LAR VS DSR: EVALUATION OF AD HOC NETWORK PROTOCOLS IN PRACTICAL MANAGEMENT OF COMMUNICATION OF ROBOTS

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Abstract

Controlling and managing of robots and their information communication to each other is an important issue, and wireless technologies without infrastructure like Ad hoc networks due to their quick trigger and cost slightness can play efficiently. Various protocols have been used in this field and in the recent study, two famous Ad hoc network protocols have been simulated for 4 km^2 work areas with changes of the same elements in types of robots like speed, pause time, number of nodes, important parameters that show network optimization rate and include PDR, Throughput, End-To-End Delay by using simulation in GloMoSim software. In this research, for suitable protocols in every time, output has been calculated by making the same chance and then, obtained information was investigated statistically. In total, LAR protocol was recognized that had higher scores than DSR and could be used as an optimum protocol in robotic industries, technically.

***Keywords*:** GloMoSim, Ad Hock; LAR, DSR, PDR, MANET

1. Introduction

Today, robotic systems have influenced drastically different aspects of human life and we can see their footprints almost everywhere. Controlling robots or machines is one the most important issues which has been researched and investigated in robotic areas. Wireless controlling and robotic communication has great advantages like better maneuverability, lower cost, and faster preparation in different area. Moreover, by using wireless facilities, a network of robots can be acted in performing the given missions as a team and by setting the wireless connection between any of robots to each other, very novel capabilities can be obtained, practically. The robots are often equipped with low-cost, low-power short-range wireless network interfaces, which only permit direct communication with their close neighbors. Therefore, it is practically impossible for each node to know the entire network topology at any given time. Under these situations the only useful approach to distributed command, control and sensing is to employ an ad hoc wireless networking scheme [Winfield, (2000); Wang *et al.*, (2005)]. In the present study, two major ad hoc wireless networking protocols have been studied and compared with each other in a simulation program.

2. Literature Survey

A mobile ad hoc network (MANET) is one of the best choices to control robots. In this system a set of wireless nodes or routers coming together to form a network in which every node acts as a router [Yeshwanth, (2010)]. In fact, any hardware that could identify radio waves and enter the network, it is taken into account as a node. Design of ad hoc networks has been to set fast communications in military and spatial that information exchange and routing between nodes have been focused based on dynamic routing protocols, ad hoc protocols can be classified inside security and searcher protocols, widely [Basagni and Capone, (2007); Ilyas, (2003)]. Although mobility has many advantages, it also causes a number of disputes in ad hoc networks. For example, as nodes may be mobile, entering and leaving the network, the topology of the network will change constantly [Manickam *et al.*, (2011)]. To overcome such problems, routing protocols using several mobility metrics have been proposed [Yeshwanth, (2010)]. One unsolved subject in ad hoc network is to produce a routing protocol that has almost 100 percent optimal behavior in all unpredicted work conditions. More than ten ad hoc protocols have been introduced and investigated their performance and capabilities.

2.1. *Ad hoc Protocols*

In general ad hoc wireless networks, routing protocols could be divided to proactive, reactive, both proactive and reactive, or hierarchical routing protocols. Proactive protocols which are famous as table-driven routing preserves, fresh lists of destinations and their routes by intermittently distributing routing tables throughout the network. These protocols need each node to maintain one or more tables to store routing information, and they reply to changes in network topology by propagating updates throughout the network in order to preserve a consistent network view [Royer and Toh, (1999)]. In other words, any node has one or several routing tables (including node identifier and paths that lead to the same node) for all nodes in the network; and based on the type of protocol, a number of these tables are different and it has routed according to the same tables. In these such routings, storing the information of a network breadth, is a serious duty for nodes, when topology is mostly changed that are known as Protective Protocols [Reddy *et al.,* (2006); Al Agha *et al.,* (2009); Alotaibi and Mukherjee, (2012); Wu and Stojmenovic, (2004); Wang *et al.,* (2005)].

The second type of protocols is source-initiated on-demand routing. This type of routing generates routes only when desired by the source node. In fact, operation of discovery of route is only being done when a path is requested from a node toward destination node and only information is stored that is required for real paths. When a node needs a route to a destination, it initiates a route detection procedure within the network. This process is finalized once a route is found or all potential route permutations have been tested. Once a route has been recognized, it is maintained by a route maintenance process until either the destination develops inaccessible along every path from the source or until the route is no longer wanted. These paths are preferred since they can decrease induced cost of a network that are known as Reactive protocols [Elsonbaty *et al.,* (2009); Wang *et al.,* (2005); Witkowski *et al.,* (2008); Royer and Toh, (1999)]. The Dynamic Source Routing (DSR) protocol is based on the concept of source routing [Johnson and Maltz, (1996)]. Mobile nodes are required to maintain route caches that hold the source routes, of which the mobile is aware. DSR is similar to some other protocols, however, there are a couple of important differences. The greatest notable of these is that the overhead of DSR is potentially larger than that of some of protocols like Ad-hoc On-demand Distance Vector routing (AODV), since each DSR packet must transmit full routing information, whereas in AODV packets need only hold the destination address [Royer and Toh, (1999)]. The last protocol, which in the present study has been tested is Location-Aided Routing Protocol (LAR) which belongs to this class as well. LAR is a source routing protocol, as a DSR. Initially it starts flooding in all the directions from the source after expecting the destination the routing is so easy in a network that will be in the direction of the destination [Gupta, (2012); Das and Lobiyal, (2012); Radwan *et al.,* (2011)]. Routinely the LAR protocol uses the GPS (Global Positioning System) to get this locality information. With the accessibility of GPS, the mobile hosts know their physical position [Malany, (2009); Attada and Shetty S, (2013)].

Next class is hybrid protocols that have advantages both of proactive and reactive routing features of both protocols. A few hybrid routing protocols have been made, whereby the routing is first started with some proactive routes and then serves the demand from other nodes through the reactive flooding [Yeshwanth, (2010)]. In large ad hoc networks, proactive, reactive and hybrid protocols can be used simultaneously [Rahman *et al.,* (2010); Sharma and Singh, (2011); Zeiger *et al.,* (2008); Manickam *et al.,* (2011); Royer and Toh, (1999)]. Zone routing protocol (ZRP) and temporally ordered routing algorithm (TORA) are two typical routing protocols in this class [Yeshwanth, (2010)].

The last class is hierarchical routing protocols. The network's capability to provide an acceptable level of service to packets even in the existence of a great number of nodes in the network is known as scalability which is one of the major tribulations in ad hoc networking [Omari and Sumari, (2010)]. With this class of protocol the choice of proactive and of reactive routing based on the hierarchic level of an existing node. The routing is principally established with some proactively prospected routes and then services the demand from additionally driven nodes through reactive overflowing on the minor levels. The choice for one or the other technique requires proper ascription for respective levels [Omari and Sumari, (2010); Wu and Jiang, (2008)].

3. Methodology

In the present study, Global Mobile Information System Simulator (GloMoSim) 2.03, which is a network protocol simulator software and has been developed by UCLA was used [Samar and Wicker, (2004)]. GloMoSim has the capacity to simulate networks with up to a thousand nodes and supports multicast, multi-hop wireless communications using ad hoc networking, asymmetric communications using direct satellite broadcasts, and traditional Internet protocols [Zeng *et al.,* (1998); Mohapatra and Krishnamurthy, (2006)]. GloMoSim also has support for the random waypoint mobility model. Moreover, tools are provided for generating different types of data traffic [Yeshwanth, (2010)]. DSR and LAR protocol were simulated using GloMoSim and important parameters of network optimization including, Packet Delivery Ratio (PDR), Throughput, End To End Delay, were calculated based on changes of nodes number, movement speed of nodes, pause time of nodes in working area of 4 km^2 with array of scattering nodes as uniform in work time of 15 min and any diagram of Excel including, work curve of three protocols in the same chance conditions, was drawn, then meaningfulness of outputs difference were investigated by using SPSS 22 software by using one way repeated measures analysis of variance (ANOVA) followed by Tukey's range test as post hoc test. Differences between different protocols were considered significantly different when the P value was less than 0.05.

4. Experiment Result

Difference of testing protocols was shown in figures 1 to 9. As it is shown in Fig. 1 to 3, for End to End Delay factor, DSR protocol was significantly better than LAR protocol in this regard ($p<0.05$). Interestingly, by increasing node numbers from 150 and above, LAR showed similar outcomes like DSR protocol. Increasing pause time also could improve End to End delay of LAR protocol. By increasing max speed in this simulation test, End to End Delay factor increased drastically for LAR protocol.

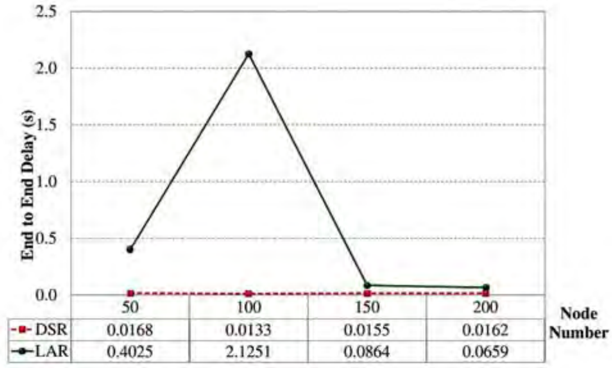


Fig. 1. Comparison of different protocols in End to End Delay based on node numbers

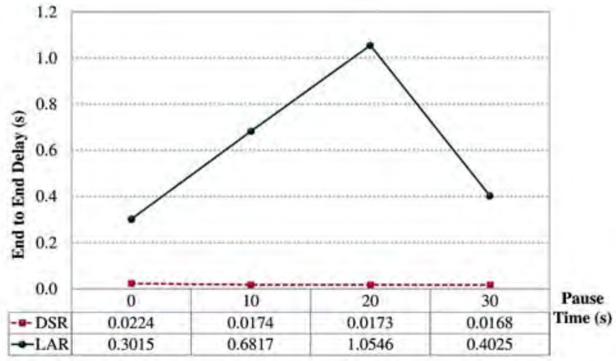


Fig. 2. Comparison of different protocols in End to End Delay based on pause time

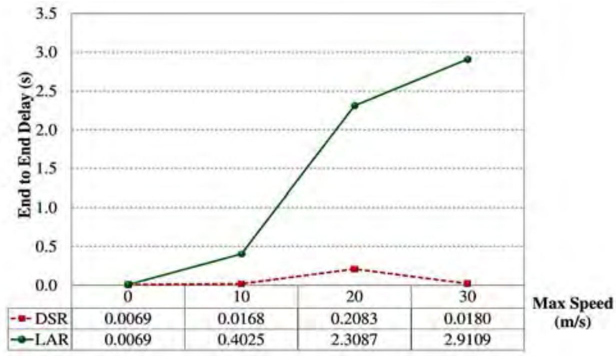
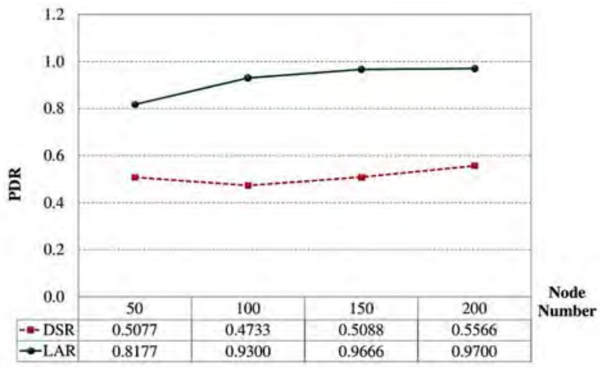


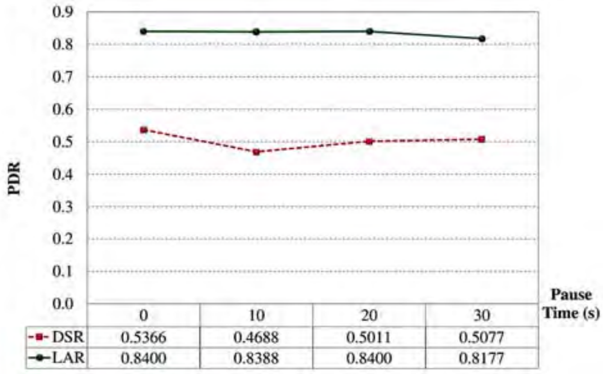
Fig. 3. Comparison of different protocols in End to End Delay based on max speed

As it is shown in Fig. 4 to 6, for PDR factor, LAR protocol had a significantly higher PDR than DSR protocol based on node numbers, pause time and max speed ($p<0.05$). Although increasing speed has a positive effect on PDR factor of the DSR protocol, still it was far behind LAR protocol in this regard ($p<0.05$).



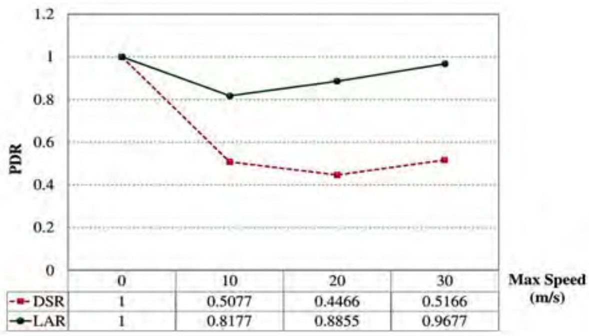
	50	100	150	200
DSR	0.5077	0.4733	0.5088	0.5566
LAR	0.8177	0.9300	0.9666	0.9700

Fig. 4. Comparison of different protocols in PDR based on node numbers



	0	10	20	30
DSR	0.5366	0.4688	0.5011	0.5077
LAR	0.8400	0.8388	0.8400	0.8177

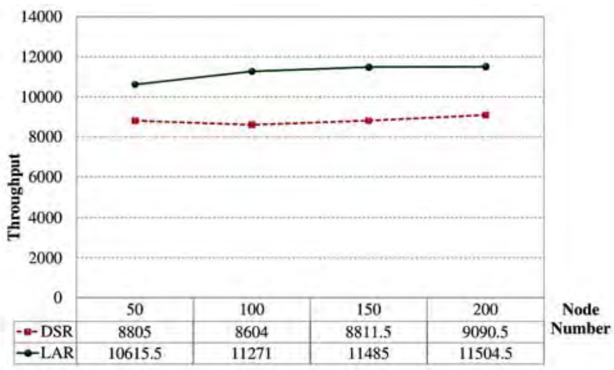
Fig. 5. Comparison of different protocols in PDR based on pause time



	0	10	20	30
DSR	1	0.5077	0.4466	0.5166
LAR	1	0.8177	0.8855	0.9677

Fig. 6. Comparison of different protocols in PDR based on max speed

Similar to PDR factor, as it is illustrated in Fig. 7 to 9, for throughput factor, LAR protocol had a significantly higher throughput than DSR protocol based on node numbers, pause time and max speed ($p<0.05$). Also based on the present study, increasing speed has a minor positive effect on throughput factor of DSR protocol.



	50	100	150	200
DSR	8805	8604	8811.5	9090.5
LAR	10615.5	11271	11485	11504.5

Fig. 7. Comparison of different protocols in throughput based on node numbers

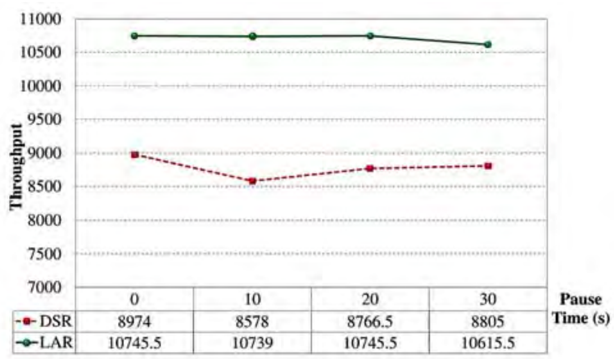


Fig. 8. Comparison of different protocols in throughput based on pause time

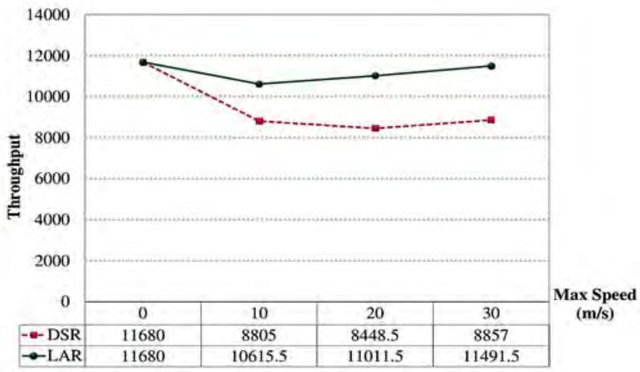


Fig. 9. Comparison of different protocols in throughput based on max speed

As Table 1 shows, End to End Delay rate in sending data in LAR protocol was significantly more than DSR protocols based on the pause time factor ($p<0.05$). Although in first glimpse, End to End delay of LAR protocol was significantly higher than DSR, LAR has shown better results in both PDR and throughput significantly ($p<0.05$).

Table 1 - Comparison of the mean and standard deviation of different protocols based on key elements of pause time changes on the network nodes

Factor	Mean±SD	
	DSR	LAR
End To End Delay	0.0185±0.0027 [a]	0.6101±0.3372 [b]
Throughput	8780.8750±162.5261[a]	10711.3750±63.9901[b]
PDR	0.5036±0.0278 [a]	0.8341±0.0110 [b]

[ab] Values with the different superscripts are significantly different at $p<0.05$ based on one way ANOVA, Tukey-B post hoc test.

As displayed in Table 2, End to End Delay has not shown a meaningful difference between tested protocols. Though in first view, values of DSR were less than LAR, due to high standard deviations, this difference has become meaningless.

Table 2 - Comparison of the mean and standard deviation of different protocols based on the variation of the number of nodes on the main elements of the network

Factor	Mean±SD	
	DSR	LAR
End To End Delay	0.0154±0.0015	0.6700±0.9823
Throughput	8827.7500±199.9027 [a]	11219.0000±416.0058 [b]
PDR	0.5116±0.0342 [a]	0.9211±0.0713 [b]

[ab] Values with the different superscripts are significantly different at $p<0.05$ based on one way ANOVA, Tukey-B post hoc test.

As Table 3 illustrates, the effect of changes in node speed on optimization elements of the network did not show a meaningful difference which was due to high fluctuations in tested elements ($p>0.05$). Though a meaningful difference was not seen, like two previous tests, LAR protocol has a better situation in Throughput and PDR, practically ($p<0.05$).

Table 3 - Comparison of the mean and standard deviation of different protocols based on key elements of speed changes on the network nodes

Factor	Mean±SD	
	DSR	LAR
End To End delay	0.0625±0.0973	1.4073±1.4194
Throughput	9447.6250±1499.2836	11199.6250±480.4665
PDR	0.6177±0.2567	0.9177±0.0823

5. Discussion and Conclusion

End-to-End delay means the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission as well as containing all possible delays affected during route discovery latency, propagation and transfer times, and retransmission delays at the MAC. Only successfully delivered data packets to destinations would be counted. Therefore, higher end-to-end delay indicates weakness of performance of the protocol due to network congestion. In the present study, DSR protocol showed significantly better performance than LAR. Number of nodes in this issue is an important factor and likewise previous studies [Das and Lobiyal, (2012); Arora and Rizvi, (2014)], the present study showed that by increasing the node numbers, LAR had similar results like DSR. Although few studies LAR have shown significantly lower End to End delay than DSR [Kumar and Kumar, (2013); Broustis *et al.*, (2006)], this difference might be due to number of testing nodes in different studies and overall, it also proves that increasing node numbers lead to decreasing End to End delay. The PDR displays how effective a protocol performs delivering packets from source to destination. It measures the loss rate as seen by transport protocols, and as such, it characterizes both the correctness and efficacy of ad hoc routing protocols [Manickam *et al.*, (2011)]. A high packet delivery ratio is desired in any network. The higher in the value give us better results. The result of the present study was supported with some of previous study [Kumar and Kumar, (2013); Mikki, (2009); Singh *et al.*, (2013)]. Throughput is given as the actual amount of data is being transmitted in a given time. Therefore, high throughput gives better performance for protocol. The present study showed significantly higher throughput of LAR protocol than DSR which was similar to previous studies [Parsendia and Sinhal, (2012); Singh *et al.*, (2013); Radwan *et al.*, (2011)]. Even increasing node numbers did not have significantly different positive effect of the DSR protocol, which also was similar to previous studies [Singh *et al.*, (2013)]. Therefore, LAR protocol is suitable for wireless robotic systems. Scalability and throughput are two very important factors for mobile ad-hoc network protocols, as it determines if a protocol will function or fail when the number of mobile users increases and also shows the performance of the ad hoc network [Arora and Rizvi, (2014)].

Surely, increasing movement speed of the robot, or in other words, more softness in movement of robot in response to commands in different conditions needs higher speed of the robot processor unit which improve efficiency of the network and help the performance of protocols. Even in this case, by increasing the speed of robot movement consequently network topology will change faster, which might cause errors in robot movement management. Moreover, possible breaking connection links due to robots breakdown by a crash with objects will increase End to End Delay in sending data, decrease throughput, decrease PDR, and hence increase network scoria and decrease network efficiency. To prevent such crises choosing correct network protocols will be very effective in managing them. Even though, on simulation basis, it was concluded that the LAR routing protocol gives the best performance compare to DSR routing protocol, unfortunately, no one solution fits all criteria of an ideal protocol. Study on both massive number nodes as well as little number nodes with different protocols and new algorithm which can decrease errors and improve the simulation test is recommended.

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References

[1] Al Agha, K. et al. (2009) Which Wireless Technology for Industrial Wireless Sensor Networks? The Development of OCARI Technology. IEEE Transactions on Industrial Electronics. 56 (10), 4266–4278.

[2] Alotaibi, E. & Mukherjee, B. (2012) A survey on routing algorithms for wireless Ad-Hoc and mesh networks. Computer Networks. 56 (2), 940–965.

[3] Arora, R. & Rizvi, N. F. (2014) A Behavioral Comparison of LAR with AODV And DSR Routing Protocols. International Journal of Innovative Research in Computer and Communication Engineering. 2 (1), 2558–2563.

[4] Attada, V. & Shetty S, P. (2013) Performance Evaluation of DSR and LAR Routing Protocols with MAC Layer in MANET ' s. International Journal of Computer Science and Mobile Computing. 2 (11), 277–284.

[5] Basagni, S. & Capone, A. (2007) Recent research directions in wireless ad hoc networking. Ad Hoc Networks. 5 (8), 1205–1207.

[6] Broustis, loannis et al. (2006) 'A Comprehensive Comparison of Routing Protocols for Large-Scale Wireless MANETs', in 2006 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks. pp. 951–956.

[7] Das, S. & Lobiyal, D. K. (2012) A Performance Analysis of LAR Protocol for Vehicular Ad Hoc Networks in City Scenarios. CoRR. abs/1210.3.

[8] Elsonbaty, A. et al. (2009) A Cooperative Multi-Robot Control Using Ad Hoc Wireless Network. World Academy of Science, Engineering and Technology. 992–999.

[9] Gupta, N. (2012) Optimization of Performance Metrics of LAR In Ad-Hoc Network. International Journal of Wireless & Mobile Networks. 4 (3), 87–103.

[10] Ilyas, M. (2003) The Handbook of Ad Hoc Wireless Networks. 1st edition. CRC Press.

[11] Johnson, D. B. & Maltz, D. A. (1996) 'Dynamic Source Routing in Ad Hoc Wireless Networks', in Tomasz Imielinski & Henry F. Korth (eds.) Mobile Computing. The Kluwer International Series in Engineering and Computer Science. Boston, MA: Springer US. pp. 153–181.

[12] Kumar, P. & Kumar, A. (2013) Simulation Based Analysis of DSR, LAR and DREAM Routing Protocol for Mobile Ad hoc Networks. MIT International Journal of Computer Science & Information Technology. 3 (2), 58–62.

[13] Malany, A. (2009) Throughput and Delay Comparison of MANET Routing Protocols. Int. J. Open Problems Compt. Math. 2 (3), 461–468.

[14] Manickam, P. et al. (2011) Performance Comparisons of Routing Protocols in Mobile Ad Hoc Networks. International Journal of Wireless & Mobile Networks. [Online] 3 (1), 98–106.

[15] Mikki, M. A. (2009) Energy Efficient Location Aided Routing Protocol for Wireless MANETs. International Journal of Computer Science and Information Security. 4 (1), .

[16] Mohapatra, P. & Krishnamurthy, S. (2006) AD HOC NETWORKS: Technologies and Protocols.

[17] Omari, S. A. K. A. & Sumari, P. (2010) An Overview of Mobile Ad Hoc Networks for the Existing Protocols and Applications. International Journal on Applications of Graph Theory In wireless Ad Hoc Networks And sensor Networks. 2 (1), 87–110.

[18] Parsendia, N. & Sinhal, A. (2012) Comparative Analysis of Throughput and Dropped rate for Location-Aided Routing Protocol. International Journal of Computer Science and Information Technologies. 3 (3), 4113–4118.

[19] Radwan, A. et al. (2011) Performance Measurement of Some Mobile Ad Hoc Network Routing Protocols. International Journal of Computer Science Issues. 8 (1), 107–112.

[20] Rahman, M. A. et al. (2010) 'A simulation based performance comparison of routing protocol on Mobile Ad-hoc Network (proactive, reactive and hybrid)', in International Conference on Computer and Communication Engineering (ICCCE'10). May 2010 IEEE. pp. 1–5.

[21] Reddy, T. B. et al. (2006) Quality of service provisioning in ad hoc wireless networks: a survey of issues and solutions. Ad Hoc Networks. [Online] 4 (1), 83–124.

[22] Royer, E. M. & Toh, C.-K. (1999) A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks. IEEE Personal Communications. (April), 46–55.

[23] Samar, P. & Wicker, S. B. (2004) 'On the behavior of communication links of a node in a multi-hop mobile environment', in Proceedings of the 5th ACM international symposium on Mobile ad hoc networking and computing - MobiHoc '04. 2004 New York, New York, USA: ACM Press. p. 145.

[24] Sharma, M. & Singh, G. (2011) Evaluation of Proactive , Reactive and Hybrid Ad hoc Routing Protocol for various Battery models in VANET using Qualnet. International Journal of Smart Sensors and Ad Hoc Network. 9738 (2248), 65–69.

[25] Singh, S. et al. (2013) A Modified Location Aware Routing Algorithm for MANET. International Journal of Software and Web Sciences. 12 (372), 89–99.

[26] Wang, Z. et al. (2005) Protocols and Applications of Ad-hoc Robot Wireless Communication Networks : An Overview. INTERNATIONAL JOURNAL OF INTELLIGENT CONTROL AND SYSTEMS. 10 (4), 296–303.

[27] Winfield, A. F. (2000) 'Distributed Sensing and Data Collection Via Broken Ad Hoc Wireless Connected Networks of Mobile Robots', in Lynne E. Parker et al. (eds.) Distributed Autonomous Robotic Systems 4. Tokyo: Springer Japan. pp. 273–282.

[28] Witkowski, U. et al. (2008) 'Ad-hoc network communication infrastructure for multi-robot systems in disaster scenarios', in IARP/EURON Workshop on Robotics for Risky Interventions and Environmental Surveillance. 2008

[29] Wu, J. & Jiang, Z. (2008) 'A hierarchical structure based coverage repair in wireless sensor networks', in 2008 IEEE 19th International Symposium on Personal, Indoor and Mobile Radio Communications. [Online]. September 2008 IEEE. pp. 1–6.

[30] Wu, J. & Stojmenovic, I. (2004) Ad Hoc Networks. Ad Hoc Networks. (February), 29–31.

[31] Yeshwanth, M. (2010) Enhanced AODV (EN-AODV) in ad hoc networks. Wichita State University.

[32] Zeiger, F. et al. (2008) Challenges in Realizing Ad-Hoc Networks based on Wireless LAN with Mobile Robots. Proceedings of the 6th Intl Symposium on Modeling and Optimization.

[33] Zeng, X. et al. (1998) 'GloMoSim: a library for parallel simulation of large-scale wireless networks', in Proceedings. 12th Workshop on Parallel and Distributed Simulation. EEE Comput. Soc. pp. 154–161.

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