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Chapter 1 : Energy Efficient Link Aware Routing with Power Control in Wireless Ad Hoc Networks

Energy Issues and Energy aware Routing in Wireless Ad-hoc Networks receives this packet but it cannot decode it. These two problems generate loss of energy.

Source node receives route reply packets. Choose node with min cost function as relay node. Source node chooses power level for transmitting nodes. Monitor link for failure. Relay node sends error notification message to source. Source initiates route discovery process. Results and Discussion The proposed scheme has been tested through simulation against the existing protocol AODV [1]. The constant CBR traffic of bytes is generated at a constant data rate of 11 Mbps and the nodes are assumed to transmit at a max power level of 15 dBm, with variable power level of 10 dBm and 12 dBm. The frequency of node movement can be varied by varying the pause time. The path loss exponent is set as 4. The simulation is run for s and the radio transmission range is m. The simulated network is shown in Figure 2. Throughput and end-to-end delay are the most important metrics for evaluating best-effort traffic and the routing overhead evaluates the efficiency of the routing protocol [18]. Packet Delivery Ratio It is defined as the number of data packets delivered to the destination to the number of packets generated by the CBR traffic source. Figure 3 shows the packet delivery ratio under different pause times. This is due to the fact that mobile nodes may cause packet losses, which in the proposed scheme is overcome due to the availability of the forwarding candidate nodes. Packet delivery ratio versus pause time. Figure 4 shows the packet delivery ratio under different node speeds considering the mobile nature of the wireless ad hoc network. Packet delivery ratio versus node speed. Normalized Routing Overhead It is defined as the ratio of the control packets transmitted to the total number of data packets delivered to the destination. Figure 5 shows the routing overhead incurred due to route discovery and route rediscovery processes. Normalized routing overhead versus pause time. Packet Drop Ratio It is the total number of packets dropped out of the total number of packets generated by the sources. Figure 6 shows the packet drop ratio when the nodes are made mobile with different pause times. Packet drop ratio versus pause time. End-to-End Delay It is the time interval between the generation time at the source and the arrival time of the packets at the destination and includes buffering of packets, route discoveries, and transmission, retransmission, and propagation delays. Figure 7 illustrates that the end-to-end delay incurred in a mobile network, using the proposed protocol, is appreciably less than that incurred in the existing protocol. End-to-end delay versus pause time. Total Energy Consumption It is the total energy consumed in the network for the transmission of all the packets from source to destination. Figure 8 shows the total energy consumed in the network for the packet transmission while varying the pause time of the mobile nodes. This in turn improves the lifetime of the network and therefore there is increased traffic carrying capacity. Total energy consumption in the network versus pause time. Average Residual Energy It is the amount of energy available with the nodes at the end of packet transmission. It is an important parameter for monitoring the lifetime of the battery powered mobile network. Average residual energy versus pause time. Network Lifetime The network lifetime is a measure of the network disconnectivity when a node is completely depleted of its energy. Since the proposed protocol considers the energy level of the node while making the relay node selection, the scheme achieves increased network lifetime when compared to the existing scheme. Figure 10 shows that the network lifetime increases with increase in the network size in the proposed scheme due to knowledge of the residual energy and link state of the nodes. When the number of nodes is less from 5 to 15, the network lifetime increases but there is no appreciable change when the node numbers increase rapidly. Network lifetime versus number of nodes. Execution Time Figure 11 shows the difference in the execution of the two protocols. Execution time versus node density. The proposed protocol requires more resources for computation but the difference is very marginal. This may be contributed due to the selection of relay nodes according to the multiple metrics instead of the single metric computation. As node density increases, more nodes are available as relay nodes and the computation increases. From all the comparative studies carried out, it is shown that the proposed approach achieves significant improvement in the performance of the wireless network in a mobile environment. It uses the concept of discovering routes based on the energy level and the instantaneous link quality. A variable transmit power level has been implemented and the evaluation using simulations shows that the proposed protocol improves the network performance in terms of various QoS parameters when considering the multiple metrics for routing when compared to the existing single metric based routing protocol. Conflict of Interests The authors declare that there is no conflict of interests regarding the publication of this paper. View at Google Scholar C. View at Scopus M. View at Scopus R.

Chapter 2 : A Distance-Based Energy Aware Routing Algorithm for Wireless Sensor Networks

Marco Fotino and Floriano De Rango (January 30th). Energy Issues and Energy Aware Routing in Wireless Ad Hoc Networks, Mobile Ad-Hoc Networks Xin Wang, IntechOpen, DOI: / Available from: Marco Fotino and Floriano De Rango (January 30th). Energy Issues and Energy Aware Routing.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license http: This article has been cited by other articles in PMC. Abstract Energy efficiency and balancing is one of the primary challenges for wireless sensor networks WSNs since the tiny sensor nodes cannot be easily recharged once they are deployed. Up to now, many energy efficient routing algorithms or protocols have been proposed with techniques like clustering, data aggregation and location tracking etc. However, many of them aim to minimize parameters like total energy consumption, latency etc. In this paper, a Distance-based Energy Aware Routing DEAR algorithm is proposed to ensure energy efficiency and energy balancing based on theoretical analysis of different energy and traffic models. During the routing process, we consider individual distance as the primary parameter in order to adjust and equalize the energy consumption among involved sensors. The residual energy is also considered as a secondary factor. In this way, all the intermediate nodes will consume their energy at similar rate, which maximizes network lifetime. Simulation results show that the DEAR algorithm can reduce and balance the energy consumption for all sensor nodes so network lifetime is greatly prolonged compared to other routing algorithms. Introduction Wireless sensor networks WSNs have received lots of attention in recently years due to their wide applications like military and disaster surveillance, industrial product line monitoring, agricultural and wildlife observation, healthcare, smart homes, etc. Cheap and tiny sensor nodes are usually randomly deployed in a physical environment to be monitored and they will transmit their collected data to certain remote sink node or base station in an autonomous and unattended manner. Energy efficiency and balancing is one of the primary challenges to the successful application of WSNs since the sensor nodes are powered with limited batteries and they cannot be easily recharged once deployed. Up to now, many energy efficient routing algorithms or protocols have been proposed with techniques like clustering, data aggregation, multi-path and location tracking, etc. However, many of them aim to minimize parameters like total energy consumption or delay during the routing process, which might cause some hotspot nodes as well as a partitioned network due to the overuse of certain nodes. Since the network lifetime is usually defined as the time when the first node dies from lack of energy, huge amounts of energy will be wasted by the remaining sensor nodes. Hop number and hop distance have a very important impact on many network metrics like energy consumption, routing overhead, interference, latency, etc. Intuitively, if the hop number is too large, the energy consumption can be reduced at the cost of long end-to-end latency and large control overhead. If the hop number is too small e. Therefore, an optimal hop number with suitable individual distance s needs to be deduced as a tradeoff in order to achieve energy reduction and energy balancing. Hotspot problems are caused by an unbalanced energy consumption among the sensors [2 â€” 5]. It is a big challenge to overcome under the random and dynamic topology of WSNs. Besides, the routing scheme and traffic pattern vary under different applications, which add to the difficulty of energy balancing and will usually lead to hotspot nodes and partitioned networks. For example, when all sensors use direct transmission, the nodes far away from sink node will die earlier since the energy consumption is proportional to the fourth order of the long distance. Meanwhile nodes close to the sink node will have much residual energy. On the other hand, when multi-hop transmission is used, nodes near a sink node will have more traffic to forward and will die quickly while nodes far from a sink node will have much remaining energy by using short distance multi-hop transmission. To effectively alleviate the hotspot problem, we need to balance energy consumption among all sensors by considering factors like manner of transmission, traffic patterns, hop number and distance, etc. Based on our previous work in [5], we find that the final residual energy is still not well balanced when the first node dies, even though the energy consumption is largely reduced and the network lifetime is extended. The main reason is that in [5] we tried to minimize the total energy consumption on each route so that some nodes close to sink node are overused, which causes a hotspot problem. In order to alleviate the hotspot problem, we study the energy consumption under different energy and traffic models and aim to let all sensor nodes consume their energy at similar rate. In other words, we are not trying to Min.

Chapter 3 : Energy Aware Clustered Based Multipath Routing in Mobile Ad Hoc Networks

Energy aware issues of routing protocols in Abstract - A MANET is group of wireless devices which Restricted physical security-Ad hoc networks are.

 Abstract In wireless ad hoc networks, the traditional routing protocols make the route selection based on minimum distance between the nodes and the minimum number of hop counts. Most of the routing decisions do not consider the condition of the network such as link quality and residual energy of the nodes. Also, when a link failure occurs, a route discovery mechanism is initiated which incurs high routing overhead. If the broadcast nature and the spatial diversity of the wireless communication are utilized efficiently it becomes possible to achieve improvement in the performance of the wireless networks. In contrast to the traditional routing scheme which makes use of a predetermined route for packet transmission, such an opportunistic routing scheme defines a predefined forwarding candidate list formed by using single network metrics. In this paper, a protocol is proposed which uses multiple metrics such as residual energy and link quality for route selection and also includes a monitoring mechanism which initiates a route discovery for a poor link, thereby reducing the overhead involved and improving the throughput of the network while maintaining network connectivity. Power control is also implemented not only to save energy but also to improve the network performance. Using simulations, we show the performance improvement attained in the network in terms of packet delivery ratio, routing overhead, and residual energy of the network. Introduction Wireless ad hoc networks have a wide variety of applications which include disaster management, emergency rescue operations, monitoring, and surveillance. They command vast deployment due to the lack of infrastructure requirement and easy deployability. But these ad hoc networks suffer in terms of two major resources, energy and bandwidth. Most of the devices are battery powered and the optimal utilization of the power becomes a critical issue. It becomes important to implement an energy aware scheme that would achieve a better network performance. Routing in wireless ad hoc networks is a demanding issue especially while considering the unreliable wireless links and the rapidly diminishing node energy. The traditional routing protocols [1 , 2] discover a single fixed path between the source and destination that mainly considers the distance metric and the hop count. But the wireless ad hoc network is subject to frequent link breaks, due to the mobility of the nodes and the depleted energy level. It becomes important to include the nature of the wireless channel and the energy levels while making routing decisions. Opportunistic routing [3] makes use of the broadcast nature of the medium in which the packets are broadcasted instead of the unicast packets. All the nodes that are within the transmission radius of the sending node coordinate to select the best possible relay. Biswas and Morris [4] proposed ExOR which adopts batch transmission of packets, uses the Expected Transmission Count as the metric, and works better than traditional routing schemes but suffers from duplicate packet transmission. The authors Hsu et al. The authors in [7] have proposed a routing protocol that considers the quality of the communication links while selecting the route. Most wireless nodes are aware of location information and geographical routing protocols such as Greedy Perimeter Stateless Routing [8], Geographic Random Forwarding [9], and Beacon Less Routing [10] make use of their location information to make routing decisions. As many forwarding nodes are involved, the probability of correct transmission through at least one forwarding node increases when compared to the conventional routing schemes. It has been shown in literature [11] that the throughput capacity of the network can be greatly increased since the forwarding reliability increases. There has been extensive work done in the area of power control schemes [13 â€” 15]. Jantti and Kim [16] have achieved improvement in the lifetime of the network with the implementation of joint routing and variable rate transmissions. Most of these schemes have shown that optimization of transmit power level would increase the lifetime of the network and increase the spatial reuse. In this paper, we first propose a novel energy and link quality aware routing scheme which selects optimal forwarding candidates. The route discovery also includes calculation of optimal transmit power by classifying the nodes into clusters based on the transmission radius. Constant link monitoring also ensures route discovery before the failure of the node. To address these issues, a novel approach is proposed in this paper which considers energy and link quality during the routing decisions. The contributions of this paper are as follows. The problem of energy efficient routing is addressed, by taking the SNR, link quality, and residual energy into consideration. A variable power level is used for packet transmission based on the distance between nodes, which results in minimization of the power consumption, leading to more residual energy, thereby increasing the lifetime of the network. A constant link monitoring with error notification addresses the issue of high overhead incurred due to the usage of periodic control packets. Materials and Methods The lifetime of a wireless network can be extended by proper selection of relay nodes that act as forwarding candidates. The selection of a nearby short hop neighbour would be a better choice than a long distance neighbour, since it would consume more power. In this protocol, a relay node is selected from a set of potential forwarding candidates based on multiple metrics of link quality and residual energy which is an extension of the traditional AODV protocol that works on a single distance metric. A variable adaptive transmit power level is used for packet transmission based on the range of distance of the destination node. The flow diagram of the proposed methodology is shown in Figure 1. The algorithm is divided into computation of selection metric, selection mechanism, monitoring of link failure, and implementation of power control.

Chapter 4 : CiteSeerX â€" Implementing an Energy Aware Issues in MANET by Designing Efficient Routing

In this paper, we present a clustering-based energy aware secure routing protocol that computes trustworthy and energy efficient secure routes for wireless ad hoc networks (WANETs). Clustering in ad hoc networking paradigm is very useful for achieving scalability and robustness as it helps to save.

This is mainly due to the mobility of nodes. The nodes in the network not only act as hosts but also as routers that route data to or from other nodes in network. In mobile ad-hoc networks a routing procedure is always needed to find a path so as to forward the packets appropriately between the source and the destination. The main aim of any ad-hoc network routing protocol is to meet the challenges of the dynamically changing topology and establish a correct and an efficient communication path between any two nodes with minimum routing overhead and bandwidth consumption. The design problem of such a routing protocol is not simple since an ad-hoc environment introduces new challenges that are not present in fixed networks. The simulation is carried out using network simulator NS The performance metrics used for evaluation are packet delivery ratio, throughput, and energy consumption. These protocols offer varying degrees of efficiency. This paper aims to find out an energy efficient routing protocol. It also aims to limit power consumption of mobile nodes in the network in order to prolong the network life time. This can be done by measuring energy with respect to network size and taking into consideration the remaining battery power [1]. They do not use any access points to connect to other nodes [1]. It must be able to handle high mobility of the nodes. Routing protocols can be mainly classified into 3 categories -Centralized versus Distributed -Static versus Adaptive -Reactive versus Proactive In centralized algorithms, all route choices are made by a central node, while in distributed algorithms, the computation of routes is shared among the network nodes. In static algorithms, the route used by source destination pairs is fixed regardless of traffic condition. It can only change in response to a node or link failure. This type of algorithm cannot achieve high throughput under a broad variety of traffic input patterns. In adaptive routing, the routes used to route between source-destination pairs may change in response to congestion. These routing protocols update the routing table information either periodically or in response to change in the network topology. The advantage of these protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput, especially in the case of a large number of high node mobility. There are various types of Table Driven Protocols: When a route is found, the route maintenance is initiated to maintain this route until it is no longer required or the destination is not reachable. The advantage of these protocols is that overhead messaging is reduced. One of the drawbacks of these protocols is the delay in discovering a new route. The different types of reactive routing protocols are: In hybrid routing a combination of proactive and reactive routing methods are used which are better than the both used in isolation. It includes the advantages of both protocols. As an example facilitate the reactive routing protocol such as AODV with some proactive features by refreshing routes of active destinations which would definitely reduce the delay and overhead so refresh interval can improve the performance of the network and node. These protocols can incorporate the facility of other protocols without compromising with its own advantages. Packet delivery ratio It is the ratio of the data packets delivered to the destinations to those generated by the sources. Energy consumptionThis is the ratio of the average energy consumed in each node to total energy. Throughput The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packets arriving at the sink per ms. Simulation Environment Ns-2 simulator was used in our simulations. The following parameters given in the table 1 are use for the simulation. The following are the observations from the above graphs 1. TORA has a poor packet delivery ratio than all the other protocols. TORA is consuming the maximum energy. More research is needed to combine and integrate some of the protocols presented in this paper to keep MANETs functioning for a longer duration. ACM Press, , pp. Danxia, Research on multicast routing protocols for mobile ad-hoc networks, Science Direct Vol. Protocol Design Shiva Prakash, J.