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Research Article

Mobile Ad-hoc Network (MANET) Routing Protocol Comparison between Temporary Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR) – A Review

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A b s t r a c t

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The apparition of mobile ad-hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Such networks are envisioned to have dynamic, sometimes rapidly-changing, multihop topologies which most of the time are composed of relatively bandwidth-constrained wireless links. The mobile nodes are put together to form an ad-hoc network without the use of any centralised structure. It functions like a router in order to maintain connectivity in the network since there is no centralized infrastructure to establish communication. Meanwhile, collections of these mobile nodes are frequently broken due to lack of maintained infrastructure. Hence, the need for Routing Protocols that works at a low data rate and can dynamically adapt to the changing topologies. This paper presents a review of performance comparison between Temporary Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR) protocols to suggest a promising protocol that will overcome the limitations associated with MANETs. NS2 network simulator is used in the experiment over a LAN.

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1. Introduction

Mobile Ad-Hoc Networks (MANETs) are autonomous and decentralized wireless systems that changes locations and configure itself automatically. It is a collection of mobile nodes in which the wireless links are frequently broken down due to mobility and dynamic infrastructure. Hence, routing is a significant issue and challenge in ad hoc networks [1]. MANETs make use of wireless connections in order to connect with different networks [2, 3, 4]. This can either be a Wi-Fi or wireless connection, cellular or satellite transmission [5, 6]. Some MANETs are mostly within local area of wireless devices such as mobile devices, laptops, while sometimes requires internet connection. For instance, Vehicular Ad Hoc Network (VANET) as shown in Figure 1 is a typical example of MANET that allows tracking equipment's to communicate with vehicles, but is not directly connected to the Internet. However, the wireless roadside equipment sometimes is connected to the Internet, allowing data or information from the vehicles to be sent through the Internet [7, 8, 9]. The data gathered from vehicles may be used to measure the stat of traffic.

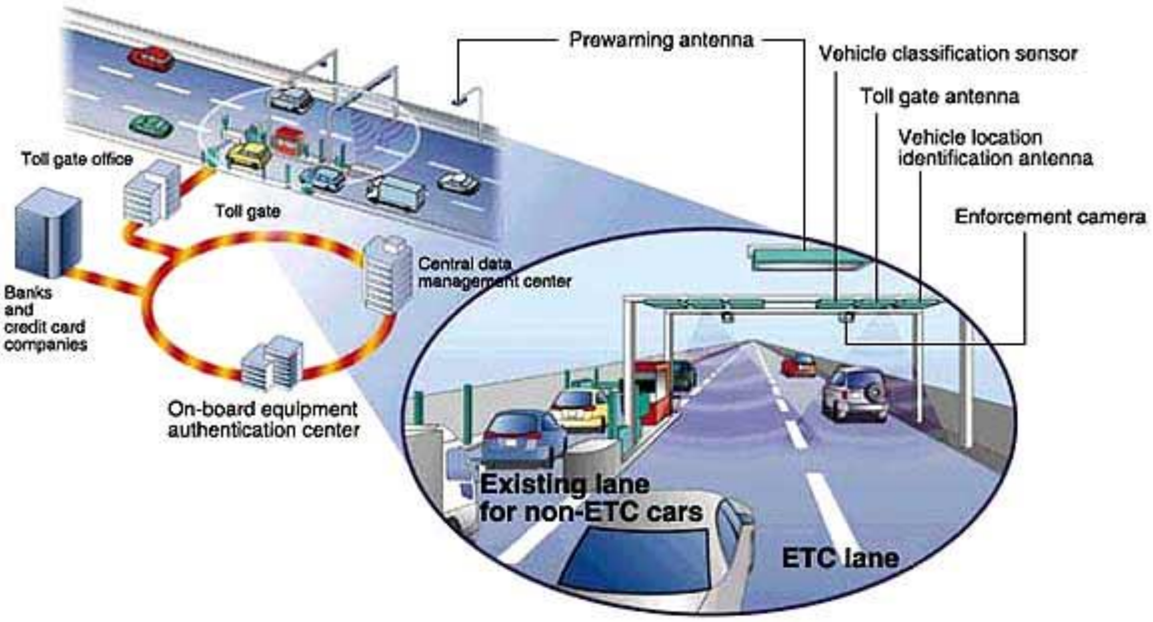


Fig.1: Vehicle Ad-hoc Network [10]

According to Barakovi & Barakovi [3], MANETs are made up of several components such as Internet, social networks, World Wide Web in addition to wireless mobile nodes that are capable of changing its ad-hoc network topology freely. This type of network allows devices and people to smoothly interwork in areas without any base station [11, 12, 13]. In MANET, the network system can join and leave at any point in time.

Figure 2, explained MANET in two different forms using mobile devices and mobile host connected together to establish a network.

Fig.2: Example of host and mobile devices connected together [14]

This type of network is either on peer-to-peer or remote access communication that establishes connection without the use of a base station. They can be deployed where there is no wireless infrastructure present and can act as an extension to existing networks. Additionally, they are cost effective and possess dynamic network topology due to its mobile nodes. However, challenges of MANETs include: mobility and bandwidth constraints, data lost, route acquisition delay and routing overhead, inability to deliver packets on time and finding shortest available path [15].

Moreover, the dynamic nature of MANETs are security challenged as the data sent over them may be at high risk. Users may need to be cautious of the kind of data sent over them [16, 17, 18]. In MANETs, assembling or routes integration is complex and challenging, as a result communication within the routes changes every time causing the links to be updated frequently and messages sent over and over again thereby constituting traffic [19, 20]. Hence the need for a dynamic routing protocol to overcome these limitations associated with MANETs.

2.0 Routing Protocols for MANET;

Many Routing protocols have been proposed so far to improve the routing performance and reliability**.** Presented below are the characteristics of some of them.

2.1 Reactive Routing Protocols: Reactive MANET protocol has proven to be the best protocol for networks having high node mobility, where data are transmitted to the nodes frequently. In this protocol when need arise to send data, it finds its route to the destination node. However, the source node starts by transmitting the route request throughout the network, after which the sender waits for the destination node routes to reply with a list of intermediate. This is said to be global flood search. This method of flooding brings delay before the packet is transmitted. It also requires the transmission of the significant amount of control traffic. Dynamic Source Routing (DSR) is a typical example of reactive protocol [19, 20].

2.1.1 Dynamic Source Routing (DSR):

DSR uses the method of source routing, it is a wireless mesh networks routing protocol where the sender knows the route to the destination stored in route cache, because the data packets carries the source route in the packet header. DSR reduces the rate at which bandwidth is used once the mobility is low. It is an efficient and simple routing protocol that is used in ad-hoc networks as a result of its route maintenance and discovery. When a node in the ad-hoc network sends packet to a destination and does not know the route, it dynamically determine the route using route discovery process which has to do with flooding the entire network with Route Request (RREQ) packets Figure 3 shows a route recovery in DSR. Each of the nodes receives a RREQ and rebroadcasts it as shown in Figure 4 until it reaches the destination or reach a node that has a route stored in its cache. Once the request reaches the destination, the node replies the route request with a Route Reply (RREP) packet which will be routed back to the sender. RREP and RREQ packets are also source routed. The RREQ travels so fast and also builds up the path. The RREP are then forwarded back to the source by traveling through the same path backwards. The route which is used to send back the RREP packet is stored for future purposes. Meanwhile, if a source route link is broken, the Route Error (RERR) packet is used to notify the source node and make adjustment to the routes by removing the link from its cache and initiate a new route discovery. DSR can aggressively uses route caching and source routing.

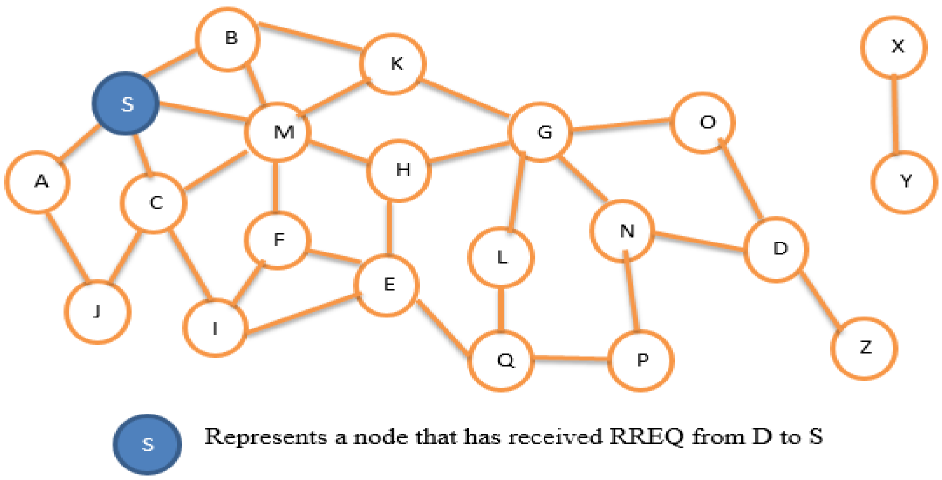


Fig.3: Represents route discovery in DSR

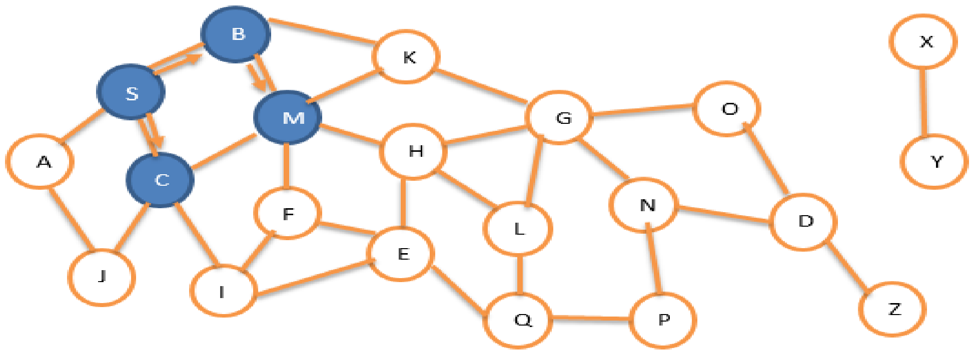


Fig.4: Represents transmission of router request (RREQ)

- Nodes L and N both broadcast RREQ to node G as shown in Figure 5.
- Since node L and N are hidden from each other, their transmission may collide
- However, Z, X, and Y does not receive the RREQ because they are not in range.

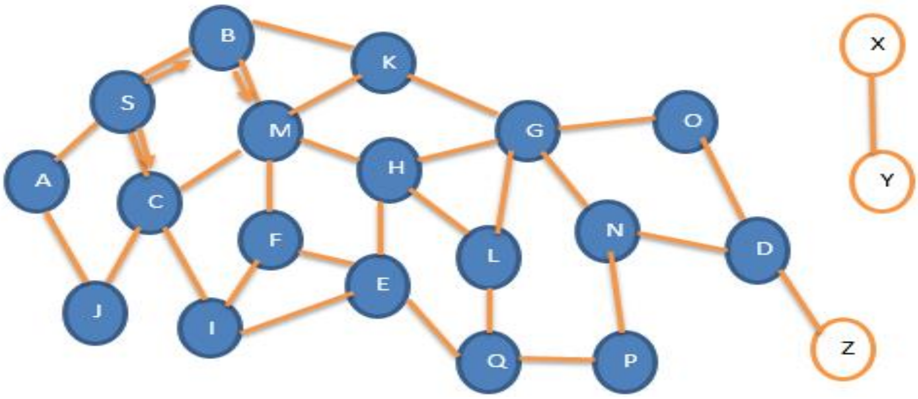


Fig.5: Diagram represent distributing of RREQ

2.2 Proactive Routing Protocols: These are a table driven protocols that actively determines the layout of the network. It determines a regular exchange of the packets in the network topology between the nodes in the network. The purpose of this is to maintained network at each node. Meanwhile, PRP use to experience a little delay in determining the route to be taken, which may pose a great challenge especially for time critical traffic [21].

Nevertheless, in proactive MANET protocol, the time at which the link establishes connection or the life span of a link is mostly short. This method is brought about essentially to overcome the problem of increased mobile nodes, which can render the information in the routing table invalid quickly. Thus proactive MANET is most appropriate and works perfectly in networks where the nodes transmit data frequently or having low mobility [22].

2.3 Hybrid Protocol: As the name implies, hybrid protocol integrates two or more protocols. It is developed to find a balance between the reactive and the proactive routing protocols, since both protocols work best in opposite different cases [23, 24]. The main reason of hybridizing these routing protocols is to use reactive routing mechanisms at certain level in part of the network where it work best and reactive routing protocol to be used where it is best fit in the network. The proactive operations are active and function in a small domain or area to reduce the delays and control overhead. The reactive routing protocol is used to locate nodes outside the domain, which is more band-width efficient in a network that changes frequently. Temporary Ordered Routing Algorithm is an example of hybrid routing protocols [25].

2.3.1 Temporary Ordered Routing Algorithm (TORA): is a hybrid routing protocol that combines reactive and pro-active routing protocol with efficient, highly adaptive and scalable distributed routing algorithm that is-based on link reversal concept. This is proposed for multi-hop wireless networks and highly dynamic mobile. It is a source initiated on demand routing protocol, TORA finds the routes from source node to the destination node through different routes. In order to achieve this, the nodes in the network maintain the routing information of the adjacent nodes. The functions of this protocol are basically route erasing, route creation and route maintenance. TORA have no limit in the convergence time in worst-case scenarios, they maintain multiple routes to the destination. With this, once a route change or route error occurs it does not have any effect but only react when the entire routes to the destination are lost. This form of routing protocol detects the partition and erases all the invalid routes in term of network partitioning [26].

3.0 Performance Evaluation of DSR and TORA. Table 1 explicates the characteristics of TORA and DSR in several forms [27, 28, 29, 30, 31, 32, 33].

Table 1: Differences between TORA and DSR

Dynamic Source Routing (DSR)	**Temporary Ordered Routing Algorithm (TORA)**
DSR is part of the reactive protocols	It's a hybrid protocol
Uses source routing	Distributed execution
Provides loop-free routes	Loop-free routing.
Supports unidirectional links and asymmetric routes	Multi-path routing.
With the optimizations that is available it is a good choice	TORA uses an excellent approach in hop-by-hop routing to guide every packet to its destination
The amount of throughput in DSR is very low.	The amount of throughput for TORA is higher
DSR permits nodes to find out a route network dynamically.	The routing portion of the protocol is performed by TORA but still depends on other functions on the internet MANET encapsulation protocol (IMEP)
DSR routing protocol is perfect for proxy enable node.	TORA routing protocol is perfect for proxy enabled node as well.

Table 2: Simulation Parameter

Parameters	**Values**
Software	NS-2
Protocols	TORA, DSR
Traffic Source	Constant Bit Rate (CBR)
Simulation Time	900s
Number of Nodes	10, 20, 30, 40
Simulation Area	1500 m x 3000 m
Speed Time	0-20 m / s
Pause Time	10 s

4.0 Performance Result

4.1. Performance Metrics

Three matrices are evaluated namely:

(a) ***Packet delivery fraction (PDF):*** PDF is the ratio of the data packets that is been delivered to the destination. Equation 4.1 depicts the packet delivery fraction of packet sent.

$\sum$ (Number of packet received) / $\sum$ (Number of connections) *(4.1)*

(b) ***Packet end-to-end delay;*** is the amount of time that a packets travel within the network, that is the time it takes from the sender to the receiver which are mostly expressed within some seconds including the delays in the network. The time it takes to transmit, buffer queues, MAC control exchanges and delays induced by routing activities. Equation 4.2 show the packet end-to-end delay fraction

$\sum$ (Arrive time – Send time) / $\sum$ (Number of connections) *(4.2)*

The lower the value of the end to end delay the better the performance of the protocol.

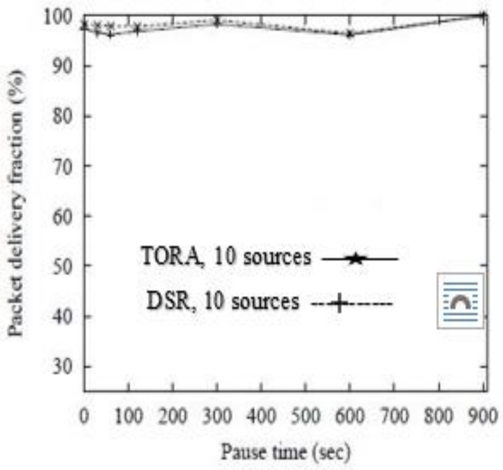
(c**)** ***Normalization Routing Load****;* which is the number of routing packets per data packets that is delivered at the destination.

4.2 Experimental Results and Observations

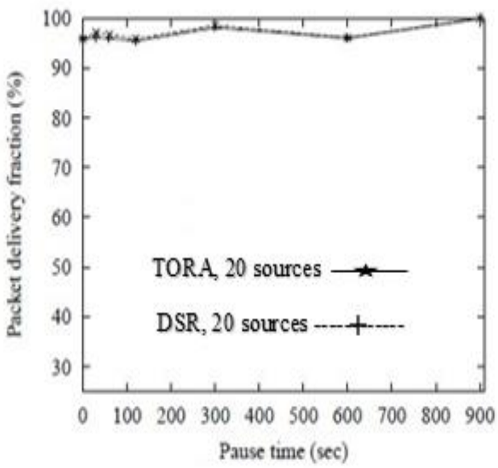
In the simulation experiment, researchers verify mobility and numbers of sources in the network. Several numbers of sources at different pause times were tested. At first 10, 20 and 30 traffic sources using packet rate of 4 packets/sec, while 40 traffic sources uses 3 packets/sec. It was noted that packet delivery fractions for TORA and DSR were very similar for 10 and 20 sources in Figure 6(a) and (b). With 30 and 40 sources, TORA outperforms DSR were very similar for 10 and 20 sources in Figure 6(a) and (b). With 30 and 40 sources, TORA outperforms DSR in Figure 6(c) and (d) except at a high pause times (low mobility). DSR loses about 31.50% packets than TORA for lower pause times (higher mobility).

DSR has lower routing load than TORA as shown in Figure 7a to d by a factor of 5-8, despite its delay and delivery performance get worse, the normalization routing load in TORA and DSR is constant with increasing number of sources.

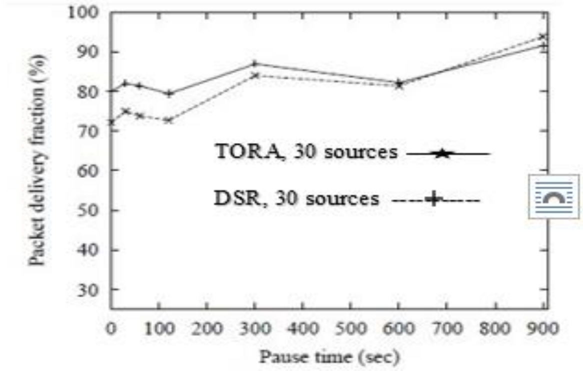
In terms of delay as illustrated in Figure 8a to c, TORA has the worse delay compare to DSR in 20 and 40 sources, it was noted that the more the sources the more the delay in TORA.



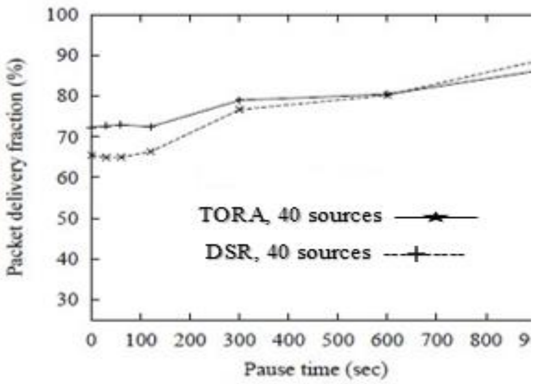
(a) 10 Sources



(b) 20 Sources

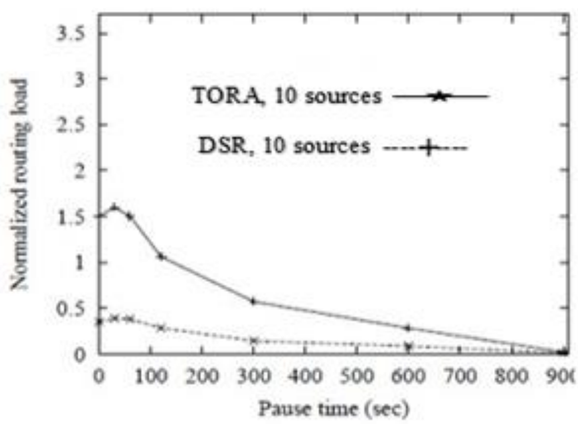


(c) 30 Sources

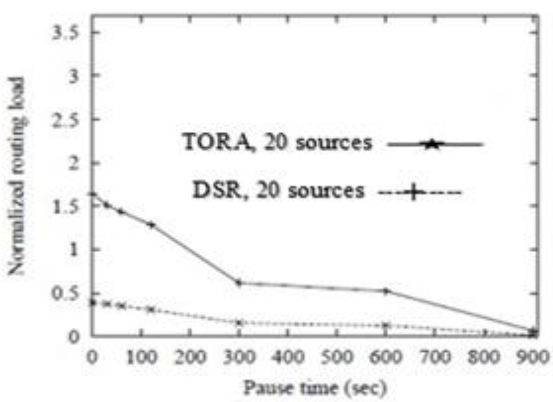


(d) 40 Sources

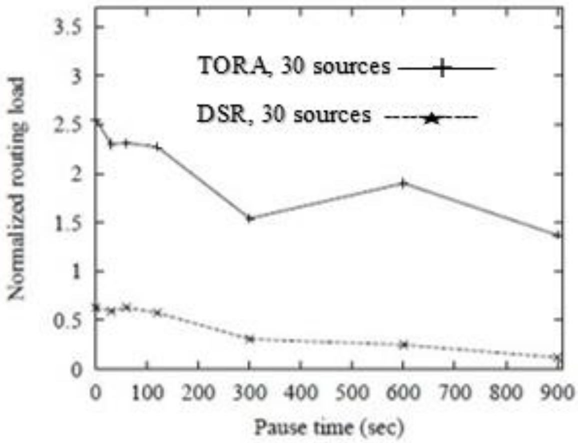
Fig.6: (a)-(d) Packet delivery fraction for 50 node model with several sources



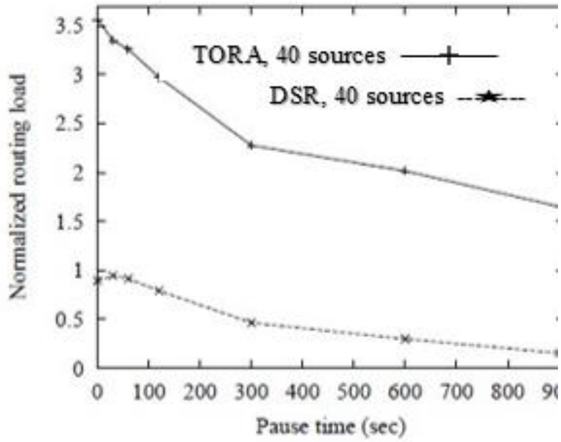
(a) 10 Sources



(b) 20 Sources

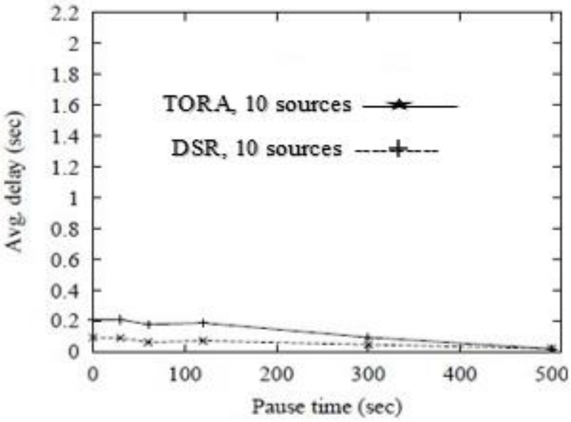


(c) 30 Sources

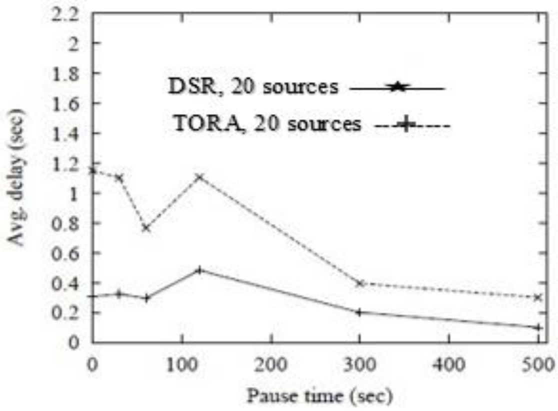


(d) 40 Sources

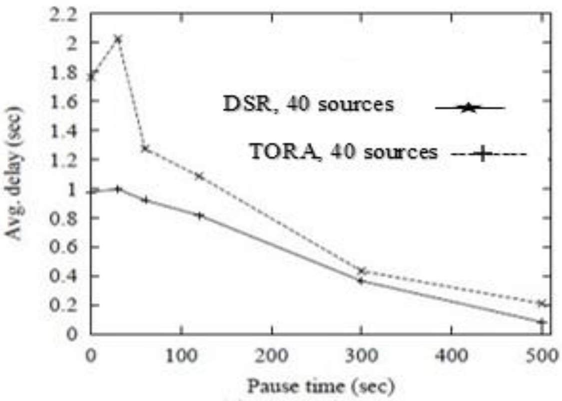
Fig.7: (a)-(d) Normalization routing load for 50 node model with several sources



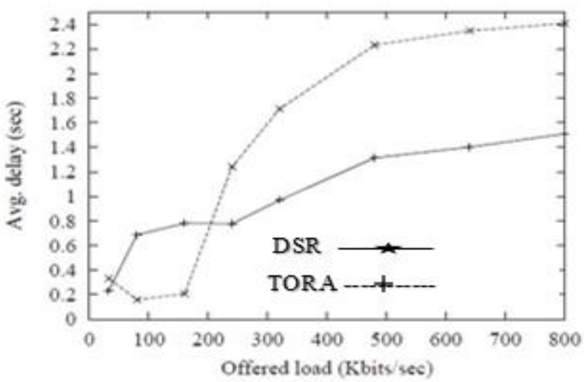
(a) 10 Sources



(b) 20 Sources



(c) 40 Sources



Average delay

Fig.8: (a)-(c) Average data packet delay for 50 nodes with several sources

During the course of simulation, it was noted that DSR uses cache route and most times send traffic to the routes that are not favourable and causes retransmission which leads to excessive delay while the delay in TORA is due to the process of discovering its route. DSR replies all the RREQ which makes it complex in determining the least congested route and has average path of 15% to 30% shorter than TORA.

Table 3: Rate of Performance (No of Node= 50, Mobility = 10ms, packet size=1600byte).

	Packet Sent	**Packet Received**	**PDF**	**End-to-End Delay**	**Normalization Routing Load**
DSR	417.00	410.00	78.00	253.00	0.20
TORA	753.00	748.00	99.40	131.00	-

5. Conclusion

The research paper focused evaluating TORA and DSR in order to suggest the best routing protocol to overcome the challenges associated with MANETs. The evaluation involves analyzing the end to end delay fraction, PDF by increasing their number of nodes, and normalizing routing loads in the simulation experiment. Performance characteristics on different scenarios of both Temporary Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR) protocol shows that DSR outperform TORA in term of loss of distance information, route acquisition delay and poor route construction. TORA spent long time waiting for new routes to be determined while; DSR Route Discovery was faster, therefore shows a better performance than TORA and also recorded a low pause time in high mobility. However, in terms of congestion control in high traffic, TORA outperforms DSR. Consequently, integration of TORA and DSR in MANETs will yield a better performance.

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