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Energy Efficient Multicast Routing in Mobile Ad Hoc Networks: Contemporary Affirmation of Benchmarking Models in Recent Literature

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Abstract- The Mobile Ad hoc Networks playing critical role in network aided communication requirements. The features such as ad hoc and open architecture based connectivity and node mobility are elevating the mobile ad hoc networks as much as feasible to deploy and use. The direct communication between any of two nodes in this network is possible if target node is in the range of source node. If not, the indirect communication took place, which is usually referred as multi hop routing. The multi hop routing occurs as either a unicast model (one source node to one destination node), multicast model (one source node to multiple destination nodes) or multiple casting (manifold unicast routing). In these routing strategies, provision of service quality in multi hop routing is a challenging task. The optimal quality of service in routing, magnifies the delivery ratio, transmission rate, network life span and other expected characteristics of the ad hoc routing. Among the quality service provision factors minimal energy conservation is prime factor, which is since the nodes involved in routing are self-energized and if discharged early then the route will be destructed that causes discontinued routing. The energy consumption is more specific in multicast routing, hence it is grabbing the more attention of the current research contributions.

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ENERGYEFFICIENTMULTICASTROUTINGINMOBILEADHOCNETWORKSCONTEMPORARYAFFIRMATIONOFBENCHMARKINGMODELSINRECENTLITERATURE

Energy Efficient Multicast Routing in Mobile Ad Hoc Networks: Contemporary Affirmation of Benchmarking Models in Recent Literature

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Abstract -The Mobile Ad hoc Networks playing critical role in network aided communication requirements. The features such as ad hoc and open architecture based connectivity and node mobility are elevating the mobile ad hoc networks as much as feasible to deploy and use. The direct communication between any of two nodes in this network is possible if target node is in the range of source node. If not, the indirect communication took place, which is usually referred as multi hop routing. The multi hop routing occurs as either a unicast model (one source node to one destination node), multicast model (one source node to multiple destination nodes) or multiple casting (manifold unicast routing). In these routing strategies, provision of service quality in multi hop routing is a challenging task. The optimal quality of service in routing, magnifies the delivery ratio, transmission rate, network life span and other expected characteristics of the ad hoc routing. Among the quality service provision factors minimal energy conservation is prime factor, which is since the nodes involved in routing are self-energized and if discharged early then the route will be destructed that causes discontinued routing. The energy consumption is more specific in multicast routing, hence it is grabbing the more attention of the current research contributions. In this regard this manuscript reviewed the contemporary literature and the significant contributions of energy efficient multicast routing strategies.

Keywords: multicast routing protocols, mobile ad hoc network (manet), energy efficient routing. tree based multicast route, mesh based multicast route, zone based multicast route, hybrid multicast route, residual energy.

I. Introduction

Mobile ad hoc networks (MANET) [1] is one of the critical class of network aided distributed communication. The features such as dynamic connectivity,less infrastructure ability of node mobility enables to establish network aided communication in civilian environments such as army communication in battle grounds, natural calamities handling and social media sharing between hand held and mobile devices. The direct communication between any devices of the MANET is possible only if receiver is in the range of sender. If receiver is not in the range of the sender, then the route can be established between sender and receiver by using the intermediate devices called nodes. The phenomenal growth in computer aided network communication demands instant access to any network in order to exchange digital data. The video conferences, digital data sharing between students in academic strategies, service search and information sharing in business enterprises and social media are the few examples to justify the demand of ad hoc network strategies. The constraints such as indefinite node density of a network, unpredictable mobility of the nodes, and other operational factors of a node such as egress and ingress capacity, residual energy levels compromised behavior of the nodesevincing that intermediate nodes selection to establish route between source and destination is a challenging task. Though the many contributions found in contemporary literature to establish optimal routes, they limited to one or two quality factors. Hence the quality provisioning in route discovery is still an open issue for current research domain. Multicasting is significantly sensitive to discover optimal routes, which since the load of transmission is significantly high and often intermediate nodes are necessarily transmit data to multiple nodes in order to transmit data to multiple target nodes. Hence the node life span is most critical to retain the multicast route to complete data transmission between one source to many destination nodes. Hence, this manuscript reviewed contemporary literature on energy efficient multicast routing strategies.

The paper is organized as follows. Section 2 describes nomenclature of the multicast routing strategies. Section 3 is the contemporary affirmation of the benchmarking energy efficient multicast routing models fund in recent literature. Section 4summarizing the manuscript contributions.

II. Nomenclature of the Multicast Routing Strategies

The categorization of the multicasting routing strategies are usually based on the topologies such as tree, mesh, zone and hybrid topologies are used to build multicast routes. Further these multicast routing models under divergent topologies are categorized

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based on service provision strategies such as reliability, bandwidth usage, delay, bandwidth delay and power aware or energy efficient.

The tree based multicast routing protocols of these categories are subcategorized as source-rooted and core-rooted schemes according to the roots of the multicast trees. The source node acts as root node of the tree and maintains the topology related information and addresses of all nodes involved in multicast route, hence the model is evincing the constraints such as process, route maintenance and traffic overheads. The other category of tree based multicast routing models are core-rooted models, which is the set of subtrees and each sub tree behaves as source rooted trees. Each subtree is formed by a node involving multicasting as root node. The core-root tree based multicast routing strategies are optimal than source-root tree based multicast routing strategies but route stability is a questionable factor. Though the tree based multicast models are is establish but frequent destruction of the route due to node mobility is quite often that abandons the data transmission till the reformation of the tree happens.

The sub categories of the mesh based multicast routing models are also based on either core or central nodes, which are as similar as source and core root based multicast trees. But mesh based multicast routing models are node mobility resistant. Hence the route destruction due to node mobility is least significant in mesh based ulticast routing models.

The multicast models of the zone based topology partitions the network region as virtual zones. Further the nodes of each zone are used to core-root tree or core-point mesh. The node that considered as core-root or core-point is the zone head. The inter zone communication is done through the zone heads. The considerable advantage of the zone based multicasting models is, the node mobility needn't be tracked, instead, notifying zone change of the node is sufficient. The visible constraints of these zone based multicasting are overhead of zone formation, route discovery and route maintenance.

The hybrid models of multicast routing protocols are the combination of either all of tree, mesh and zone topologies or any of two.

The other considerable category of multicast routing protocols are hierarchical models. This category is often fall under hybrid models. This multicast routing protocols are set of connected multicast routing protocols of one or more of the types called tree, mesh and zone based topologies. The constraints specific to these topologies can be evinced even in hierarchical models.

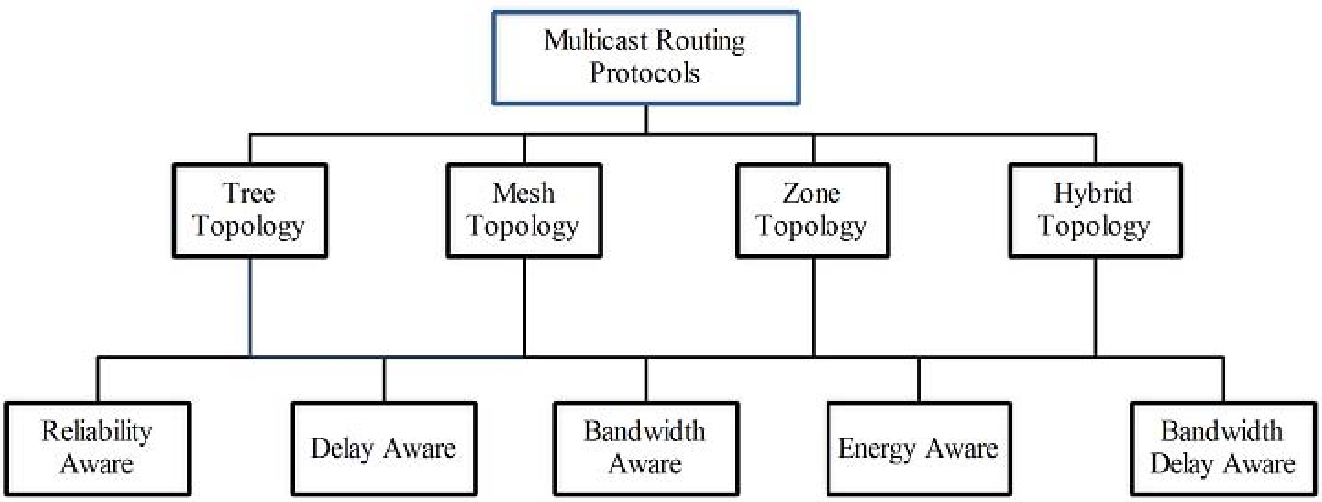

Figure 1 : Nomenclature of the multicast routing strategies for mobile ad hoc networks

The classification of the multicast routing strategies based on the tree, mesh, zone and hybrid topologies explores issues in multicast routing specific to reliability, delay, bandwidth usage, bandwidth delay, link stability and energy usage.

The context of this manuscript is reviewing energy efficient multicast routing protocols, hence the benchmarking energy efficient multicast routing protocols that fall in either of the category explored and found in contemporary literature are informed in detail in following section.

III. Contemporary Affirmation of Benchmarking qos Multicast Routing Protocols

This section explores the some of the benchmarking energy efficient multicast routing models found in contemporary literature.

The minimum energy-per-bit for multicasting Wu et al., [2] defined a coding aware multicasting with minimal energy consumption. The objective of the model is to minimize bit level energy consumption. In regrad to this network coding is adapted to in multicast routing. The empirical analysis of the model claimed the significance of the network coding to achieve bit level energy consumption to be minimal and construction of multicast tree that consumes overall energy as much as low. The considerable constraint is that if transmission distance increased between nodes then the energy consumption is complemented and often route destruction evinced if noise found during transmission.

Guo et al., [3] proposed an energy efficient multicast routing model for Wireless ad hoc networks with Omni antenna based neighbor node communication strategy. In case of source initiated multicast traffic, power saving capability achieved through the usage of adaptive antennas. In order to select nodes those transmit data as radio frequency with minimal usage of the energy, the mixed integer linear programming (MILP) is adapted here in this model. The experimental study noticed that, this model is highly adaptable only for low and midsize networks to achieve minimal energy consumption. The constraints observed for the model [2] even found in this model.

A distributed minimum energy multicast model [4] proposed for mobile ad hoc networks with nodes using Omni directional antennas. The objective of the proposal is to minimize the energy usage for radio frequency transmission. In order to build an energy efficient multicasting tree, this model is considering the factors such as managing distinct levels of energy usage, balancing the flooding in multicast tree and multicasting tree maintenance. The overall routing process is in two dimensions and those are achieving minimal energy consumption and continuous reformation of the multicast tree to avoid the route failure due to node mobility. The energy consumption in regard to radio frequency (RF) transmission is estimated by the distance between source and destination Omni directional antennas. The experimental study indicating that the model is out performed in Manets with low mobility nodes. The significant constraint of the model is that it is not considering the route lifespan (residual energy is not assessing), which causes often route destruction, also not considering the signal to noise ratio, hence the energy saving is not optimal if noise found in RF transmission medium.

Li et al., [5] proposed an Energy efficient multicast routing in ad hoc wireless networks that equipped with Node-Join-Tree, Tree-Join-Tree and directed Steiner tree based multicast tree building algorithms. An approximation algorithm is used to overcome the NP-Hard problem of the multicast tree formation [6]. The greedy approaches NJT (Node-Join-Tree) and TJT (Tree-Join-Tree) are used to perform optimal node joins to build multiple sub trees and optimal sub tree joins to build multicast tree respectively. Each neighbor node verification and each sub tree verification are the critical computational constraints observed in NJT and TJT respectively. In order to overcome this Steiner tree method is used to achieve greediness in node verification and subtree verification in respective NJT and TJT. The empirical study evincing optimal performance of this model in Manets with nodes with less transmission distance between them. The constraints noticed for models [2][3] are noticed even for this model.

Gua et al., [7] extended their earlier contributions [3][4] with basic energy-efficient multicast (BEEM) and distributed maximum lifetime multicast (DMLM), for increasing the lifetime of the network. Distinct energy usage scheme is adopted from [4], and node location identification is done by positioning system. The experimental study compared the performance of BEEM, DMLM and ODMRP in the context of maximal lifespan of the network. The comparison evinced that DMLM increased the network lifespan through minimal energy usage that compared to BEEM and ODMRP and the network lifespan observed under BEEM is much better than the ODMRP. The computational and process control overhead also found high in the order of DMLM, BEEM and ODMRP, which is considerable constraint of the proposal.

Shafigh et al., [8] proposed a mesh based multicast routing that selects nodes based on their residual energy. In order to this the proposed model is using fuzzy reasoning to segregate nodes with low residual energy and high residual energy. The proposed models is on demand multicasting model that uses fuzzy reasoning to select optimal nodes in order to build mesh based multicast route. The fitness function of the fuzzy logic is assessing the residual energy levels of the nodes capable to involve in route establishment. The empirical study compared the values obtained for metrics (such as PDR, control overhead, end-to-end delay) with the values obtained for ODMRP, which are evincing the phenomenal advantage of this model over ODMRP. The constraints observed are downfall in packet delivery ratio and energy usage is complimented against increase in control packet transmission, which is specific to dense networks.

Xiang et al. [9] proposed a multicast routing protocol, which is labeled as efficient geographic multicast protocol. This protocol builds zone based bidirectional multicast tree that dilutes the complexity of route discovery and maintenance. In order to this the overall network range is partitioned into virtual zones such that direct communication between any two nodes in a zone is possible. Each zone is equipped with a zone head and if node want to communicate to a node that exists in other zone then the source node seeks zone head role in order. Since the data transmission is zone level but node level, hence route maintenance is phenomenally very low, since the protocol rather monitoring the node mobility, it handles the zone

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change of the nodes due to their mobility. The transmission over head is shared between all member nodes of the zone, hence transmission overhead also be found very low. The empirical study that compared PDR, control overhead and delay observed for this protocol with other benchmarking model called ODMRP and SPBM [10]. The empirical study results evincing that this model performance is optimal than other two. The minimal energy consumption and maximal residual energy are not considered to select a zone based multicast tree, which is a significant constraint to achieve maximum network lifespan.

Tavli et al., [11] devised a cross layer architecture based protocol for multicasting with minimal energy consumption, which is using time reservation strategy in multicasting. This protocol also balancing the other QoS factors that includes spatial reuse. This architecture used in this protocol is the combination of multicast mesh and multicast tree structures, where the multicast tree is active and that surrounded by the passive multicast mesh. The passive multicast mesh helps to handle the broken links in active multicast tree efficiently. This protocol is an extension to the earlier model called multi hop time reservation using adaptive control for energy efficiency [12]. This model switches idle nodes to sleep mode and also surpasses the recurrent data transmissions in order to achieve minimal energy conservation. The experimental study evincing the minimal energy consumption and delay that compared to other benchmarking model called ODMRP [13]. The considerable constraint this model is complex cross layer architecture.

Fareena et al [14] proposed a multicast routing model that limiting the overall energy consumption by selecting nodes based on their mobility speed and direction. This is a cross model of mesh and tree architectures. The density of neighbor count also considered in order to select nodes for multicast route building. The metrics node mobility speed and direction, neighbor count and residual energy of each node are used as critical factors by this model to devise energy efficient multicast route. Switching the idle nodes into sleep state is also boosting this model to minimize the energy consumption. The empirical study signifies that the model is optimal as the packet delivery ratio is high, energy consumption and end-to-end delay is low that compared to the ODMRP. The constraints are, control flow overhead and process overhead. The overall energy consumption observed for data packets and control packets transmission is not optimal.

Nasab et al. [15] proposed a multicast routing strategy to achieve minimum energy consumption. The devised model is using PSO (particle swarm optimization) [16] technique to discover the route with maximum residual energy, minimal energy consumption and end-to-end delay. The initial multicast tree that includes all nodes in the network is built by prims algorithm and further optimal multicast tree is discovered by applying PSO. The nodes involved in initial tree are considered as particles with the properties called mobility speed, position and direction of mobility. The PSO traverse these particles in order to select qualified particles. Further the optimal nodes are being selected from these qualified nodes through the fitness function, which is assessing the node fitness by their residual energy levels, energy consumption ratio. The experimental study evinced that the PSO model is the best fit model to derive energy efficient multicast tree that compared to traditional GA approach. The computational overhead observed for PSO is considerable constraint of the model, which is also lagging to achieve energy efficiency in noisy channels (signal to noise ratio is low in discovered multicast tree). Varaprasad et al., [17] proposed a multicasting protocol that aimed to achieve maximum link stability and minimal energy consumption. Tis proposed model relied on two factors called residual energy of the battery and maximal relay scope. The establishment of route with the nodes having high residual energy and high relay capacity evinced reliable communication. This model is not considering the minimizing the energy consumption to enhance the network life span, which is found to be critical constraint of this model and other constraint is process load due to additional control traffic.

Lu et al., [18] proposed a multicast routing model, which is to achieve minimal energy consumption and minimal end-to-end delay. The route discovery strategy is an evolutionary model that uses genetic algorithm in route selection. In order to obtain the optimal multicast tree path, the proposed model is applying genetic evolutions on possible multicast trees discovered in route request phase. The cost function estimating the energy consumption ratio and end-to-end delay in order to notify the fitness of the resultant multicast trees of the GA crossovers. The empirical study of the model evinced the discovery of optimal multicast tree with minimal energy consumption and least end-to-end delay. The critical constraint of the proposal is computation overhead, since the genetic algorithm process complexity is not linear, hence the process complexity is complimented if network size is increased. The other constraint of the model is, it is not considering the overall multicast tree lifespan as a factor route selection.

The review of contemporary multicast routing with minimal energy consumption and maximal network lifespan models was done here in this section. The review evincing that the all of these models are found to be fit under the specific factors considered. All of these models are divergent at multicast route discovery process in order to achieve minimal energy consumption and maximal network lifespan. The common constraints of these models observed is limiting the performance if transmission influenced by noise, computational overhead observed in route discovery phase and process overhead observed at route maintenance phase.

IV. Conclusion

This manuscript reviewed the energy efficient multicast routing strategies found in recent literature. The review evinced the context of the multicast routing protocols and the strategies followed in order to achieve energy efficient transmission and limits. The multicast routing models reviewed were fall in either of the routing topologies called tree, mesh, zone and hybrid topology, but common objective of all these protocols is multicast routing under minimal energy consumption and maximal network lifespan. The review of these models reveal that scalability issues such as compatibility to dense networks, nodes with high mobility and transmissions under noise in fluencesare not considered by most of the approaches. The assessment of the performance of all these models are at limited extent of QoS factors and heterogeneous factors of mobile ad hoc networks such as all-to-all multicast routing, many-to-many multicast routing and multiple unicast routing. Hence it is obvious to notify that a vast research scope to devise energy efficient multicast routing protocols.

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