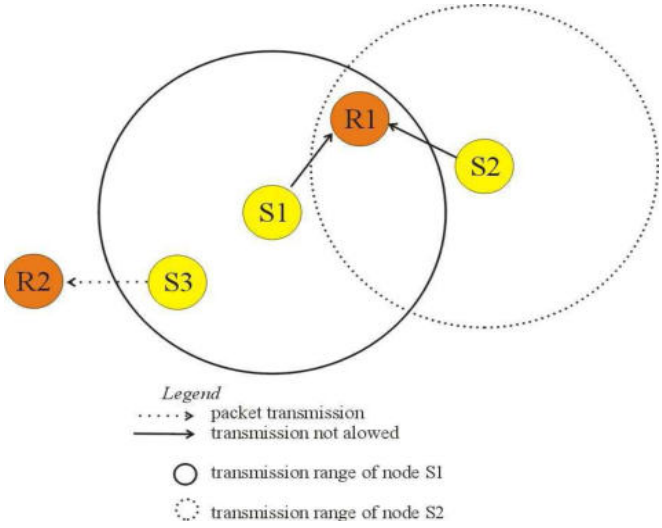

Fig 2.1 Routing Protocol

3.0 ROUTING IN MANET

The Network layer's major aim [22] is to select the best path for transmitting packets from a source to a destination. Routing protocols accomplish this by creating and maintaining routing tables, which contain information on where packets should be delivered next in order to reach their destinations. Routing protocols should be able to determine the best paths and deal with various network topologies from a data source to a data destination. Traditional wired network routing protocols cannot be readily applied to Ad-Hoc Wireless Networks due to the significant mobility of nodes [17]. other features should be examined when selecting a wireless routing protocol.

3.1 Classification

A Mobile Ad-Hoc Network (MANET) is a collection of mobile, wireless nodes that work together to forward packets in a multi-hop fashion without the need for centralized administration. Because the network structure varies constantly, each mobile node works as a router as well as an end node that is either source or destination in a MANET [15]. The topology of mobile ad-hoc networks is dynamic, multihop, and rapidly changing. Routing protocols are classified as follows:

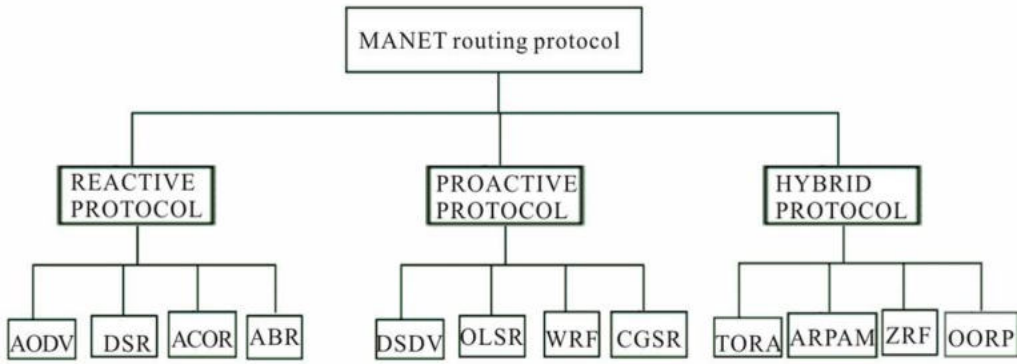

Figure 3.1 Classification of MANET Routing Protocol

4.0 PROPOSED METHODOLOGY

4.1 MAC Algorithm

Medium Access Control (MAC) Algorithms are used to let several users to share a single communication channel at the same time in order to maximize channel utilization while minimizing conflict and collisions. MAC is comparable to highway traffic restrictions. For example, on a highway, numerous vehicles may cross the same road at the same time, but there are laws in place to prevent collisions, such as following traffic lights and constructing flyovers. [1]. Layer 1 of the OSI reference model is the Data Link Control layer, and layer 2 is the MAC. The Media Access Control layer and the Logical Link Control (LLC) layer make up Layer 2. The DLC's job is to create a secure point-to-point or point-to-multipoint connection between two or more devices over a wired or wireless media.
Ad-Hoc Networks use either Omni-directional Antennas or Directional Antennas, and MAC Algorithms are classed in two categories of antenna.

4.2 The Network Simulator

Simulation is widely utilized in system modeling for a wide range of applications, including engineering research, business analysis, production planning, and biological science testing, among others. In comparison to analytical modeling, simulation usually requires less abstraction in the model (i.e. fewer simplifying assumptions), because the simulation model can include practically every element of the system's specifications to best depict the actual system. A simple mathematical formulation may not be possible when the system is quite huge and complex. The simulation approach is frequently favoured over the analytical approach in this scenario

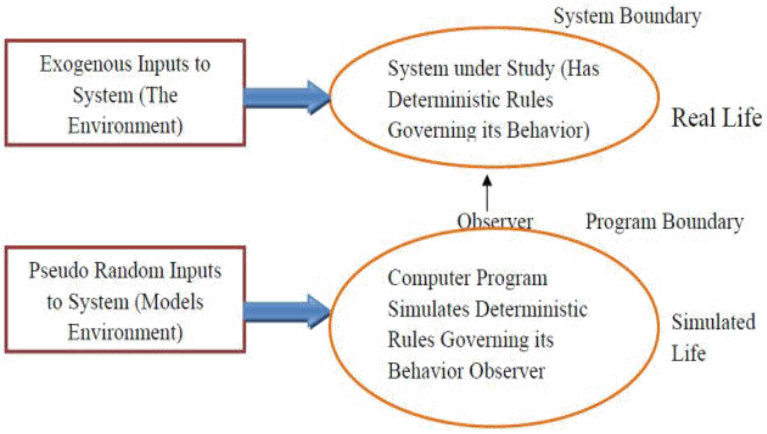

Figure 4.1 Running NS-2 Simulations

4.3 Simulation Goal

- Encourage networking education and research.
- Protocol design, traffic analysis, and so forth.
- A comparison of protocols.
- Create an atmosphere conducive to collaboration.
- Open source software that is freely distributed.
- Share code, protocols, and models, for example.

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4.4 Type of Network Simulators

There is various type of simulator exists. Each simulator has its own features and performance capability. All type of simulator can be tested on the performance based and accuracy in the results. Table 6.1 is showing different type of simulator based on availability in the market.

Table 6.1 Types of Simulator

License type	Network Simulator Name
Commercial	OPNET, Qualnet
Open Source	NS-2

4.4.1 Commercial and Open Source Simulators

Simulators come in a variety of shapes and sizes. Each simulator has its unique set of features and capabilities. All types of simulators can be put to the test in terms of performance and accuracy. Table 6.1 depicts the many types of simulators available on the market.

4.4.1.1 Advantages of Commercial Simulator

- Provide complete code for uses.
- Provide full documentation for uses.
- Properly maintain by the vendor.

4.4.1.2 Disadvantages Of Commercial Simulator

- Not freely available and very costly.

5.0 NETWORK SIMULATOR (NS-2)

NS-2 is one of the most popular open source network simulators. The original Network Simulator is a discrete event simulator targeted at networking research.

Network Simulator

- A package of tools that simulates behavior of networks.
- Create Network Topologies, Log events that happen under any load.
- Analyze events to understand the network behavior.

5.1 Creating Topology of Ns-2

Figure 6.4 is showing the simple topology in the network.

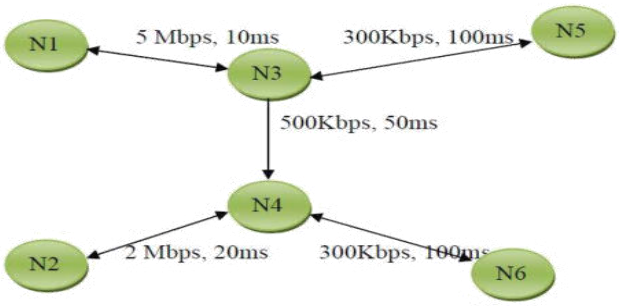

Figure 5.1 Topology in the NS-2

- ❖ Nodes
  - Set properties like queue length, location.
  - Protocols, routing algorithms.
- ❖ Links
  - Set types of link – Simplex, duplex, wireless, satellite.
  - Set bandwidth, latency etc.

5.2 Observing Network Behavior

Observe behavior by tracing events, eg. Packet received, packet drop etc. figure 6.5 is showing the behavior of the network.

```
+ 0.1 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
- 0.1 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
r 0.114 1 2 cbr 1000 ------- 2 1.0 5.0 0 0
+ 0.114 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
- 0.114 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
r 0.240667 2 3 cbr 1000 ------- 2 1.0 5.0 0 0
```

Figure 5.2 Network Behavior

6.0 CONTENTION BASED DYNAMIC RESERVATION/COLLISION RESOLUTION

In order to overcome the CSMA problem of hidden and exposed terminals, researchers have devised a number of protocols that are contention-based but also include some type of dynamic reservation/collision resolution. We'll go through various key contention-based techniques in the signal channel, receiver initiated, power aware, multiple channel, and QOS aware categories in particular.

6.1 Single channel MAC protocol

Single channels schemes were the first protocols designed to be implemented as MAC layer protocols. Using a single channel to share all of the information (control signals and DATA), these designs ran into a number of issues that reduced the overall network's efficiency.

6.2 Multiple access collision avoidance (MACA)

Multiple Access with Collision Avoidance (MACA) is a slotted media access control system for wireless LAN data transmission that prevents collisions caused by the hidden station problem and simplifies the exposed station problem [2], [12], [14], [15], [16]. The hidden node and exposed terminal problems are not fully solved by this MACA protocol, and nothing is done about the receiver blocked problem. Periodic access to the channel is not guaranteed to Contention Based Protocol Nodes. They are unable to handle real-time traffic. RTS—CTS—Data packet exchange is a three-way handshaking protocol. Algorithm Sender initiated Protocol with Binary Exponential backoff. The basic principle behind MACA is that before sending a data frame, a wireless network node makes an announcement to alert other nodes not to send frames at that moment. When a node wants to send a frame, it sends a Request-To-Send (RTS) signal containing the frame length. If the receiving node permits the transmission, it sends the transmitter a Clear-To-Send (CTS) signal with the length of the data frame it is about to receive. Meanwhile, a node that receives an RTS signal should remain silent in order to avoid conflict with a CTS signal, and a node that receives a CTS signal should remain silent until the data transmission is complete. When a node wants to send a data packet, it sends an RTS (Request to Send) frame first. If the receiver node permits transmission, it sends a CTS (Clear to Send) packet. The sender begins transferring the data packet after receiving the CTS packet from the receiver without error. If a packet sent by a node is lost, the node employs the binary exponential back-off (BEB) technique to delay retrying for a random amount of time.

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7.0 CONCLUSION

A mobile ad hoc network (MANET) is a self-organizing, self-managing wireless communication network with minimal infrastructure, in which all nodes can be considered hosts or routers. The Medium Access Control (MAC) protocols are in charge of coordinating access from nodes in these networks. A reliable and energy-efficient MAC protocol is required in MANETs to avoid transmission collisions. (node mobility; limited bandwidth availability; an error-prone broadcast channel; synchronization; bandwidth efficiency; hidden and exposed terminal problem, QoS support) are some of the difficulties that media access control protocol are designed to address in ad-hoc wireless networks. We give a detailed assessment of major MAC schemes in this article, which incorporates a variety of difficulties and challenges

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