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Evaluation of Routing Protocols in Ad Hoc Networks

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Abstract—*Ad hoc networks are comprised of a group of workstations or other wireless devices which communicate directly with each other to exchange information without centralized control or established infrastructure. In recent years, several routing protocols have been proposed for ad hoc networks and prominent among them are DSR, AODV and TORA. This survey paper provides an overview of these protocols by presenting their characteristics, functionality, benefits and limitations and then makes their comparative analysis. The objective is to make observations about how the performance of these protocols can be improved by using the quality assurance metrics.*

Keywords— AODV, DSR, QA, TORA.

I. INTRODUCTION

An ad hoc network is a collection of wireless mobile nodes (or routers) dynamically forming a temporary network without the use of any existing network infrastructure or centralized administration. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a stand-alone fashion, or may be connected to the Internet. Ad hoc networks therefore refer to networks created for a particular purpose. They are often created on-the-fly and for one-time or temporary use. In ad hoc mode, each client communicates directly with the other clients within the network. An ad hoc network provides a cost effective means of communication among many mobile hosts. Applications of an ad hoc network include battlefield communications where soldier need to decide for a defend or offend, riot control and law enforcement where only law enforcing personnel need to communicate while others are not allowed to do so to prevent spreading of rumours, emergency rescue missions and disaster recovery where the communication infrastructure is abolished. Further, people may communicate forming an ad hoc network in convention centres and online conferences and classrooms without routing their calls to the available infrastructure.

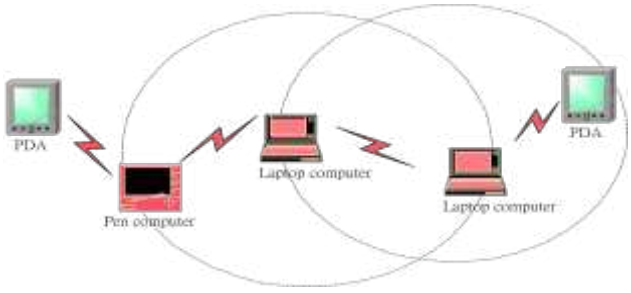

Fig.1: Wireless network (ad-hoc mode)

Quality assurance (QA) is planning to ensure the defect free service. It is a process for anticipating problems and providing the alternatives. Quality assurance is a program for the systematic monitoring and evaluation of the various aspects of a service to ensure that standards of quality are being met. Quality in use is the user's view of quality. The measure of system performance represents one of the basic evaluation criteria of a successful network, solution or a service from nearly all viewpoints: deployment, operation and customer satisfaction. In general referred to as the quality, there are basically two approaches to defining, measuring and assessing the success of meeting a specified set of requirements or an expected behaviour [FOR 2006]. The measure of performance from the network perspective is known as the Quality of Service (QoS) and involves a range of QoS mechanisms that are implemented for the purpose of meeting the defined condition in the network. Typically, QoS metrics include network operation parameters i.e. bandwidth, packetloss, delay and jitter. On the other hand, the measure of performance as perceived from the end user is known as Quality of Experience (QoE) and addresses the overall satisfaction of the end user and the ability to meet their expectation.

II. RECENT STUDIES

The problem of routing in ad hoc network has received attention among researchers, and many routing protocols devoted to ad hoc network have been proposed.

In [KUS 2010], authors Ashwani Kush and Sunil Taneja given the description of routing protocols in mobile ad hoc networks. They have given an overview of the DSR,

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AODV and TORA protocols by presenting their characteristics, functionality, benefits and limitations.

In [PAR 1997], authors V. Park and M.S. Corson given an conceptual description of the protocol Temporally-Ordered Routing Algorithm (TORA) which is a highly adaptive distributed routing algorithm and has been tailored for operation in a mobile networking environment. The basic, underlying, routing mechanism of TORA is neither a distance-vector nor a link-state algorithm; it is one of a family of "link-reversal" algorithms.

In [PER 2003], authors C. Perkins, E. B. Royer, S. Das given an overview of protocol Ad Hoc on Demand Distance Vector (AODV) which is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required.

Singh, Woo and Raghvendrain[SIN 1998], [LIN 2001] proposed a routing algorithm based on minimizing the amount of power required to send a packet from source to destination.

Holland and Vaidya [HOL 1999] have studied the behaviour of TCP in ad hoc networks, using DSR as a routing protocol; their work added explicit interaction between TCP and the Route Discovery and Route Maintenance mechanisms to allow TCP to correctly react to a route failure rather than treating it as network congestion, and to allow TCP to restart sending as soon as a new route to the destination is discovered.

For quality assurance several strategies attempting to manage limited resources such as bandwidth, computation power, memory, and battery in ad hoc wireless networks have been developed.

Jeffery P. Hansen, Scott Hissam, Daniel Plakosh and Lutz Wrage [HAN 2012] described an approach for satisfying application-specific Quality of Service (QoS) expectations operating on ad hoc wireless networks where available bandwidth fluctuates. The proposed algorithm, D-Q-RAM (Distributed QoS Resource Allocation Model) incorporates a distributed optimization heuristic that results in near optimal adaptation without the need to know, estimate, or predict available bandwidth at any moment in time.

Stephen F. Bush [BUS 2005] proposed a metric that couples network topological rate of change with the ability of a generic service to move itself to an optimal location in concert with the changing network. The metric proposed a fundamental tradeoff among adaptation (changing service location), performance (sophistication or estimated minimum code size of the service), and the network's ability to tune itself to a changing ad hoc network topology.

In [JAI 2008] authors Swati Jaiswal, Satya Prakash, Neeraj Gupta and Devendra Rewadikar given an overview of quality of service issues in mobile ad-hoc networks. Quality of services for a network is measured in terms of guaranteed amount of data which a network transfers from one place to another in a given time slot. Quality of Service support for Mobile Ad-hoc Networks is a challenging task due to dynamic topology & limited resource. The main purpose of QoS routing is to find a feasible path that has sufficient resources to satisfy the constraints.

III. SURVEY ANALYSIS

Ad Hoc on Demand Distance Vector (AODV)

AODV belongs to the class of Distance Vector Routing Protocols (DV). In a DV every node knows its neighbours and the costs to reach them. Ad hoc On Demand Distance Vector (AODV) is a reactive routing protocol which initiates a route discovery process only when it has data packets to transmit and it does not have any route path towards the destination node, that is, route discovery in AODV is called as on-demand. AODV is composed of three mechanisms: Route Discovery process, Route message generation and Route maintenance. The significant feature of AODV is whenever a route is available from source to destination; it does not add any overhead to the packets. However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply message.

Advantages:-

1. Adaptability to dynamic networks.
2. Reduced overhead.
3. Lower setup delay

Disadvantages:-

1. Periodic updates.
2. Inconsistent routes.

Dynamic Source RoutingProtocol (DSR)

The Dynamic Source Routing protocol (DSR) [JON 1994], [JON 1996], [BOR 1999] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. DSR is reactive or on demand protocol.

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The route discovery cycle used for route finding is on demand. It keeps maintenance of active routes. There is no periodic activity of any kind like hello messages in AODV. This protocol utilizes source routing (entire route is part of the header).It uses caches to store routes. The DSR protocol allows nodes to dynamically discover a source route across multiple network hops to any destination in the ad hoc network. Each data packet sent then carries in its header the complete, ordered list of nodes through which the packet must pass, allowing packet routing to be trivially loop-free and avoiding the need for up-to-date routing information in the intermediate nodes through which the packet is forwarded. By including this source route in the header of each data packet, other nodes forwarding or overhearing any of these packets may also easily cache this routing information for future use.

The protocol is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the ad hoc network. All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use.Network nodes (computers) cooperate to forward packets for each other to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network move about or join or leave the network, and as wireless transmission conditions such as sources of interference change, all routing is automatically determined and maintained by the DSR routing protocol.

Advantages:-

1. A route is established only when it is required.
2. No need to keep routing table.
3. Reducing load.

Disadvantages:-

1. Route overheads.
2. Higher delay.
3. The route maintenance.
4. Not scalable to large networks.
5. Requires significantly more processing resources than most other protocols.

Temporally Ordered Routing Algorithm (TORA)

The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal. TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. The protocol has three basic functions: Route creation, Route maintenance and Route erasure.

Route creation*:* - When a node requires a route to a destination, it initiates route creation where query packets are flooded out to search for possible routes to the destination.

Route maintenance*:* - The availability of multiple paths is a result of how TORA models the entire network as a directed acyclic graph (DAG) rooted at the destination. Route maintenance occurs when a node loses its entire outgoing links. The node propagates an update packet which reverses the links to all of its neighbouring nodes. The DAG is maintained such that all nodes have routes to the destination. The route maintenance function of TORA is the main problem as this function produces a large amount of routing overhead. It causes the network to be congested thus preventing data packets from reaching their destinations.

Route erasure:-In the event that a node is in a network partition without a route to the destination, route erasure is initiated. Route erasure is performed by flooding clear packets throughout the network. When a node receives a clear packet, it sets the links to its neighbours as unassigned. Eventually, these clear packets propagate through the network and erase all routes to that unreachable destination.

Advantages:-

1. Multiple paths created.
2. Communication overhead and bandwidth utilization is minimized.

Disadvantages:-

1. Routing overheads.
2. Depends on synchronized clocks among nodes.

IV. CONCLUSION

When choosing a protocol to a specified network one should consider the following issues:

Size of the network:-If the network could be considered or forecasted to be large, the chosen protocol should support scaling issues.

Degree of mobility:-how often links bare assumed to cut off. Some protocols (usually reactive) have better performance over some other protocols (usually proactive) when mobility is high.

User applications:-for the underlying network. Real-time applications require quite different services compared to non-time critical message delivery.

When the network structure and the node behaviours are understood, the right or at least near optimal protocol could be chosen.

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Comparison of protocols

Protocol	Update destination	Update period	Unidirectional links	Multiple routes	Advantages	Disadvantages
AODV	Source	Event driven	No	Yes	1. Adaptability to dynamic networks 2. Reduced overhead. 3.Lowersetup delay	1. Periodic updates. 2. Inconsistent routes.
DSR	Source	Event driven	Yes	Yes	1. A route is established only when it is required. 2. No need to keep routing table. 3. Reducing load.	1. Route overheads. 2. Higher delay. 3. The route maintenance. 4. Not scalable to large networks. 5. Requires significantly more processing resources than most other protocols.
TORA	Neighbours	Event driven	Yes	Yes	1. Multiple paths created. 2.communication overhead and bandwidth utilization is minimized.	1.Routing overheads 2.Depends on synchronized clocks among nodes

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