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MANET – A Wireless Network: Paradigm for Multi-hop Communication

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Abstract:
Mobile Ad-hoc Networks (MANETs) are self-configurable, infrastructure less, wireless networks where node mobility prediction plays a role of critical component. Node mobility is a challenge in MANETs, as it is a highly dynamic, unpredictable network where nodes move freely in the environment and form network as per the requirement which leads to the dynamic changes in the network and its topology which are highly difficult to predict in order to make network stable and scalable. With efficient node mobility prediction MANETs can be more robust in terms of routing, resource allocation and network management. This research paper is about the working of MANETs and the areas that needs to be addressed in MANETs which further allow this network to be more reliable, robust and highly efficient.

Keywords: MANETs, Node, Topology, Network, Host, Router, Decentralized, Self-Configurable, Wi-Fi, OLSR, AODV, DSR, MAC.

1. Introduction

MANET stands for Mobile Ad Hoc Networks; it is a wireless network that allow nodes (devices) to connect without infra support. It is a network where nodes are allowed to move freely that further make this network dynamic. As nodes move dynamically in the environment though this network is self-configurable, which means, it has no fixed topology to rely on, it changes topology as per the requirement and movement of the nodes. These properties make MANET different and more relevant from other networks as per the ask of current tech world. Being highly independent network, it has some areas, that required to be improved and enhanced to make it more robust and reliable network. Dynamic movement of the node is a strong property of MANET but this is the ultimate cause of network break down and network reliability as it is highly difficult for MANET to track the node movement. MANET is the connectivity between the available devices that further referred as a node which knowingly forms a network to allow movement of the dataset. Here in MANETs, each device or node such as laptop, phone act as both the router and the host, which means, sometimes the node uses the network (act as host) and sometimes the node transfers the dataset for the network (act as router). In order to discover the next or neighbour nodes in the network each node broadcasts the “Hello” messages to announce its presence and availability in the environment. This process localizes the presence of nodes that further allow network to be formed independently.

In MANETs, when the node wants to send a message then first it looks for the finest, shortest path to deliver the same to the destination. When intermediate node receives a message and found it is for different destination node, not for itself, then it starts acting as a router, which further allow it to move the message to the destination node where destination node start acting as a receiver. During data transmission, MANET nodes consistently checks their connectivity with the neighbour nodes in order to maintain the timely and secure delivery of a message, in case of node unavailability or node out of range scenarios (sudden node movement) the network starts repairing itself by searching another available node in the environment. MANETs have been used widely in emergency and impossible situations like disaster relief, tactical operations, defence operations and many more as the network is highly dynamic, independency, decentralized, and self-configurable.

2. MANET Mechanics

As MANETs are highly dynamic, decentralized, and self-configurable network though it works by having every node to be inclined in such a way where they cooperate in a sync to establish, maintain and route the data without a centralized, fixed structure of routers and access points. In an environment, when mobile nodes are brought in the proximity, they automatically start discovering each and other nodes that are available to form a network using Wi-Fi, radio frequencies and signals. MANETs doesn't have a "leader" or "centralized authority", hence, here each node decides how to connect and route traffic independently. This property makes network more reliable and robust towards the failure of any single device. These nodes have limited transmission range though sending data directly to the destination node is not feasible for the source node which is the reason why it requires more nodes to act as a router and to transmit the data from source to the destination. Hence it is called as a multi-hop routing network. In simple, we can say that, it is like passing a message hand in hand down a long line of people instead of throwing it.

3. Phases of MANETs

MANET works in two phases that are interlinked and serves each other.

- Route Establishment
- Data Movement and Maintenance

Below mentioned diagram explains both phases in detailed view:

PHASE 1 – ROUTE ESTABLISHMENT		
1	**Node Joins**	A new mobile node power on.
2	**Neighbour Discovery**	The node broadcasts a "Hello" message to find intermediate neighbour nodes.
3	**Table Building**	Based on replies and acknowledgement, the node builds its neighbour table (Who is connected to whom).
4	**Need Data**	Sender checks its routing table for the path to the destination.
5	**Route Missing**	If no path exists, the node starts route discovery (Flooding a route RREQ).
6	**Path Found**	RREQs reach the destination, which sends a route reply (RREP) back along the discovery path.
7	**Route Established**	All nodes along the path update their routing tables with the best path.

PHASE 2 – DATA MOVEMENT AND MAINTENANCE		
1	**Data Starts**	Sender begins sending data packets along the established path.
2	**Forwarding**	Each Intermediate node forwards the packet to its next hop.
3	**Link Monitoring**	Every node continuously monitors the quality and stability of its link to the next hop.
4	**Link Degradation Detected**	A node realizes its connection to the next hop is failing (due to mobility).

5	**Handoff/Reroute Triggered**	The node initiates route maintenance to find a new, stable path around the failing link.
6	**New Path Selected**	The node quickly establishes a connection with a new, stable neighbour or utilizes a pre discovered backup route.
7	**Table Update**	The node updates its local routing table with the new next hop address.
8	**Data Resumes**	Data transmission continues seamlessly on the new, stable path.
9	**Delivery**	Packet reach the receiver node.

This mentioned step by step flow explains the core logic of MANET working from setting up a route to move the data by fixing the route when node mobility breaks it.

4. MANET Roadblocks

As MANET is highly dynamic network due to the uncertain node movement, though it contains some challenges that hinders its performance. Some of the major challenges are mentioned below:

- **Frequent Link breaks:** In MANETs node movement is uncertain and unpredictable though once node moves the network breaks, which impact the performance and consumes more time then estimated.
- **Route Discovery Overhead:** Whenever the link breaks, the routing protocol runs to form a new route by generating many control packets (RREQ), this control traffic consumes bandwidth and node energy, leading to network congestion.
- **Limited Energy:** Every action, consumes energy. Transmitting, receiving, forwarding, and running routing protocol, drains the battery. Which is the reason why, MANET has limited energy due to the high consumption of the same in every step.
- **Limited Bandwidth:** Wireless links has less capacity then the wired ones. As MANET is wireless network completely though it has lower bandwidth then other networks.
- **Open Medium:** As the communication in MANETs is in the air, though it is very easier for attackers to eavesdrop and capture the confidential information.
- **Malicious Nodes:** As in MANETs nodes have to act as a host and a router, though being a router node can be compromised or can be selfish by disrupting the service or performing attacks.
- **Interference and Noise:** As the shared medium is an air, which is highly susceptible to the interferences from other devices or environmental factors that cause transmission errors and packet loss.

5. Network Layers in MANET

Network layers in MANET are bifurcated in two different sections, the one that focus on routing and the other that focus on access.

- **Network Layer:** This is the critical section of MANET, it contains routing protocols, route maintenance and route overhead scenarios. There are three classifications of routing protocols: Proactive (Table driven), the protocols that maintain routes constantly (Example - OLSR) (Learns about their overheads vs route availability). Reactive (On Demand), the one that discover routes only when needed (Example – AODV, DSR) (Learns about the route request (RREQ) and route reply (RREP) mechanisms. And the third is the Hybrid, the protocols that combines the aspects of both.
- **Data Link/MAC Layer:** This layer is about the management of wireless medium. This includes the characteristics of wireless channels such as understanding fading, attenuation, and interference. This layer addresses the wireless collision problems that includes hidden and exposed terminals. MAC stands

for Medium Access Control, that learns about the protocols such as 802.11 (Wi-Fi), and how these protocols can be adopted, does they need any modifications or not for the ad hoc environment of MANET.

6. Performance and Metric (Evaluation)

There are some metrics that measure MANET performance, that further allow us to understand and analyse that the MANET network is working well or not. The performance metrics has been divided in few below mentioned KPIs (Key Performance Indicators):

- **Packet Delivery Ratio (PDR):** It is the percentage of packets successfully delivered.
- **End to End Delay:** It is the time taken for a packet to travel from source to the destination.
- **Throughput:** It is defined as the total volume of the data that has been successfully transformed over time.
- **Jitter:** It is measured as the variation in the packet delay (it is crucial for multimedia).

7. Conclusion and Future Research Work

This research work elaborated about and the working of the MANET which is wireless, self-configurable, and highly dynamic network. Unlike other wired networks, MANET is completely wireless, that means it doesn't rely on a fixed infrastructure and it is highly independent. As it is the network of dynamic and mobile network nodes, though here every node performs dual functions of being host and router simultaneously. Hence, MANET is the network that performs both peer to peer communication through dynamic, multi hop pathways. This research highlights significant challenges of MANETs that needs to be addressed in order to make network more reliable and robust. The dynamic movement of the nodes leads network link breaks between the nodes, chances of packet loss, extra energy consumption due to the re-routing and re-path building, as well as the high congestion along with the chances of route overhead. Further research required on the mentioned challenges like limited battery life, constrained wireless bandwidth, high congestion, instability of the network due to the node movement.

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