International Journal Of Advanced Research In Engineering Technology & Sciences
ISSN: 2394-2819
May- 2015 Volume 2, Issue-5
Email: editor@ijarets.org www.ijarets.org

A Comparative Study of Various Routing Protocols for Wireless Mobile Adhoc Network

Ankur Rana
Assistant Professor
Quantum School of Technology
Roorkee, INDIA

Kamal Kant Verma
Assistant Professor
Quantum School of Technology
Roorkee, INDIA

Satender Kumar
Sr. Assistant Professor
Quantum School of Technology
Roorkee, INDIA

ABSTRACT:
A mobile Ad Hoc network is a collection of wireless mobile hosts which form a temporary network without any centralized administration, in which individual nodes communicate by forwarding packets to each other. MANET is a temporary network which is used for performing specific task in certain time period. There are various issues in MANET. An important and essential issue for mobile ad hoc networks is routing protocol design that is a major technical challenge due to the dynamic nature of the network. During the last few years, active research work resulted in a variety of proposals. This paper presents a state-of-the-art review and a comparison for typical representatives of routing protocols designed for mobile ad hoc networks. The paper aims at providing criteria according to which the protocols can be compared and classified.

KEYWORDS – MANET, Routing algorithms, Ad-hoc network etc.

INTRODUCTION TO MOBILE ADHOC NETWORK:

Mobile ad hoc network is collections of wireless nodes that can allow people and devices to communicate with each other without help of an existing infrastructure, e.g., disaster recovery environments. All nodes are capable of movement and can be connected dynamically in any random manner. The nodes itself is responsible for organizing, controlling and managing the entire network. The entire network is mobile, and the individual terminals are allowed to move at their will relative to each other. In this type of network, some pairs of terminals may not be able to communicate directly to with each other and relaying of some messages is required so that they are delivered to their destinations. The nodes of these networks also function as routers, which discover and maintain routes to other nodes in the networks. The nodes may be located in or on airplanes, ships, and trucks, cars, perhaps even on people or very small services. Effective routing has become an issue of significant concern in MANET. There for choosing an effective and efficient routing protocol for MANET is a crucial factor which must be always taken to be consideration.

LIMITATIONOF ROUTING PROTOCOLS:

Routing is a fundamental issue for networks. A lot of routing algorithms have been proposed for wired networks and some of them have been widely used. Dynamic routing approaches are prevalent in wired networks. Distance Vector routing [31] and Link State routing [31] are two of the most popular dynamic routing algorithms used in wired networks. Distance Vector routing protocols are based on the Bellman-

IJARETS

Ford routing algorithm. In Distance Vector routing, every router maintains a routing table (i.e. vector), in which it stores the distance information to all reachable destinations. A router exchanges distance Information with its neighbors periodically to update its routing table. In Link State routing algorithm,each node periodically notifies its current status of links to all routers in the network. Whenever a link state change occurs, the respective notifications will be flooded throughout the whole network. After receiving the notifications, all routers re-compute their routes according to the fresh topology information. In mobile ad hoc networks, when using a Distance Vector routing or Link State based routing protocol designed for wired networks, frequent topology changes will greatly increase the control overhead. Distance Vector and Link State routing algorithms will cause routing information inconsistency and route loops when used for dynamic networks.

CHARACTERISTICS OF ROUTING PROTOCOLS:

To compare and analyze mobile ad hoc network routing protocols, appropriate classification methods are important. Classification methods help researchers and designers to understand distinct characteristics of a routing protocol and find its relationship with others. Therefore, we present protocol characteristics which are used to group and compare different approaches.

A. Proactive, Reactive and Hybrid routing:

One of the most popular methods to distinguish mobile ad hoc network routing protocols is based on how routing information is acquired and maintained by mobile nodes. Using this method, mobile ad hoc network routing protocols can be divided into proactive routing, reactive routing and hybrid routing.

A proactive routing protocol is also called "table driven" routing protocol. Using a proactive routing protocol, nodes in a mobile ad hoc network continuously evaluate routes to all reachable nodes and attempt to maintain consistent, up-to-date routing information. Therefore, a source node can get a routing path immediately if it needs one.

B. Structuring and delegating the routing task:

Another classification method is based on the roles which nodes may have in a routing scheme. In a uniform routing protocol, all mobile nodes have same role, importance and functionality. In zone based routing protocols, different zone constructing algorithms are exploited for node organization, e.g. some zone constructing algorithms uses geographical information. Also zones may overlap or not depending on the constructing method. A cluster based routing protocol uses specific clustering algorithm for cluster head election. Mobile nodes are grouped into clusters and cluster heads take the responsibility for membership management and routing functions. In core-node based routing protocols for mobile ad hoc networks, critical nodes are dynamically selected to compose a "backbone" for the network. The “backbone” nodes carry out special functions, such as routing paths construction and control/data packets propagation. Core-Extraction Distributed Ad Hoc Routing (CEDAR) [22] is a typical core-node based mobile ad hoc network routing protocols.

C. Exploiting network metrics for routing:

Metrics used for routing path construction can be used as criteria for mobile ad hoc network routing protocol classification. Most routing protocols for mobile ad hoc networks use "hop number" as a metric. If there are multiple routing paths available, the path with the minimum hop number will be selected. If all wireless links in the network have the same failure probability, short routing paths are more stable than the long ones and can obviously decrease traffic overhead and reduce packet collisions. However, the assumption of the same failure properties may not be true in mobile ad hoc networks. Therefore, the stability of a link has to be considered in the route construction phase. For example, routing approaches

IJARETS

such as Associativity Based Routing (ABR) [24] and Signal Stability based Routing (SSR) [26] are proposed that use link stability or signal strength as metric for routing.

D. Evaluating topology, destination and location for routing:

In a topology based routing protocol for mobile ad hoc networks, nodes collect network topology information for making routing decisions. Other than topology based routing protocols, there is some destination-based routing protocols proposed in mobile ad hoc networks. In a destination–based routing protocol a node only needs to know the next hop along the routing path when forwarding a packet to the destination. For example, DSR is a topology based routing protocol. AODV and DSDV are destination based routing protocols. The availability of GPS or similar locating systems allows mobile nodes to access geographical information easily. In location-based routing protocols, the position relationship between a packet forwarding node and the destination, together with the node mobility can be used in both route discovery and packet forwarding. Existing location-based routing approaches for mobile ad hoc networks can be divided into two schemes. In the first scheme, mobile nodes send packets merely depending on the location information and do not need any extra knowledge. The other scheme uses both location information and topology information. Location Aided Routing (LAR) [6] and Distance Routing Effect Algorithm for Mobility (DREAM) [15] are typical location-based routing protocols proposed for mobile ad hoc networks.

E. Multicast routing protocols:

Most classification methods used for unicast routing protocols for mobile ad hoc networks are also applicable for existing multicast routing protocols. For example, multicast routing algorithms for mobile ad hoc networks can be classified into reactive routing and proactive routing. The Ad-hoc Multicast Routing (AMRoute) [46] and Ad hoc Multicast Routing protocol utilizing Increasing id-numbers (AMRIS) [47] belong to category of proactive multicast routing and the On-Demand Multicast Routing Protocol (ODMRP) [44] and Multicast Ad hoc On-demand Distance Vector (MAODV) [61] are reactive multicast routing protocols. There is a classification method particularly used for multicast routing protocols for mobile ad hoc networks. This method is based on how distribution paths among group members are constructed. According to this method, existing multicast routing approaches for mobile ad hoc networks can be divided into tree based multicast routing, mesh based multicast routing, core based multicast routing and group forwarding based multicast.

COMPARSION OF VARIOUS ROUTING PROTOCOLS:

In this section we will compare the different proactive, reactive, zone based, location based routing protocols one by one.

A. Comparison of Various Proactive Routing Protocols:

Proactive approaches have the advantage of readily available routes the moment they are required. Because each node consistently maintains an up-to-date route to every other node in the network, a source can simply check its routing table when it has data packets to send to some destination and begin packet transmission. However, the primary disadvantage of these protocols is that the control overhead can be significant in large networks or in networks with rapidly moving nodes. Proactive protocols tend to perform well in networks where there are a significant number of data sessions within the network. In this section we compare WRP, DSDV and FSR three proactive routing protocols.

Comparison of WRP, DSDV and FSR Protocols:

Control traffic overhead and loop-free properties are two important issues when applying proactive routing to mobile ad hoc networks. The proactive routing protocols used for wired networks normally have predictable control traffic overhead because topology of wired networks change rarely and most routing updates are periodically propagated. However, periodic routing information updates are not enough for mobile ad hoc routing protocols. The proactive routing in mobile ad hoc networks needs mechanisms that Dynamically collect network topology changes and send routing updates in an event-triggered style. Different mechanisms are used in WRP, DSDV and FSR for loop-free guarantee. WPR records the predecessor and the successor along a path in its routing table and introduces consistence-checking mechanism. In this way, WRP avoids forming temporary route loops but incurs additional overhead. Every node needs to maintain more information and execute more operations. In DSDV, a destination sequence number is introduced to avoid route loops. FSR is a modification of traditional Link State routing and its loop-free property is inherited from Link State routing algorithm. WRP, DSDV and FSR have the same time and communication complexity. Whereas WRP has a large storage complexity compared to DSDV because more information is required in WRP to guarantee reliable transmission and loop-free paths. Both periodic and triggered updates are utilized in WRP and DSDV; therefore, their performance is tightly related with the network size and node mobility pattern. As a Link State routing protocol, FSR has high storage complexity, but it has potentiality to support multiple-path routing and QoS routing.

B. Comparison of Various Reactive Routing Protocols:

Reactive routing techniques, also known as on-demand routing, take a very different approach to routing than proactive routing approaches. A large percentage of the overhead from proactive protocols stem from the need for every node to maintain a route to every other node in the network at all times. In this section we compare DSR, AODV and TORA three Reactive routing protocols.

Comparison of DSR, AODV and TORA Protocols:

DSR exploits source routing and routing information caching. A data packet in DSR carries the routing information needed in its route record field. DSR uses flooding in the route discovery phase. AODV adopts the similar route discovery mechanism used in DSR, but stores the next hop routing information in the routing tables at nodes along active routes. Therefore, AODV has less traffic overhead and is more scalable because of the size limitation of route record field in DSR data packets.

Both DSR and TORA support unidirectional links and multiple routing paths, but AODV doesn't. In contrast to DSR and TORA, nodes using AODV periodically exchange hello messages with their neighbors to monitor link disconnections. This incurs extra control traffic overhead. In TORA, utilizing the "link reversal" algorithm, DAG constructs routing paths from multiple sources to one destination and supports multiple routes and multicast [37]. In AODV and DSR, a node notifies the source to re-initiate a new route discovery operation when a routing path disconnection is detected. In TORA, a node re-constructs DAG when it lost all downstream links. Both AODV and DSR use flooding to inform nodes that are affected by a link failure. However, TORA localizes the effect in a set of node near the occurrence of the link failure. AODV uses sequence numbers to avoid formation of route loops. Because DSR is based on source routing, a loop can be avoided by checking addresses in route record field of data packets. In TORA, each node in an active route has a unique height and packets are forwarded from a node with higher height to a lower one. So, a loop-free property can be guaranteed in TORA. However, TORA has an extra requirement that all nodes must have synchronized clocks. In TORA, oscillations may occur when coordinating nodes currently execute the same operation.

C. Comparison of Various Zone-Based Routing Protocols:

ZRP is a well-known hybrid protocol that is most suitable for large-scale networks. Its name is derived from the use of "zones" that define the transmission radius for every participating node. This protocol uses a proactive mechanism of node discovery within a node's immediate neighbors, while inter-zone communication is carried out by using reactive approached.ZRP utilizes the fact that node communication in ad hoc networks is mostly localized, thus the changes in the nodes topology within the vicinity of a node are of primary importance. ZRP makes use of this characteristic to define a framework for node communication with other existing protocols. Local neighborhoods, called zones are defined for nodes. The Size of a zone is based on a factor defined as the number of hops to the perimeter of the zone. There may be various overlapping zones, which helps in route optimization. In this section we compare ZRP; HARP and ZHLS three zone based routing protocols.

Comparison of ZRP, HARP and ZHLS Protocols:

In ZRP, the network is divided into overlapping zones according to the topology knowledge for neighboring nodes of each node. In HARP, the network is divided into non-overlapping zones dynamically by DDR through mapping the network topology to a forest. For each node in HARP, the topology knowledge for neighboring nodes is also needed and the zone level stability is used as a QoS parameter to select more stable route. ZHLS assumes that each node has a location system such as GPS and the geographical information is well known, and the network is geographically divided into non-overlapping zones. The performance of a zone based routing protocol is tightly related to the dynamics and size of the network and parameters for zone construction. However, because zones heavily overlap, ZRP in general will incur more overhead than ZHLS and HARP. All three zone-based routing protocols presented in this subsection use proactive routing for intra-zone communication and reactive routing for inter-zone packet forwarding. Performance of a zone based routing protocol is decided by the performance of respective proactive and reactive routing protocols chosen and how they cooperate each other.

D. Comparison of Various Cluster-Based Routing Protocols:

In this section we compare CGSR, HSR and CBRP Cluster routing protocols.

Comparison of CGSR, HSR and CBRP Protocols:

Different clustering algorithms have been introduced to group mobile nodes and elect cluster heads in cluster based routing protocols. In HSR, hierarchical addressing is used and the network may have a recursive multi-level cluster structure. Moreover, a location management mechanism is used in HSR to map the logical address to the physical address. CGSR is based on DSDV, a proactive routing protocol for mobile ad hoc networks, and every node keeps routing information for other nodes in both the cluster member table and the routing table. In CBRP, every node keeps information about its neighbors and a cluster head maintains information about its members and its neighboring cluster heads. CBRP exploits the source routing scheme and the addresses of cluster heads along a route are recorded in the data packets.

E. Comparison of Various Core-node Based Routing Protocols:

In this section we compare CEDAR, OLSR and LANMAR Cluster routing protocols.

Comparison of CEDAR, OLSR and LANMAR:

In a core-node based routing protocol, the core-node extraction method is a key component. CEDAR, OLSR and LANMAR apply totally different approaches for core node extraction purpose. In LANMAR, the landmark nodes are application related and pre-defined according to their mobility pattern. Obviously, landmark nodes are suitable for tracing groups of nodes that have the same movement patterns. LANMAR is only suitable for specific mobile applications, which meet the assumptions that during the network lifetime, landmark nodes will not change their roles and mobile nodes will not change their mobility patterns. In CEDAR, a minimal (or nearly minimal) set of core nodes is selected to cover the network according to a certain optimization algorithm. The core nodes can be thought as a dynamically constructed "backbone" as in a cellular network. Core nodes keep link state information of the network. The link state information may include bandwidth, stability or delay information that can be exploited for QoS support and route optimization. The link state propagation is a function of link stability and quality. Only core

IJARETS

nodes are involved during route discovery operations. The main disadvantages of CEDAR are that the core extraction algorithm is needed and core nodes have to handle additional traffic associated with route discovery and maintenance. Different from CEDAR, a node selects its MPR independently in OLSR. A node propagates its MPR set changes through the network, but only MPRs re-broadcast control messages. Thus, OLSR reduces the traffic overhead and improves scalability.

F. Comparison of Various Location-Based Routing Protocols:

In this section we compare LAR, DREAM and GLS Cluster routing protocols.

Comparison of LAR, DREAM and GLS:

Location based routing protocols exploit location and node mobility information for the routing process. LAR, DREAM and GLS use the information in different ways and provide different services. LAR can be integrated into a reactive routing protocol and its main objective is to perform more efficient route discovery and limit the flooding of route request packets. Using LAR, a sender includes its location in the packets. In contrast to LAR, DREAM itself is a proactive routing protocol and every node keeps location information of all participants in the network. In DREAM, the location update frequency is determined by the relative distance between nodes and their mobility characteristics. GLS is not a routing protocol, but only provides a location service. In GLS, every node has several location servers scattered throughout the network which provide location information. Although the flooding is constrained in both LAR and DREAM by using location information, they are still not suitable for large-scale ad hoc networks. Their poor scalability roots in the directional flooding reactively initiated in LAR and proactive location information flooding in DREAM. In contrast, GLS can be used in large-scale mobile ad hoc networks with high node density. In GLS, a node chooses a small set of location severs throughout the network. Compared to LAR and DREAM, GLS doesn't exploit flooding for location update and query. Hence, its traffic overhead is greatly reduced. Simulation results in [40, 41] showed that GLS has a high query success ratio in large networks with high node density. However, simulation work in [42] also showed that the performance of GLS greatly declines in small size networks with lower node density. Because LAR is used for route discovery and GLS provides only location service, they should be used with appropriate location based forwarding schemes [57]. However, DREAM itself is a routing protocol and comprises location service and packet forwarding.

G. Comparison of Various Link Stability Based Routing Protocols:

In this section we compare CEDAR, OLSR and LANMAR Cluster routing protocols.

Comparison of ABR and SSR :

Although ABR and SSR are all based on Link State routing algorithm, they have distinct features and different mechanisms. ABR is a reactive routing protocol and is proposed to incorporate the link stability into routing to construct long-lived routing paths. The metric associativity is used in ABR to measure how long a wireless link lasts without failure. Following the assumption that the number of the associativity tags of a link reflects how long the link will be available in the future, a route path with greatest associativity tags is constructed. SSR can be seen as an extension of ABR. SSR uses signal stability as routing metric and route requests are propagated only through strong channels. SSR also assumes that the current signal strength of a channel can be used to predict its state in the future. Additionally, in SSR the messages are only propagated through strong channels to reduce the traffic overhead.

IJARETS

CONCLUSION:

Routing is an essential component of communication protocols in mobile ad hoc networks. The design of the protocols are driven by specific goals and requirements based on respective assumptions about the network properties or application area. This thesis tries to review typical routing protocols and reveal the characteristics and trade-offs. There are still many issues which have not been considered in this thesis e.g. related to quality of service or recent work on position-based and geographical routing.

REFERENCES:

1. IETFManetcharter, ttp://www.ietf.org/html.charters/manet-charter.html.
2. Corson S. and Macker J., RFC 2501: Mobile Ad Hoc NETworking (MANET): routing protocol performance issues and evaluation considerations, Internet draft, draft-ietf-manet-issues-01.txt.
3. S. Ramanathan and M. Steenstrup, A survey of routing techniques for mobile communication networks, Mobile Networks and Applications, 1996, p89-p104.
4. C. E. Perkins and P. Bhagwat. Highly dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for mobile computers, ACM Computer Communication Review, Vol. 24, No.4, (ACM SIGCOMM'94) Oct. 1994, pp.234-244.
5. D. Johnson, D. A. Maltz, Dynamic source routing in ad hoc wireless networks, in Mobile Computing (T. Imielinski and H. Korth, eds.), Kluwer Acad. Publ., 1996.
6. Y. B. Ko and N. H. Vaidya. Location Aid Routing (LAR) in mobile ad hoc networks. In Proc. ACM/IEEE MOBICOM, Oct. 1998.
7. R. Ramanathan, M. Steenstrup, Hierarchically-orangized, multihop mobile wireless networks for quality-of-service, ACM/Baltzer Mobile Networks and Applications, Vol. 3, No. 1, pp 101-119.
8. Z. J. Haas. The Zone Routing Protocol (ZRP) for ad hoc networks, Internet Draft, Nov. 1997.
9. J. Broch, D.A. Maltz, D.B. Johnson, Y.C. Hu, and J. Jetcheva, A performance comparison of multi-hop wireless ad hoc network routing protocols, Proc. MOBICOM, 1998, 85-97.
10. M. Joa-Ng and I-Tai Lu, A peer-to-peer zone-based two-level link state routing for mobile ad hoc net-works, IEEE on Selected Areas in Communications, vol. 17, no. 8, pp. 1415 1425, 1999.
11. NavidNikaein, Christian Bonnet and NedaNikaein, HARP - Hybrid Ad Hoc Routing Protocol, in proceeding of IST 2001: International Symposium on Telecommunications, Iran/Tehran 2001.
12. Mingliang Jiang, Jinyang Li and Y. C. Tay. Cluster Based Routing Protocol (CBRP), Internet draft,draft-ietf-manet-cbrp-spec-01.txt.
13. C. C. Chiang, T. C. Tsai, W. Liu and M. Gerla, Routing in clustered multihop, mobile wireless networks with fading channel, The Next Millennium, The IEEE SICON, 1997.
14. R.V. Boppana and S.P. Konduru, An adaptive distance vector routing algorithm for Mobile, Ad Hoc Networks, INFOCOM 2001.Proceedings. IEEE, Volume: 3, 2001 Page(s): 1753 - 1762.
15. S. Basagni, I. Chlamtac, V. Syrotiuk and B. WoodWard, A Distance Routing Effect Algorithm for Mobility (DREAM). Proc. 4th MOBCOM, 1998.
16. P. Jacquet, P. Muhlethaler, and A. Qayyum, Optimized Link State Routing Protocol, IETF MANET, Internet draft, 1998.
17. C.E. Perkins and E.M. Royer.Ad hoc on demand Distance Vector routing, mobile computing systems and applications, 1999.Proceedings.WMCSA '99.Second IEEE Workshop on, 1999, p90 - p100.
18. V. D. Park and M. S. Corson. A highly adaptive distributed routing algorithm for mobile wireless networks, INFOCOM '97, Sixteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Driving the Information Revolution, Proceedings IEEE, Volume: 3, 1997 Page(s): 1405 -1413 vol.3.
19. V. Park, and S. Corson, Temporally-Ordered Routing Algorithm (TORA) Version 1 Functional Specification. IETF Internet draft, 1997.
20. Z. J. Haas and M.R Pearlman, The Zone Routing Protocol (ZRP) for ad hoc networks. IETF Internet draft , August 1998.
21. Hu Zhou and S. Singh, Content Base Multicast (CBM) in ad hoc networks.Workshop on Mobile Ad Hoc Networking and Computing (MobiHoc), August 2000.
22. P. Sinha, R. Sivakumar and V. Bharghaven, CEDAR: a Core-Extraction Distributed Ad hoc Routing algorithm. IEEE INFOCOM, March 1999.
23. A. Iwata, C.-C.Chiang, G. Pei, M. Gerla, and T.-W.Chen, Scalable routing strategies for ad hoc wireless networks. IEEE Journal on Selected Areas in Communications, Special Issue on Ad-Hoc Networks, August 1999, p1369-p1379.
24. C.-K. Toh, Associativity Based Routing For Ad Hoc Mobile Networks .Wireless Personal Communications Journal, Special Issue on Mobile Networking and Computing Systems, p103-p139, March 1997.

IJARETS

25. Shigang Chen, K. Nahrstedt, Distributed quality-of-service routing in ad hoc networks. IEEE Journal on Selected Areas in Communications, 17(8), August 1999
26. R. Dube et al., Signal stability based adaptive routing for ad hoc mobile networks, IEEE Pers. Comm., February 1997, p 36-p45.
27. NS-2 web site, available at http://www.isi.edu/nsnam/ns/
28. R. A. Meyer, PARSEC User Manual. UCLA Parallel Computing Laboratory, http://pcl.cs.ucla.ed
29. OPNET Inc. web site, available at http://www.opnet.com/
30. Ad hoc protocols implementations, http://www.wikipedia.org/wiki/ Ad_hoc_protocols_implementations
31. Andrew S. Tanenbaum, Computer Networks, 3rd edition, Prentice Hall, 1996
32. Murthy, S. and J.J. Garcia-Luna-Aceves, An Efficient Routing Protocol for Wireless Networks, ACM Mobile Networks and App. J., Special Issue on Routing in Mobile Communication Networks, Oct. 1996, pp. 183-97.
33. G. Pei, M. Gerla and T.-W. Chen, Fisheye State Routing in Mobile Ad Hoc Networks. In Proceedings of the 2000 ICDCS Workshops, Taipei, Taiwan, Apr. 2000, pp. D71-D78
34. G. Pei, M. Gerla, and X. Hong, LANMAR: Landmark routing for large scale wireless ad hoc networks with group mobility. In Proceedings of the ACM Symposium on Mobile Ad Hoc Networking and Computing (MOBIHOC), pages 11-18, 2000.
35. John Jubin and Janet D. Tornow, The DARPA packet radio network protocols. Proceedings of the IEEE, 75(1): 21-32, January 1987.
36. Gregory S. Lauer, Packet-radio routing. In Routing in Communications Networks, edited by Martha E. SteenStrup, Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
37. L. Ji and M. S. Corson, A lightweight adaptive multicast algorithm, Proceedings of GLOBECOM'98, November 1998
38. E. Royer and C.-K. Toh, A review of current routing protocols for ad hoc mobile wireless networks. IEEE Personal Communications, vol. 6, p46-p55, April 1999.
39. S. Das, C. Perkins, and E. Royer, Performance comparison of two on-demand routing protocols for ad hoc networks. INFOCOM 2000, p3-p12.IEEE.
40. Jinyna Li, J. Jannotti, D. S. J. De Couto, D. Karger and R. Morris, A scalable location service for geographic ad hoc routing. In Proc. MOBICOM'2000, Boston, MA, USA, 2000.
41. M. Kaesemann, h. Hartenstein, H. Fuessler and M. Mauve, A simulation study of a location service for position-based routing in mobile ad hoc networks. Technical report, FakultätfürMathematik und Informatik der Universität Mannheim, Nr. TR-02-007, 2002.
42. N. K. Guba and T. Camp, Recent work on GLS: a location service for an ad hoc network, Proceedings of the Grace Hopper Celebration (GHC), 2002.
43. Ching-Chuan Chiang and Mario Gerla, Routing and multicast in multihop, mobile wireless networks. Proceedings of ICUPC '97.
44. S.J. Lee, M. Gerla, C.C. Chiang, On Demand Multicast Routing Protocol. Proceedings of IEEE WCNC'99, New Orleans, pages 1298-1302, Sept 1999
45. J.J. Garcia-Luna-Aceves, E.L. Madruga, A Multicast Routing Protocol for Ad-Hoc Networks. Proceedings of IEEE INFOCOM'99, New York, pages 784-792, March 1999.
46. M. Liu, R. Talpade, A. McAuley, and E. Bommaiah, AMRoute: Ad-hoc multicast routing protocol. Technical Report, CSHCN T. R. 99-1, University of Maryland.
47. C.W. Wu, Y.C. Tay, AMRIS: a multicast protocol for ad hoc wireless networks. Proceedings IEEE MILCOM'99, Atlantic City, Nov. 1999
48. E. M. Royer and C. E. Perkins, Multicast operation of the Ad-hoc On-demand Distance Vector routing protocol. Proceedings of ACM/IEEE MOBICOM'99, Seattle, pages 207-218, August 1999
49. S.J. Lee, W. Su, J. Hsu, M. Gerla and R. Bagrodia, A performance comparison study of ad hoc wireless multicast protocols. INFOCOM 2000, March 2000.
50. D. Waitzman, C. Partridge and S. Deering. RFC 1075: Distance vector multicast routing protocol. Network Working Group. November 1988.
51. J. Moy. RFC 1584: Multicast Open Shortest Path First (MOSPF). Network Working Group. March 1994.
52. B. Fenner, M. Handley, H. Holbrook and I. Kouvelas. Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised). IETF draft. December 2002.
53. A. Adams, J. Nicholas and W. Siadak. Protocol Independent Multicast - Dense Mode (PIM-DM): Protocol Specification (Revised). IETF draft. February 2003.
54. J. Moy, RFC 2328: OSPF version 2. Network Working Group. April 1998.
55. C. Hedrick, RFC 1058: Routing Information Protocol. Network Working Group. June 1988.
56. S. R. Das, C. E. Perkins, E. M. Royer, Performance comparison of two on-demand routing protocols for ad hoc networks. Proceedings of the IEEE InfoCom, March 2000.

IJARETS

57. M. Mauve, J. Widmer, H. Hartenstein, A Survey on Position-Based Routing in Mobile Ad-Hoc Networks. IEEE Network, Vol. 15 (2001)
58. S.J. Lee, W. Su, and M. Gerla, Ad hoc wireless multicast with mobility prediction. In proceedings of IEEE ICCCN99, Boston, MA, OCT. 1999.
59. J.J. Garcia-Luna-Aceves and E.L. Madruga, The Core-Assisted Mesh Protocol. The IEEE Journal on Selected Area in Communication, vol.17, no.8, Aug. 1999, pp1380-1394.
60. A. Ballardie, Core Based Trees (CBT version 2) Multicast Routing". Internet Request for Comment 2189, September 1997.
61. E. M. Royer and C. E. Perkins, Multicast operation of the Ad hoc On Demand Distance Vector Routing protocol. ACM MOBICOM, Aug.1999.

IJARETS