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A Meta- Analysis on Mobile Ad-Hoc Networks (MANET) Performance Issues

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Abstract
With the advancement of technology and wireless communications, Mobile Ad-hoc Networks (MANETs) have increasingly been the subject of investigation for researches. Mobile Ad Hoc Networks (MANETs) has become one of the most prevalent areas of research in the recent years because of the challenges it pose to the related protocols. "MANET is the new emerging technology which enables users to communicate without any physical infrastructure regardless of their geographical location, that's why it is sometimes referred to as an ―infrastructure less network" [1]. "A mobile ad hoc network is an autonomous collection of mobile devices (laptops, smart phones, sensors, etc.) that communicate with each other over wireless links and cooperate in a distributed manner in order to provide the necessary network functionality in the absence of a fixed infrastructure" [2]. The purpose of this study is to assess some performance issues and challenges of mobile ad-hoc networks on a given set of metrics and protocols. The output of which is a MANET paradigm as a result of the performance evaluation under given circumstances. A paradigm was developed based on previous studies under similar subject matter.
Keywords: Mobile Ad-hoc Network, metric, protocols, paradigm

Introduction

The advancement of technology along the area of computing, telecommunications and broadcasting through the years have led to the increasingly widespread usage and application of wireless technology. "Mobile ad-hoc networks, also known as short-lived networks, are autonomous systems of mobile nodes forming network in the absence of any centralized support. These are collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure"[3] .
"The set of applications for MANETs is diverse, ranging from largescale, mobile, highly dynamic networks, to small, static networks that are constrained by power sources. Besides the legacy applications that move from traditional infrastructure environment into the ad hoc context, a great deal of new services can and will be generated for the new environment. MANET is more vulnerable than wired network due to mobile nodes, threats from compromised nodes inside the network, limited physical security, dynamic topology, scalability and lack of centralized management because of these vulnerabilities, MANET is more prone to malicious attacks" [4].
The purpose of this study was to assess some performance issues and challenges of mobile ad-hoc networks. The output of which is a MANET paradigm as a result of the performance evaluation under given circumstances. A paradigm was developed which will be based on previous studies under similar subject matter.

Related Literature

A mobile ad hoc network (MANET), sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links [5].

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger Internet.

The growth of laptops and 802.11/Wi-Fi wireless networking have made MANETs a popular research topic since the mid- to late 1990s. Many academic papers evaluate protocols and abilities assuming varying degrees of mobility within a bounded space, usually with all nodes within a few hops of each other and usually with nodes sending data at a constant rate. Different protocols are then evaluated based on the packet drop rate, the overhead introduced by the routing protocol, and other measures [6].

Minimal configuration and quick deployment make ad hoc networks suitable for emergency situations like natural disasters or military conflicts. The presence of dynamic and adaptive routing protocols enables ad hoc

networks to be formed quickly. Wireless ad hoc networks can be further classified by their application: mobile ad hoc networks (MANET) [7].

In the study conducted by Sergio Marti, T.J. Guili, Kevin Lai, Mary Baker (2010), their research described two techniques that will improve throughput in an ad hoc network in the presence of nodes that agree to forward packets but fail to do so. To mitigate this problem, the researchers proposed to categorize nodes based upon their dynamically measured behavior. They utilized a watchdog that identifies misbehaving nodes and a path-rater that helps routing protocols avoid these nodes. Through simulation, they evaluated watchdog and path-rater using packet throughput, percentage of overhead (routing) transmissions, and the accuracy of misbehaving node detection. [8].

In another study done by YC Tseng, SY Ni, YS Chen, JP Sheu (2002), they wrote: "broadcasting is a common operation in a network to resolve many issues. In a mobile ad hoc network (MANET) in particular, due to host mobility, such operations are expected to be executed more frequently (such as finding a route to a particular host, paging a particular host, and sending an alarm signal) [9].
According to P. Papadimitratos and Z. J. Haas (2002), the emergence of the Mobile Ad Hoc Networking (*MANET*) technology advocates self-organized wireless interconnection of communication devices that would either extend or operate in concert with the wired networking infrastructure or, possibly, evolve to autonomous networks. In either case, the proliferation of MANET-based applications depends on a multitude of factors, with trustworthiness being one of the primary challenges to be met.
Despite the existence of well-known security mechanisms, additional vulnerabilities and features pertinent to this new networking paradigm might render such traditional solutions inapplicable. In particular, the absence of a central authorization facility in an open and distributed communication environment is a major challenge, especially due to the need for cooperative network operation. In particular, in *MANET*, any node may compromise the routing protocol functionality by disrupting the route discovery process [10].

Methodology

This study made use of two (2) approaches. First, the descriptive approach will be used in the discussion of the features, characteristics and applications of Mobile ad-Hoc Networks.
Secondly, the **Classic or Glassian Meta-Analysis Approach** with which the statement of the problem or questions to be examined were defined. Collection of studies will be done, and the researcher will identify the study features and outcomes, and will analyze the relations between study features and outcomes.

The Meta-Analysis processes and procedures will be presented by the researcher in a tabular form based on the previous researches done by selected researchers along the area of Performance of Mobile Ad-Hoc Networks.

The parameters to consider in the identification of performance issues will be on: Network Load, Throughput and End-to-end delay. Each of the gathered researches will be presented side-by-side with the factors mentioned presenting the issues and challenges generated. Based on the consolidated information, a paradigm will be developed as a reference for the performance evaluation of MANETs.

Findings

MANETs Characteristics

1) Distributed operation: There is no background network for the central control of the network operations, the control of the network is distributed among the nodes. The nodes involved in a MANET should cooperate with each other and communicate among themselves and each node acts as a relay as needed, to implement specific functions such as routing and security.

2) Multi-hop routing: When a node tries to send information to other nodes which is out of its communication range, the packet should be forwarded via one or more intermediate nodes.

3) Autonomous terminal: In MANET, each mobile node is an independent node, which could function as both a host and a router.

4) Dynamic topology: Nodes are free to move arbitrarily with different speeds; thus, the network topology may change randomly and at unpredictable time. The nodes in the MANET dynamically establish routing among themselves as they travel around, establishing their own network.

5) Light-weight terminals: In maximum cases, the nodes at MANET are mobile with less CPU capability, low power storage and small memory size.

6) Shared Physical Medium: The wireless communication medium is accessible to any entity with the appropriate equipment and adequate resources. Accordingly, access to the channel cannot be restricted.

MANETs Applications

Some of the typical applications include:

1) Military battlefield: Ad-Hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarter.

2) Collaborative work: For some business environments, the need for collaborative computing might be more important outside office environments than inside and where people do need to have outside meetings to cooperate and exchange information on a given project.

3) Local level: Ad-Hoc networks can autonomously link an instant and temporary multimedia network using notebook computers to spread and share information among participants at a e.g. conference or classroom. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information.

4) Personal area network and Bluetooth: A personal area network is a short range, localized network where nodes are usually associated with a given person. Short-range MANET such as Bluetooth can simplify the inter communication between various mobile devices such as a laptop, and a mobile phone.

5) Commercial Sector: Ad hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed [11].

Criteria/metrics used in the performance assessment of MANETs

Network Load

It is the total load measured in bits/sec, which all higher layers put forward on the WLAN layers in network. It represents the effectiveness of routing protocols when the packets are being received. When there is rush of traffic on the network and it is not easy to manage this is referred as network load. For the best performance it is the quality of network to handle all the traffic in smooth manners so that the deadlock may not occur.

Throughput

Throughput is the ratio of total amounts of data that reaches the receiver from the source to the time taken by the receiver to receive the last packet. It is represented in packets per second or bits per second. In the MANET unreliable communication, limited energy, limited bandwidth and frequent topology change affect throughput.

End-to-End Delay

The average time taken by the packets to pass through the network is called end-to-end delay. This is the time when a sender generates the packet and it is received by the application layer of destination, it is represented in seconds. This is the whole time that includes all delay of network such as transmission time, buffer queues, MAC control exchanges and delay produced by routing activities. Different applications require different packet delay levels. Low average delay is required in the network of delay sensitive applications like voice. MANET has the characteristics of packet transmissions due to weak signal strengths of nodes, connection make and break, and the node mobility. These are several reasons that increase the delay in the network. Therefore the end-to-end delay is the measure of how a routing protocol accepts the various constraints of network and show the reliability [12].

Performance Issues and Challenges

Performance Metrics	Performance issues of routing protocols [12]	MANET Routing Protocols Performance Evaluation [3]	Mobile Ad-Hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations [13]
Network Load	"When the network size is increased it does not affect the performance of DSR in both mobile and static ad-hoc networks which means that DSR outperforms AODV, OLSR and TORA. DSR is a source routing and has the characteristics of on-demand routing."	"AODV perform better when the number of nodes increases because nodes become more stationary will lead to more stable path from source to destination. DSDV and AODV performance dropped as number of nodes increase because more packets dropped due to link breaks. DSDV is better than AODV when the number of nodes increases."	"The highest amount of routing traffic is sent by the OSLR routing protocol then by TORA which is followed by AODV and lastly DSR. The reason for DSR, incurring less overhead is that, it sends the routing traffic only when it has data to transmit, which eliminate the need to send unnecessary routing traffic. AODV has routing overhead slightly higher than DSR because of multiple route replies to a single route request. The routing overhead for TORA is higher than AODV and DSR because of the periodic beacon and HELLO packets, which is sent on the network for route discovery. As OSLR constantly flood the network and routing traffic to keep its routing tables updated, it leads to highest amount of routing overhead as compared with other ad-hoc routing protocols."
End-to-end delay	"The end-to-end delay of OLSR has less as compared to AODV, DSR and TORA when the traffic load is high, which means that its performance is best in both static and mobility ad-hoc network. The increase in network size does not affect the performance of OLSR in both mobile and static ad-hoc networks. The reason is that OLSR is proactive routing protocol, which means that there are routing tables with each node, and the packets are not broadcasted by all nodes."	"A-AODV does not produce so much delay even the number of nodes increased. It is better than the other two protocols. The performance of DSDV is slightly better than AODV especially when the number of nodes cross 30. It shows that, the DSDV protocol has greater delay than AODV. This is mainly because of the stable routing table maintenance. A-AODV produces lower delay due to the fact that it uses flooding scheme in the route reply. Thus the delay is reduced to a greater extent."	"OSLR has the lowest delay as it is a proactive routing protocol which means that the routes in the network are always available whenever the application layer has traffic to transmit, periodic routing updates keep fresh routes available for the use. The absence of high-latency induced by the route discovery process in OSLR explains its relatively low delay with higher number of mobile nodes. In AODV hop-by-hop initiation helps to reduce the end-to-end delay. Although in the case of 50 nodes, the delay for AODV is higher at start but it reduces in the next stages until end of simulation. DSR uses cached routes and more often, it sends traffic to the stale routes which causes retransmission and leads to excessive delays. Delay for TORA is higher because of its route discovery process. It takes a lot of time discovering and deciding a route for data transfer. "
Throughput	"In the case of throughput OLSR attains high rate in both static and mobile ad-hoc networks. When the network size is increase is does not affect the performance of OLSR, which means that OLSR outperform the AODV, DSR and TORA. OLSR is reliable in terms of large-scale environment and	"DSDV is less prone to route stability compared to AODVwhen number of nodes increased. For A-AODV, the route stability is more so the throughput does not varied when number of nodes increases. DSDV protocol produces less throughputs when number of	"The amount of throughput in all cases is the highest for OSLR as compared with other protocols as routing paths are readily available for the data to be sent from source to destination. The amount of throughput for TORA is higher at start from AODV and DSR in case of 10 and 30 nodes but it fall below AODV throughput curve as the

	high-speed. The reason for high throughput of OLSR in comparison with other protocols is that, for OLSR routing path are easily available due to the characteristic of proactive routing protocols."	nodes are increased."	nodes start moving. AODV performs better in network with relatively high number of traffic sources and higher mobility. THE DSRs throughput is very low in the network in all the cases."

Performance Evaluation of MANETs: A Paradigm

The above narrative shows the results generated from the three studies having the same scope or area of investigation. With the presented data, some commonalities had been identified to come up with a paradigm that will represent the factors that contribute to the performance of MANET. Hence, below is the model that will show all the elements to be considered in conducting performance analysis.

Figure 2. MANET Performance Model

Conclusion

Having gone through the entire research process with specific scope and limitation, MANET performance can be measured through several factors such as architecture, metrics, protocols and tools. Considering these elements, a paradigm was developed encompassing these common factors.

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