

Energy Consumption in Ad Hoc Network With Agents Minimizing the Number of Hops and Maintaining Connectivity of Mobile Terminals Which Move from One to the Others

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Abstract

Wireless mobile ad-hoc network (MANET) is a special kind of network, where all of the nodes move in time. Node is intended to help relaying packets of neighboring nodes using multi-hop routing mechanism in order to solve problem of dead communication. MANET which engages broadcasting and contains multiple hops becomes increasingly vulnerable to problems such as mobile node's energy degradation, routing problem and rapid increasing of overhead packets. This paper provides an extensive study of energy consumption in the MANET that consists of two network areas with the presence agents. Agents will minimize number of hops and its affect in linearity with the delay. As nodes grow, either in data transmission services or coverage of node's communication or more agents stand in overlapped locations, the intensive data exchange and topology construction to adapt the network are becoming an important issue. As a result, agents are needed to support these process automation, high-level connectivity, and intelligent service. We evaluate the agents' performance and network energy consumption for supporting MANET that divided into two domain/network areas. The proposed agents provides service for packets transmission between networks; e.g. determine appropriate relay nodes dynamically, maintain the transmission between networks through another nodes, share the topology knowledge among agents, and route packets between source and final destination that are unable to communicate directly. The achievement on research with this approach is conducted via simulation study. A similar network without agents is presented to derive such referential bounds by using appropriate functions of network agents. The proposed algorithm is confirmed with composite simulation results.

Keywords: Energy, Agents, Multi-hops, Connectivity

1. INTRODUCTION

MANETs is a multi-hop wireless network in which nodes can communicate with each other without support of any existing infrastructure. This network is fully autonomous and free to move anywhere (in the area or across areas) any time. Node is referred to a mobile device which equipped with built-in wireless communications devices attached and has capability similar to autonomous router. The nodes can be located in or on airplanes, ships, cars, or on people as part of personal handheld devices, and there may be multiple hosts among them. Each node is autonomous. The system may operate in isolation, or have gateways to a fixed network. In the future operational mode, multiple coverage of the network is expected to operate as global "mobile network" connecting to legacy "fixed network".

At each time and every node's positions, a wireless connectivity in the form of a random, single-hop, multi-hop path may exist between nodes and areas. This topology may change as the nodes move or adjust their parameters. Among networks, Wireless (Ad-Hoc) Mesh Network has several characteristics; i.e. dynamic topologies, bandwidth-constrained, energy-constrained operation, and limited physical security. These characteristics create a set of underlying assumptions and performance considerations for protocol design which extend beyond static topology of the fixed network. The design should react efficiently to topological changes and traffic demands while maintaining effective routing in a mobile networking context.

In this paper we propose a mobile agent - based routing protocol for delivering packets in clustered networks whose performance increases with the increasing traffic in the network due to high degree of cooperation among both the nodes and agents. The agents were used to deliver packets where they acted as a messenger that will migrate packets from a source in certain clustered network area to a final destination which is located in different network area. Thus when there are a number of sources to send messages to a final destination simultaneously; a group of parallel redundant traffic with similar responsibility will be generated. This traffic will eventually consume the energy, the bandwidth, and other crucial resources of the ad hoc wireless network. The novelty of this work is to analyze the effect of cooperating agents at the border of clustered networks to the overall network energy consumption and compare it with the similar network which has all the pairs of source-final destination carrying packets for the transmission travel across different clustered networks. Delay performance of those networks, however, will be key issues. This problem is caused by complex network interactions that complicate the multi-hop routing mechanisms. The agents, which are relieved of their responsibilities in the process, will be slept if possible and thus reducing the traffic load heavily [7].

In this paper, we analyze various formation options of agents and nodes and their potential overheads and impacts on efficiency are evaluated via simulation study. The remainder of this paper is organized as follows: Section 2 gives the previous research related with our model. Section 3 discusses the detail design of the simulation model, its notations, and assumptions. Simulation algorithm that suits mobile environment is presented in Section 4. A performance evaluation of networks and its comparison to network without implementing agents at the similar network topology are presented in Section 5 and Section 6, respectively. Section 7 concludes the paper.

2. PREVIOUS WORKS

All nodes in MANET rely on batteries or other exhaustible energy modules for their energy. For this network, the most important system design criterion for optimization is energy conservation. Thus one critical design issue for future Wireless Ad-Hoc Network is the development of efficiently energy consumption that suits communication architectures, protocols and services of network enabled wireless devices. Energy conservation means to maximize the operational lifetime of a node, thus, enhancing the overall user experience [1][18].

Previous researches for energy conservation of MANET are focus on transmission energy control and dynamic turning off active nodes in network. Adjusting the energy for transmission reduce the energy consumption significantly and increase lifetime of the network. Our previous propose framework concentrated on energy aware broadcasting technique for wireless ad hoc networks. The framework uses a packet forwarding technique where neighbor nodes can be elected to be relay on behalf of source-destination path with the goal of optimized the overall energy consumption to deliver packets in the network, while maintaining the connectivity among nodes. Transmission to a distant node may consume a higher amount of energy in comparison to transmission to a node in closer range and more energy will be used for sending packets than receiving or processing packets. In addition, transmission of larger packets may consume a higher amount of energy in comparison to transmission of smaller packets. The framework is based on the principle that adding additional relay nodes with appropriate energy and routing metric between source and final destination nodes significantly reduces the energy consumption necessary to deliver packets in Wireless Ad-Hoc Network while maintaining connectivity among

nodes [1]. Yu Wang introduced the method to control energy over network layers in MANET [2]. Energy management based on cross-layer design make network more robust and adaptive. At physical and data link layers, the method triggers nodes to transfer between energy-save mode and active mode, while at network layer, a routing protocol is equipped with new defined joint function, which can realize hop-by-hop and end-to-end energy control. Other researcher, Cartigny proposed an algorithm that requires local information, i.e. full knowledge of network its distance to all neighboring nodes and distances between its neighboring nodes. Distances can be measured by using signal strength, time delay or more sophisticated techniques like microwave distance [3]. Nodes adjust their transmission energy so as to achieve the minimum energy consumption according the local information. Ramanathan and ElBatt remarked method of adjusting energy for delivering packets implement with considering levels to achieve a desired degree of connectivity in the network [4][5]. Bergamo etc. submitted a routing algorithm based on distributed energy control, which provide optimum transmit energy while maintaining limited degradation in throughput and delay [6]. Each node in MANET estimates the energy necessary to reach its neighbors, and this estimation is used both for tuning the transmit energy and as the link cost for minimum energy routing. Simulations results confirm that this method can save the network's energy.

Most of those researches did well in one network area. Taking into consideration all the challenges mentioned above, we deal with energy control over nodes that are distributed into several network areas. The main contribution of this paper is that we propose agents that collect local network information. If agents are positioned in the overlapped area between networks, each source node in certain network area only needs to get its agents' information whenever it require to contact other node located in other network area from that is where full knowledge of network is required to make decision.

3. SIMULATION MODEL, NOTATIONS, AND ASSUMPTION

As foundation for this mobile environment, the core algorithm is developed from static mode (e.g., sensor networks). The enhancement algorithm for serving mobility then detailed in support of topology development, topology maintenance, and routing maintenance.

The model is initiated from broadcast mechanism and propagated through node-to-node based routing metrics approach. Each source injects single big packet which fragmented into multiple packets in the network, which traverse through the network until those reach the final destination. Packets are queued at each node in its path where it waits for an opportunity to be transmitted. This model is not only applicable in direct communication (one hop transmission) but it can also work in multi-hop transmission. In this situation, when the source and final destination nodes are located outside its clustered network area, source node is capable to discover multiple hop route lead to agents thus maintaining the connectivity required in comparison to standard flooding based ad hoc routing designs.

It is square of Cartesian model area with 200x200 areas and one overlapped section. We consider the case where all nodes in the network are similar, i.e., assuming a homogeneous infrastructure. Inside areas, nodes are deployed uniformly, distributed at random position in the both areas. This deployment produces a connected topology under some assumptions; sometimes a completely connected topology is built and sometimes topology is not fully connected. Simulation build a large connected component quickly using a communications radius considerably smaller than the radius needed to have the entire network connected. Agents are located in such place to facilitate communication between wireless areas and minimize the number of hops to achieve optimum throughput of mesh clients which communicate each other. Agents have static position located in the overlapped between two network areas.

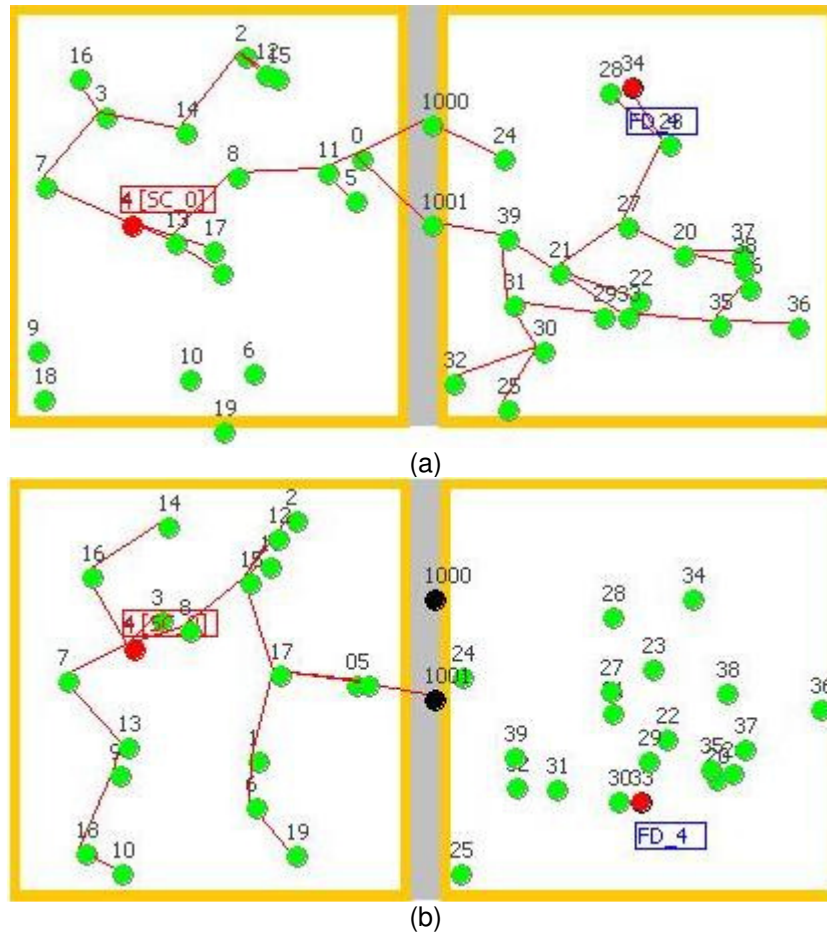


FIGURE 1: Development of network topology within two areas.
 (a) With Agents involved in delivery of packets.
 (b) Without Agents involved in delivery of packets.

This mode of messenger can be made clear from the Figure 1. At Figure 1(a), if the source (node 4 mark with red color) coming from certain clustered network area and having destinations (e.g. node 33) located at different (adjacent) clustered network area, the paths are able to meet at a common Agents (node 1000 or node 1001) simultaneously then only any one of the agents will be sufficient to carry all the messages to the proper destination. Thus our routing scheme utilizes the agents capability where a collection of independent request transmission come together for the purpose of cooperative task behaviors and maintaining these connectivity among pairs of sources - destinations. All these tasks essentially work directly through node - agent communication. The entire algorithm works on the fact that agents need to know the existence of each nodes at each clustered areas. On the other side, at Figure 1(b), predefined source (node 4) start the topology development protocol by sending (broadcast) an initial Hello Message. With receive-transmit subsequent routine, the process continues to all reachable nodes. Not every node will be selected to be part of the tree, and those which were not selected will keep silent (in the propagation of packet). Without any knowledge of destination topology (located in other network area), then the packets must travel to each vertex to reach the destination node. In both pictures, if there are more than one source nodes starts to transmit packets simultaneously, then several trees may be built in parallel.

The Model

Simulation consists of multi clustered network environment of homogeneous nodes that communicate with each other using the broadcast services of IEEE 802.11. There are nodes with different roles simulated in this simulation, namely initiator node/source node, receiver node,

sender node, destination node, and final destination node. Initiator node/source node is node that initiates transmission of packet. Packet can be either route discovery or data transmission. Like other nodes, initiator is always moving with random direction, speed, and distance. At the time it is moving, initiator node is always sensing its neighbor to maintain connectivity. Receiver node is node that can be reached by source/sender node. Nodes are defined as neighbors if it located within its distance radius range. At initial time, node senses its neighbors before packet data is required to be transmitted. Coverage neighbor nodes always receive packets that are broadcasted from sender. Destination node is selected receiver node in multi hop transmission that should relay packets to the next receiver node. Final destination node is node that became the finish destination of packets.

The layered concept of networking was developed to accommodate changes in local layer protocol mechanism. Each layer is responsible for a different function of the network. It will pass information up and down to the next subsequent layer as data is processed. Among the seven layers in the OSI reference model, the link layer, network layer, and transport layer are 3 main layers of network. The framework is configured in those layers. Genuine packets are initiated at Protocol layer, and then delivered sequentially to next layer as assumed that fragmented packets to be randomly distributed. Simulation models each layer owned with finite buffers. Limited buffer makes packets are queued up according to the drop tail queuing principle. When a node has packets to transmit, they are queued up provide the queue contains less than K elements ($K \geq 1$). To increase the randomization of the simulation process, simulation introduces some delay on some common processes in the network, like message transmission delay, processing delay, time out, etc. This behavior will result that at each instance of a simulation would produce different results. The packets exchanged between sender and receiver is of a fixed rate transmission λ based on a Poisson distribution. Nodes that have packet queued are able to transmit it out using in each available bi-directional link channel.

Our work extends the chance of contacting of the agents that arranged at the fixed cluster from nodes which are distributed randomly within the network. Agents navigating through the network for delivering messages must understand these clustered nodes whenever they are initiating a new route request and thereby increasing the degree of spatial coordination (agents must be on the same place). The temporal coordination has been enhanced with the introduction of a short waiting delay offered to each nodes/agents by the clustered overheads packets. This node – agent coordination will reduce the number of hops and waiting time in spite of further increase the overheads packets hang around with agents and head to highly the agent-chasing problem. The place hosted for the clustered agents can be called as the overlapped area within the network and the detainment period by the agents can be called agent periods.

This overlapped area actually offers a temporary space to be used by all agents for sharing network knowledge, and exchanging messages. Thus when an agent comes a fresh it can exploit all other agents who are currently experiencing their agent periods. Here the traveling agents are allowed to carry the information of already visited clusters along with them. The idea behind this is to capture and share the partial network information present with roaming agents. The integration of all such partial information at a common overlapped area helps cooperative tasks like taking the decision for next destination, suitable exchange of messages between agents, getting up-to-date knowledge of the network and reducing unnecessary redundant overhead packets used to visit nodes.

Thus the model of coordination clustered network area where the autonomous agents will be able to deliver messages within a large network with the cooperative communication between them at suitable overlapped area is necessary. There is need of knowing the routes proactively or reactively where part of the network capacity is used for exchanging chunks of routing table data.

We built network simulator to evaluate this proposed algorithm. The simulator supports physical, link and routing layers for single/multi hop ad-hoc networks. We assume that IEEE 802.11 Distributed Coordination Function (DCF) or MAC protocol which uses Channel Sense Multiple

Access with Collision Avoidance (CSMA/CA) already deployed. Successfully received packet by receiver's interface is packet whose SNR is above a certain minimum value otherwise the packets cannot be distinguished from background noise/interference. Packets are transmitting through physical layer in accordance with Poisson distribution. Communication between two nodes in IEEE 802.11 uses TCP signaling before the actual data transmission takes place. Simulation simulates this with random hearing to link's condition. If link allow packets to be sent, then sender executes some packets already queued. To execute preferential event in sequentially distributed events, we used a simple approach that consists of applying a different time-event execution by means of the triggering event sequences action. The lower and upper bound of the queuing interval are set such that they do not interfere with predefined timers used by the other events for layers and modification events.

Nodes

Nodes are equipped with antenna module installed as capable of dynamically adjusting the transmission energy used to communicate with other nodes. Industrial standard of antenna module supports a management for controlling this energy consumption. The energy consumption required to transmit packet between nodes A and B is similar to that energy required between nodes B and A if and only if the distance and the size of packet are same. The coverage distance range of the nodes is a perfect symmetric unit disk (omni-directional). If $dx,y \leq r_x \rightarrow x$ and y can see each other. This assumption may be acceptable in the condition that interference in both directions is similar in space and time; which is not always the case. Usually interference-free Media Access Control (MAC) protocol such as Channel Sense Multiple Access (CSMA) may exist. In addition, wireless link channel is assumed to have no physical noise; i.e., the errors in packet reception due to fading and other external interferences are not considered as a serious problem. Packets from sender to receiver will be transmitted as long as the bandwidth capacity is sufficient and the received signal to noise ratio (SNR) is above a certain minimum value. Thus every packet successfully received is acknowledged at the link layer and de-encapsulate at the higher layer. Each node is capable of measuring the received SNR by analyzing overheard packet. A constant bit error rate (BER) is defined for the whole network. Whenever a packet is going to be sent, a random number is generated and compared to the packet's CRC. If the random number is greater, the message is received, otherwise it is lost. The default value for the BER is 0, which means there is no packet loss due to physical link error.

Energy is power kept in each node. [13] was assumed that the radio dissipates $E_{elec} = 50$ nJ/bit to run the transmitter or receiver circuitry and $\epsilon_{amp} = 100$ pJ/bit/m² for the transmit amplifier. The radio model is shown in the Figure 2 below.

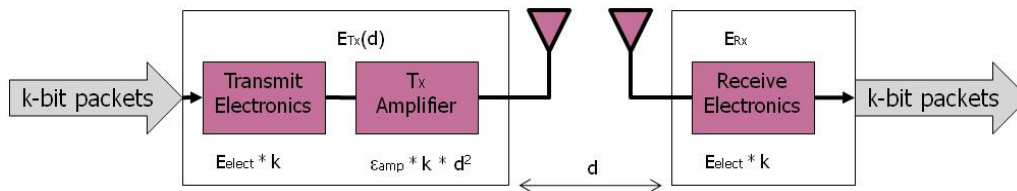


FIGURE 2: The radio model [13].

Thus, to transmit a k-bit message a distance d using this radio model, the radio expends:

$$E_{Tx}(k, d) = E_{Tx-elect}(k) + E_{Tx-amp}(k, d) \tag{1}$$

$$E_{Tx}(k, d) = E_{elect} * k + \epsilon_{amp} * k * d^2$$

and to receive this message, the radio expends:

$$E_{Rx}(k) = E_{Rx-elect}(k) \tag{2}$$

$$E_{Rx}(k) = E_{isect} * k$$

Let E_{min_j} is the minimum energy ratio of node j at which a node can still receive, process, and transmit packets. Node j finds out the energy level of neighbor node i through analyzing of received reply packet from node i as it responded the previous transmitted Hello packets. The computation of E_{min_j} is done through two-step propagations. The use of two-steps propagation model is to simulate interactive propagation in the operation of the protocol in dynamic environment. As a future research, the appropriate propagation model that best matches to this environment should replace the simple two-steps model presented here [10][15][16]. The two-steps propagation model is appropriate for outdoor environments where a line of sight communication existed between the transmitter and receiver nodes and when the antennas are omni-directional. The two-steps propagation model assumes there are two main signal components. The first component is the signal traveling on the line of sight to reached neighbors along with its reply from neighbors and the second component is a confirmation packet transmitted to selected neighbors.

The energy behaviors of node are defined as follow:

- During the idle time, a node does not spend energy. Even though this assumption has been proven untrue because being idle might be as costly as receiving data, this is still an assumption that can be done in most experiments, since the most important factor is the overhead in terms of message exchange and its associated cost.
- The nodes are assumed to have one radio for general communication. The main radio is used in all operations when the node is in active mode, and to send and receive control packets. When this radio is turned off, then no messages will be received and no energy will be used.
- Energy distribution among nodes can either be constant value, normally distributed, Poissonly distributed, or uniformly distributed.

Agents

In this paper we introduce mobile agents to hop around the networks for delivering packets. The agents are allowed to meet with other agents at fixed overlapped places as has been mentioned. The cooperation among agents will mutually benefit each other by cooperating in delivering packets. In this current flexible and decentralized framework any autonomous node can send message to any other node at any instant within the network by just issuing a mobile agent. The agent then communicates with other agents to determine the proper one to carries the message to the corresponding destination node. The selected agent then becomes responsible for delivering the message to proper destination. Analog to the real life, these agents actually play the role of messengers and the selected agent play the role of post offices in the ad hoc wireless scenario. Such cooperation among agents scheme has been explicitly designed to reduce the agent traffic in the network. The unnecessary redundant node visits made by the agents to reach destination node has been avoided by sharing and merging with other agents. These agents take the responsibility of providing communication services and improvement of overall traffic in the network.

While delivering messages, an agent will maintain the path records of all the visited nodes in both clustered networks and its corresponding topology. Carrying this network information provide coordination and share the updated network knowledge with other agents. This information field carries topology tree along with numeric values of this membership list (of nodes) collected from each clustered network. In few cases the length of the information list carried by an agent gets longer due to the course of journey made from agent to reach the proper destination. If this happened, the list has been restricted using the hop count limit in order to avoid a huge series of data to be carried along by an agent and subsequent nodes. No packet is allowed to travel forward further whenever its hop count has got exhausted and it is compelled to move back to its originating source node/agent. Thus whenever an agent has finished its forward journey it will eventually follow the same path back to the source node.

The objective of the navigation procedure is to minimize the hops between the agent at overlapped location (current location of the node where the agent is residing) and the source and destination node's location. This criterion would enable an agent to select a neighbor of its current location and take out the packets to the destination nodes. If there is no neighbor available at that instant of time satisfying the above-mentioned criterion, the agent waits for a pre specified amount of time (randomly) and tries to communicate with other agents (any agents can be reached) to get its knowledge. Such contacted agents will respond the request. Through intensive communication among agents, the best agent can be selected to take responsibility for delivering received packets.

In the simulation, when a source node within the ad hoc network wants to send some packets, it immediately senses whether an agent is needed. Each such agent attaches with itself a topology bag to accommodate the request (certain) destination node. This bag is of a given capacity, which can be made full or can be made empty. The source node after initiating the agent puts the packets to (appropriate) agent. The agents are able to exchange these packets with other agents on having suitable coordination with them, which will have the best route path with minimum hops to reach destination node. These agents will be inactive automatically when there is no more packets need to be delivered.

Because of high degree of mobility, the topology will change and it is assumed that the agent will eventually succeed to migrate [30][31]. Whenever an agent wants to leave its current location for delivering packets to some unknown networks it will collect the topology list information from the nodes and will try to reach for a boundary node through which it may get an exit point. The node lying at the boundary will have neighbors from two or more different agents and can act as gateway nodes to other clustered network area. Thus if an agent can reach such a cluster area boundary, it can start visiting a fresh (other) agents. As the location of the agents can be made available from any node of that same clustered network area it can easily track the new nodes there, which has been compulsory. Though the order of cluster visits take place in a random manner still the redundancy in the path visit has been avoided by maintain the path visit list (using BFS function). The agents are free to roam among the overlapped area within the network in a random manner. This agents' capability will be presented on the next paper.

4. Performance Evaluation

In this section, an evaluation of the framework is discussed and followed by a number of performance issues associated with network traffic and network energy consumption. The following evaluation and subsequent charts are obtained from simulation with 40 nodes. Nodes are randomly positioned in both network areas. There are two scenarios with simulation in order to show the effectiveness of agents, i.e. simulation with agents and simulation without agents. Same initial topologies are created for both scenarios. The simulation then follows its autonomous movement during simulation. To simulate agents, 4 nodes are positioned in the overlap area. Nodes are moving during 10 steps of simulation with speed of 20 km/h. The source is set to transmit packet with length of 10Kbyte to reach final destination, either located in same network area or different network area. The following charts show the energy consumption, span of network and average transmitted packets as parameters change. The energy of network is defined as the period from the beginning of simulation to the end of simulation when all nodes exhaust their energy.

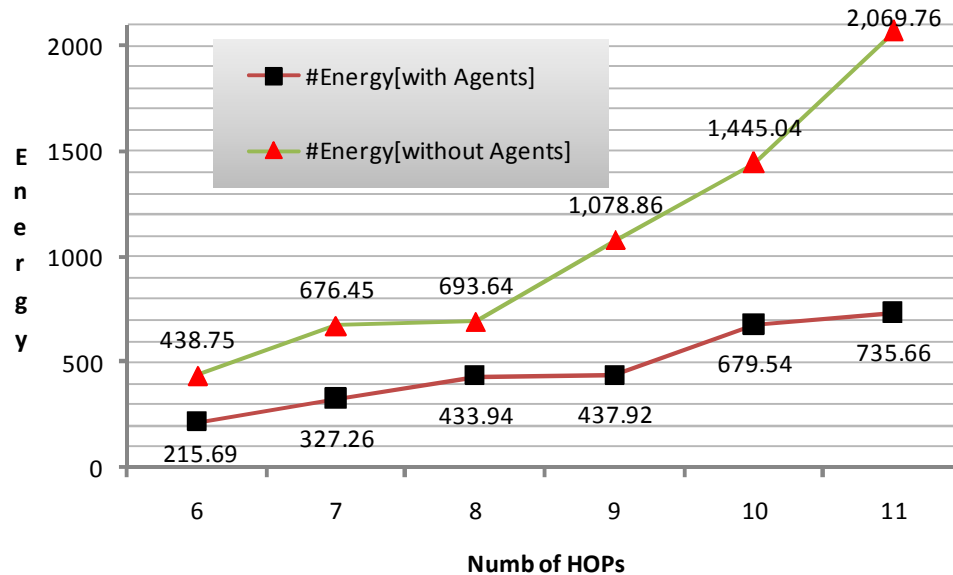


FIGURE 3: The comparison of average energy consumption (in nJ/bit) on nodes in the network using agents and without agents in each successful data transmission with certain number of hops between source and final destination (with pair of source and final destination nodes are located in different network area).

In this set of simulations, we evaluate the performance of schemes with and without agents' mode. CBR is used to send packets and random way-point is adopted as is and the one hop routing discovery is applied. The data packets can be persistently transmitted along the existing route and more energy will be saved. Figure 3 shows the relationships between the network energy consumption and number of hops, for a 10Kbyte file being transferred between source and final destination nodes.

As is shown in the Figure 3, with the performance of both routing scheme stay the same, network achieve low energy consumption as well as longer span-time of network because agents can dynamically limits the propagated packets and consider the residual energy of node in routing setup phase. While the mobility of nodes is high, the advantage of the agents based routing becomes more remarkably. The actual gain in this scheme, expected by the use of agents, ranges around 37% for 64% saved energy. Simulation methods for energy conservation are focus on broadcast energy control and dynamic turning off active nodes in network. Controlling the broadcast energy allows to significantly reduce the energy consumption for data transmission and increase lifetime of the network. Another proposed protocol based on energy management where each node requires the knowledge of its distances to all neighbor nodes, throughput metric, and direction metric is being prepared. Nodes adjust their transmission energy so as to achieve the minimum energy consumption according the neighborhood information.

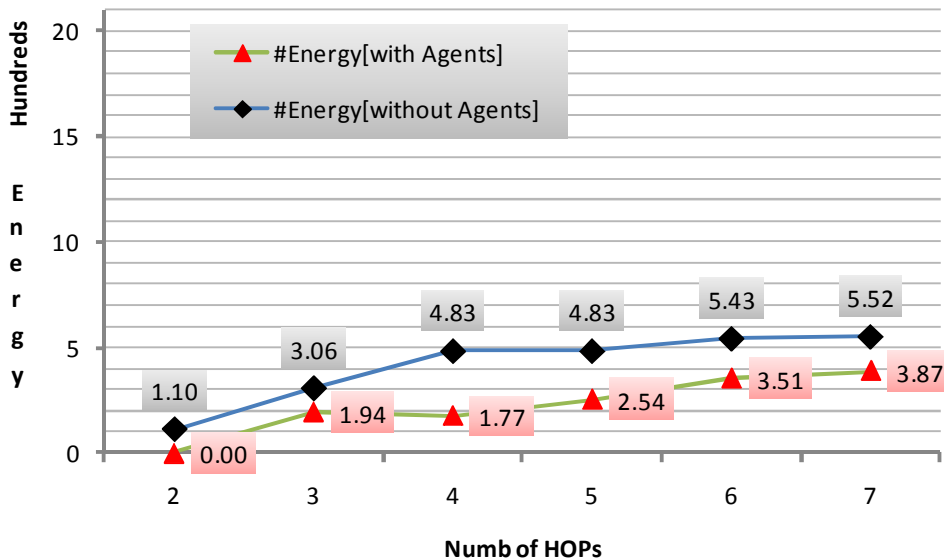


FIGURE 4: The comparison of average energy consumption (in nJ/bit) on nodes in the network using agents and without agents in each successful data transmission with certain number of hops between source and final destination that both located in the same network area.

In the simulation, where source and final destination nodes are located in the same network area, agents also give important results. Communication between source and final destination nodes is set to complete if data packets are received by correct final destination node and its corresponding response packet already arrived at source node. As the traffic load and number of hops increases, high data collision results in more energy consumption as well as end-to-end delay. While the scheme with agents' mode gains energy efficiency because of dynamically reducing the number of waking nodes. Again, network with agents' mode can achieve nearly 50% energy conservation. They prevent packets from propagating to other network areas. With such an agent's capability, the dissipated energy for network to broadcast packets is significantly reduced. It can be shown in Figure 4. Almost for different numbers of hops, the network with agents has lower dissipated energy at the same hops compared with the other without agents. In obtaining this result, the two similar networks are simulated with the same initial topology.

The following chart shows the energy consumption, redundant packets of network and successful transmission as the number of source nodes changes. Simulation is taken with 40 nodes and constant speed of network at 20 km/h. High mobility of nodes will result in more frequent changing of network topology. Logically, the greater the pause time of nodes (the instant time of node to have static position) is, the more stable network topology is and the routing discovery and maintenance will be simple. The data packets can be persistently transmitted along the existing route and more energy will be saved.

Figure 5 and Figure 6 show the dissipated energy consumption for redundant packets as the number of source nodes of network changes. Redundant packets are received by active nodes and then relayed to the next hop in order to reach the final destination, but these packets do not arrive at the correct destination or final destination nodes. These packets exist during wireless network with broadcast mechanism. The behavior of packets is illustrated either pair of source and final destination nodes located in the same network area or different network area. Each of those locations determines different results. We can observe that the energy of network is proportional to the number of source nodes and their neighborhood in network. With the source nodes increasing, the energy of network grows gradually. Since the shortest path based routing scheme uses the maximal transmission energy to send data packets, the increasing number of nodes will not extend the survival time of network. As mentioned in section 3, the topology based

routing adds some packets to gain knowledge of nodes' neighborhood, which increases the size of control packets. As is shown in Figure 5, in the case of network with 40 nodes, the network without agents' scheme consumes more energy because the routing control message guide packets to propagate with more active nodes and brings additional energy consumption.

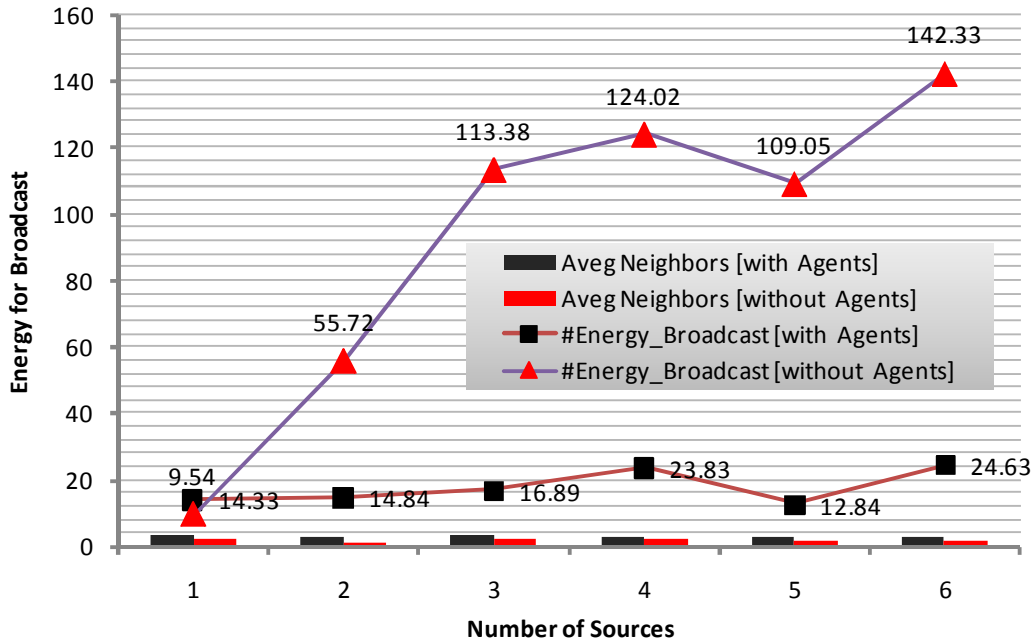


FIGURE 5: The comparison of total Energy dissipated during broadcast of redundant packets for nodes in between the network with agents and without agents (with pair of source and final destination nodes are located in different network area).

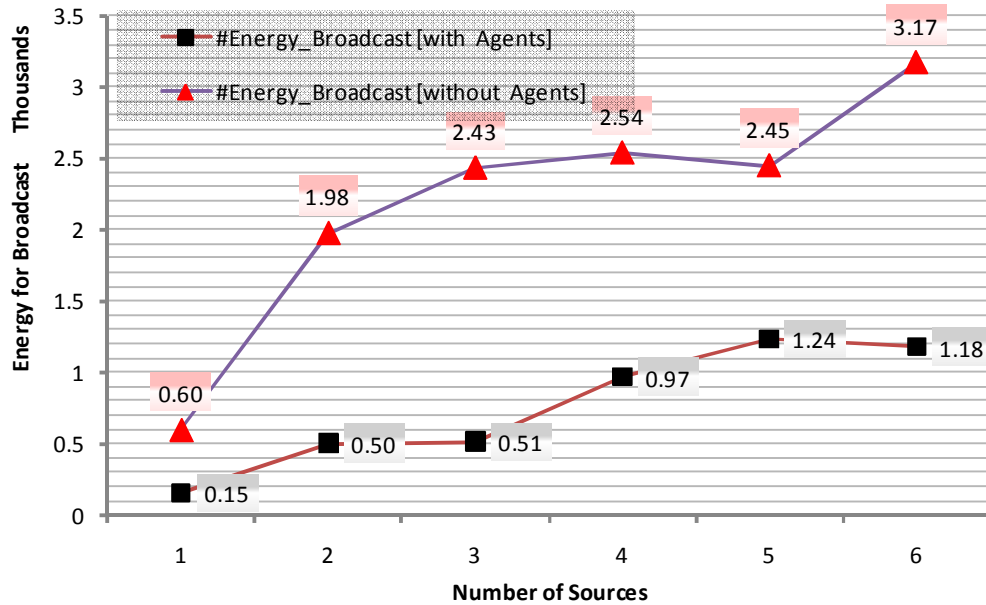


FIGURE 6: The comparison of total Energy dissipated during broadcast of redundant packets for nodes in between the network with agents and without agents (with pair of source and final destination nodes are located in same network area).

First, Figure 5 is considering the situation where the pair of source and final destination is located in different network area. The chart with red marker value shown in Figure 5 is 10% lower than real value for #Energy_Broadcast [without Agents] to make different view with the small value of other with Agents. The chart has slope when number of sources is 5 because the average neighbor in that situation is come down for about 30% compared with the previous. Agents have affected the whole network in reducing broadcast flooding of unnecessary packets. Agents will not propagate packets to next relay nodes if final destination cannot be reached. If such situation happened, agents inform the source to stop the broadcast. They segment the network to make effective the data transmission. Second, even if the source and final destination nodes located in the same network area, agents still play an important role, as shown in Figure 6.

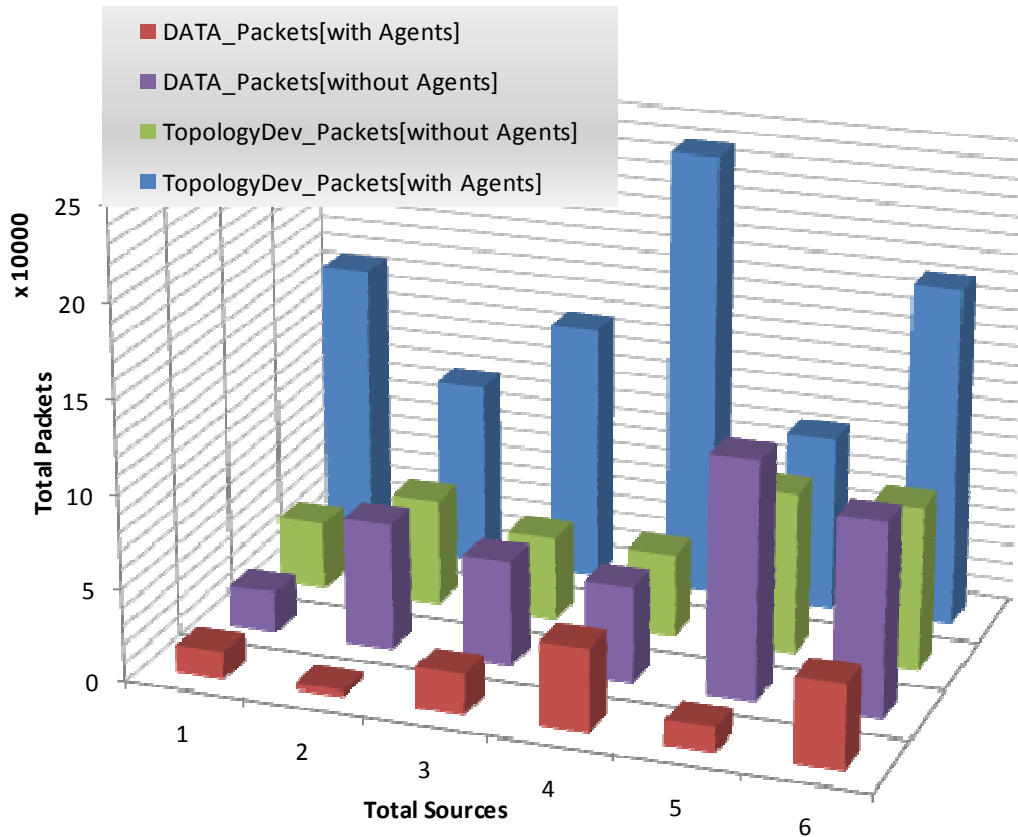


FIGURE 7: Total redundant packets for different number of sources of simulation with agents and without agents (with pair of source and final destination nodes are located in different network area).

These total redundant packets in the network with agents and without agents are illustrated in Figure 7. The previous energy chart in Figure 5 and Figure 6 are made clearer with the total redundant packets propagated during simulation. Although the network with agents is flooded with overhead packets, it experiences fewer redundant data packets (packet with data contained inside). Overhead packets in network with agents are required to prepare agents with knowledge about network topology at its both sides. Depending on nodes' position and neighborhood, agents may or may not able to have route paths to all nodes. If source cannot contact agents to reach final destination, it gives up sending packets. With the same situation, if final destination node cannot be reached by agents, immediately agents notify the source. Such this agent's behavior, it gives significant effect because most data packets have size longer. If nodes receive and relay

redundant packets, they will consume energy which actually could be saved for other execution (useless).

5. DISCUSSION

In this research, we focus on the impact of energy models on the performance of data packets transmission in the large MANET that segmented into two domain areas. Significant academic and industrial research that led to the development of a variety of MANET protocols, and also the development of platforms and architectures for reliable communication provided by the MANET assumed that reliable communication mostly be provided in the single uniform network. Research approached in the field, like SANDMAN [34] and DEAPSpace [33], is done by grouping nodes with similar mobility patterns into clusters in one network area; where in each cluster/group, one of the nodes (called cluster head) stays awake permanently and answers discovery requests. However, by splitting the network into independent layer 3 domains, it has been shown that the small domains allow energy dissipated, average energy consumption, and flooding of overhead packets to operate limitary on fewer nodes, with cross-domain interaction only through overlapped area nodes. This division has several key benefits. First, it reduces overall protocol overhead. Second, it made network life time longer. Nodes have salient feature of energy-constrained devices. The battery of node is depleted by: (i) computational processing and (ii) transmission/reception of signal to maintain the signal-to-noise ratio above a certain threshold. Although the energy consumption by computations can be further reduced with new developments in low power devices, the energy consumption by communications cannot be overcome. Therefore, partitioning network into smaller domain is essential to develop efficient networking algorithms and protocols that are optimized for energy consumption. As a consequence, when partitioning a big network into domains, there are some engineering rules that need to be taken into account. For example, the partitions should minimize the expected traffic among different areas so as to not overload the overlapped area; there must be at least one path between every pair of nodes in certain area and the nodes in overlapped area, and at least one path must exist from overlapped area to nodes that belong to other area for such transmission exchange-area to be successfully take place; there must be at least one node that existed in the overlapped area to act as an relay exchange-area domain. Such nodes are called agents. Agents ensure that no single area suffers adversely from a disproportionately large volume of overhead and data packets.

As in line with our previous research results [1], this proposed framework implemented broadcast oriented scheme to construct and maintain such network topology. Compared with topology control oriented scheme, this framework emphasize the broadcast process from a given source node by means of the minimum-energy broadcast tree. It has condition that the source can reach every node of the network. While other researcher, e.g. [32], describes a localized protocol where each node requires only the knowledge of its distance to all neighboring nodes and distances between its neighboring nodes (or, alternatively, geographic position of itself and its neighboring nodes), while our proposed framework optimized the broadcast mechanism by means of energy level and distance metrics. We compare the performance of the network life time that consist of two network areas either with agents or without agents. The performance of both schemes degrades while number of source nodes increase. Especially, the energy consumption of the network without agents grows drastically under high traffic, which results in poor survival time of network. When the traffic load is high, more packets need to be transmitted. In the network with agents, the propagation mechanism is analyzed before relaying packets so as to effectively save energy. Furthermore, since the residual energy of nodes is also considered in such routing function, it can achieve load balance and extend life-span of network. It needs to propose the optimal transmitting energy of the nodes in the routing setup stage. This mechanism will be covered in the next research.

6. CONSLUSION & FUTURE WORK

In this paper, we present an energy management model which can effectively reduce energy consumption in MANET. Mobile nodes in such model transfer packets between pairs of source

and final destination nodes in multiple network area modes. Simulation is intensively conducted and it triggered by communication events execution. Base on the agents' existence, we evaluate routing protocol with joint function considering both transmission energy and agents' connectivity. This framework is analyzed and compared its performance to similar network without existence of agents. Simulation experiments show that the proposed agents with energy control mode can achieve higher performance and extend the life-span of network. In the future research, we will try to effectively reduce the end to-end delay with agents' capability, evaluate the agents with higher mobility of nodes, and proposed optimal transmitting energy in the routing setup.

7. REFERENCES

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