ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

INCREASING THE LIFETIME OF MANETS BY POWER AWARE PROTOCOL - SPAN

K. SARAVANAN[1], T.VELMURUGAN[2], A. BAGUBALI[3]
[1]Professor, School of Electronics Engineering, VIT University, Vellore,
[2]Asst.Prof (SG), School of Electronics Engineering, VIT University, Vellore,
[3]Asst.Prof, School of Electronics Engineering, VIT University, Vellore,
[1] kasisaravanan@vit.ac.in, [2] velu_251@rediffmail.com, [3]bagubali@vit.ac.in

ABSTRACT

Energy consumption is a critical issue for battery-powered mobile devices in ad hoc networks. Ad hoc wireless networks are power constrained since nodes operate with limited battery energy. If the routing protocol is not power aware, nodes simply get drained out of energy not being able to send, receive or forward packets to the destinations, thus degrading the performance of the network and network lifetime. Thus, routing protocols should be designed along with features of power aware protocols. This paper presents 'Span' a power aware protocol which is exploited by the routing protocols to increase the lifetime of networks.
Keywords: *MANET, Coordinator, Power Aware Protocol, Increasing Lifetime*

1. INTRODUCTION

Wireless mobile networks and devices are becoming increasingly popular as they provide users access to information and communication anytime and anywhere. The nodes in a mobile ad hoc network intercommunicate via single-hop and multi-hop paths in a peer-to-peer fashion. Intermediate nodes between a pair of communicating nodes act as routers. Thus the nodes operate both as hosts as well as routers. The nodes in the ad hoc network could be potentially mobile, and so the creation of routing paths is affected by the addition and deletion of nodes. The topology of the network may change randomly, rapidly, and unexpectedly.

One critical issue for almost all kinds of portable devices supported by battery powers is *power saving*. Without power, any mobile device will become useless. Battery power is a limited resource, and it is expected that battery technology is not likely to progress as fast as computing and communication technologies do. Hence, increasing the lifetime of batteries is an important issue, especially for MANETS, because batteries support MANETs widely.

One of the significant objective in wireless mobile networking is to minimize the energy utilization [3],[8].As mobile devices consume more power frequently in the wireless network interface, enough progress has been made on low –power hardware design [4], [10] for mobile devices. In view of the fact that the network interface could be often inactive, radio can be turned off when it is not working in order to save power. In practice however, this approach is not straight forward: a node should be required to turn its radio in active mode not just to transmit packets , but also to obtain packets addressed to it and to contribute in any high-level steering and manage packets. The constraint of support between power reduction and routing protocols is for the most part sensitive in the case of multi-hop adhoc wireless networks, where nodes must transmit packets for each other. Bringing together of power reduction with routing in ad hoc wireless networks is the focus of this study

2. FEATURES OF POWER SAVING PROTOCOL-SPAN

A good power-reduction management technique for wireless ad-hoc networks should have the subsequent qualities. It must permit as numerous nodes as probable to switch off their radios receivers most of the time, in view of the fact that still an unused receiver circuit can put away exactly as much energy as an active transmitter. In contrast, it should transmit packets between any source and destination with simply more delay than if all the nodes were alert. From above situation it is obvious that enough nodes must stay alert to form a coupled backbone.

The algorithm for picking this backbone should be distributed, requiring each node to make a local decision. In addition, the backbone formed by the

Journal of Theoretical and Applied Information Technology
20th August 2013. Vol. 54 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

alert nodes should offer about as much total facility as the novel network, since otherwise overcrowding may increase. This means that paths that could function without interference in the novel network should be represented in the backbone. For example, Figure 1 illustrates a topology that violates this principle. In this topology, black nodes are coordinators.

Nodes that are within radio range of each other are connected by solid or dotted lines. Packets between nodes 3 and 4 may contend for bandwidth with packets between nodes 1 and 2 (solid lines). On the other hand, if node 5 was a coordinator, node 3 can send packets to node 4 via the path shown by the dotted arrow, and no contention would occur.

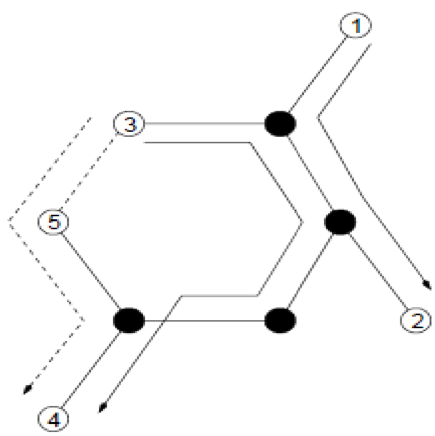

Figure.1:Backbone Network

Figure.1: Shows a connected backbone does not necessarily preserve capacity. In this connected topology, black nodes are coordinators. Nodes that are within the radio range of each other are connected by solid lines or dotted lines. Solid lines represent connections to and between coordinators. Packets between nodes 3 and 4 may contend for bandwidth with packets between nodes 1 and 2. On the other hand, if node 5 was a coordinator, no contention would occur.

A good management practice should not make any assumptions about the link layer's services for being dead to the world; it should work with any link-layer that provides for sleeping and episodic polling, including 802.11's ad-hoc power saving mode. Finally, power reducing should inter-operate correctly with whatever routing scheme the ad-hoc network uses.

The algorithm presented in this paper, span, fulfils the above requirements. Each node in the network running period makes episodic, local decisions on whether to slumber or stay alert as a controller and contribute in the forward backbone topology structure. To preserve capacity, a node volunteers to be a coordinator if it discovers, using information is gathered from local broadcast messages, that two of its neighbors cannot be in contact with each other in straight or through one or two active coordinators[6]. To keep the number of out of work coordinators short and turn around this task amongst all nodes, each node delays announcing its readiness by a unsystematic period that takes two factors into account: the amount of residual battery energy, and the number of pairs of neighbors it can connect collectively. This grouping ensures, with high likelihood, a capacity-preserving connected backbone at any point in time, where nodes tend to consume energy at about the same rate. Span does all this using only local information, and consequently scales well with the number of nodes. Simulation results, with energy parameters from measurements of today's 802.11 wireless interfaces, show significant reduction in energy consumption and increase in network lifetime using span when without affecting the throughput.

3.SPAN DESIGN

Span [1] adaptively elects "coordinators" from all nodes in the network. Span coordinators stay alert always and perform multi-hop packet forwarding within the ad hoc network, while other nodes stay in power-saving mode and regularly check if they should wake up become a coordinator.

Span achieves four goals. First, it make sure that enough coordinators are chosen so that every node is in radio range of at least one coordinator. Second, it rotates the coordinators in order to make sure that all nodes divide the task of providing global connectivity approximately equally. Third, it attempts to diminish the number of nodes chosen as coordinators, thereby rising network lifetime, but lack of suffering a important loss of capacity or an rise in latency. Fourth, it elects coordinators using only local information in a decentralized method- each node only consults condition stored in local routing tables during the election procedure.

Span is proactive: each node at regular intervals broadcasts HELLO messages that include the node's status (i.e , whether or not the node is a coordinator), its current coordinators, and its

Journal of Theoretical and Applied Information Technology
20th August 2013. Vol. 54 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

current neighbors. From these HELLO messages, each node constructs a list of node's neighbors and coordinators, and for each neighbor, a list of its neighbors and coordinators.

Routing layer	GPSR	DSR	AODV
	Span		
MAC/PHY	802.11		

Figure.2: Span Protocol

Figure.2: shows a Span is a protocol that operates under the routing layer and above the MAC and physical layers. The routing layer uses information Span provides, and Span takes advantage of any power saving features of the underlying MAC layer.

As shown in figure 2 , Span runs above the link and MAC layers and interacts with the routing protocol. This structuring allows Span to take advantage of power-saving features of the link layer protocol, while still being able to affect the routing process. For example, non-coordinator nodes can periodically turn on their radios and listen or poll for their packets[7]. Span leverages a feature of modern power-saving MAC layers, in which if a node has been asleep for a while, packets destined for it are not lost but are buffered at a neighbor. When the node awakens, it can retrieve these packets from the buffering node, typically a coordinator. Span also requires a modification to the route lookup process at each node- at any time, only those entries in a node's routing table that correspond to currently active coordinators can be used as valid next-hops (unless the next hop is the destination itself).

A Span node switches situation from time to time between being a controller and being a non-controller. A node includes its present state in its HELLO messages. The following sections expain how a node make a decision that it should proclaim that it is a coordinator, and how it decides that it should remove from being a controller.

3.1 Coordinator Announcement

At regular intervals a non-coordinator node determines if it should become a coordinator or not. The following coordinator eligibility rule in Span make sure that the whole network is covered with enough coordinators:

Coordinator eligibility rule: A non-coordinator node should become a coordinator if it discovers, using only information gathered from local relay messages, that two of its neighbours cannot arrive at each other directly or via one or two coordinators.

This selection algorithm does not give away the least number of coordinators necessary to merely maintain connectedness. However, it roughly make sure that that every populated radio range in the whole network contains minimum of one coordinator. Because packets are routed through coordinators, the resulting coordinator topology should yield good capacity.

Announcement argument happens when multiple nodes find out the lack of a coordinator at the same time, and all make a decision to become a controller or coordinator. Span resolves the argument by delaying coordinator announcements with a randomized backoff delay. Each node chooses a delay value, and delays the HELLO message that announces the node's volunteering as a controller for that quantity of time. At the end of the delay, the node revaluates its capacity based on HELLO messages recently received, and makes its announcement if and only if the capacity rule still holds.

Range of factors is considered in the derivation of the backoff delay. Consider first the case when all the nodes have roughly equal energy, which implies that only topology should play a role in deciding which nodes become coordinators. Let N_i be the number of neighbors for node i and let C_i be the number of additional pairs of nodes among these neighbors that would be connected if i were to be become a coordinator and forward packets. Clearly, $0 \le C_i \le (2^{N_i})$. $(C_i/2^{N_i})$ is called the utility of node i. If nodes with high C_i becomes coordinators, fewer coordinators in total may be needed in order to make sure every node can talk to a coordinator; thus a node with a high C_i should volunteer more quickly than one with smaller C_i.

If there are multiple nodes within radio range that all have the same utility, then Span prevents too many of them becoming coordinators. This is because such coordinators would be redundant- they would not increase system capacity, but simply drain energy. If the potential coordinators make their decisions simultaneously, they may all decide to become coordinators. If, on the other hand, they decide one at a time , only the first few

Journal of Theoretical and Applied Information Technology
20th August 2013. Vol. 54 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

will become coordinators, and the rest will notice that there are already enough coordinators and go back to sleep. To handle this, we use a randomized "slotting-and-damping" method reminiscent of techniques to avoid multiple retransmissions of lost packets by multicast protocols, such as XTP [2], IGMP [3] and SRM [4]: The delay for each node is randomly chosen an over an interval proportional to N_i *x* T, where T is the round-trip delay for a small packet over the wireless link. Thus, when all the nodes have roughly equal energy, the above discussion suggests a backoff delay of the form:

$$Delay = ((1-C_i/2^{Ni})+R)xN_ixT \qquad (1)$$

Randomization is achieved by picking R uniformly at random from the interval (0 ,1).

Consider the case when nodes have unequal energy left in their batteries. We observe that what matters in a heterogeneous network is not necessarily the absolute amount of energy available at the node, but the amount of energy scaled to the maximum amount of energy that the node can have. Let E_r denote the amount of energy (in joules) at a node that still remains, and E_m be the maximum amount of energy available at the same node. A reasonable (but not the only) notion of fairness can be achieved by ensuring that a node with a larger value of E_r/E_m is more likely to volunteer to become a coordinator more quickly than the one with a smaller ratio. Thus, we need to add a decreasing function of E_r/E_m that reflects this, to equation 1. There are an infinite number of functions, from which I choose a simple linear one: $1 - E_r/E_m$. In addition to its simplicity, this choice is attractive because it ensures that the rate with which a node reduces its propensity to advertise (as a function of the amount of energy it has left), is constant.

Considering this with equation 1 yields the following equation for the backoff delay in Span:

$$\text{Delay} = ((1-E_r / E_m)+(1-C_i/2^{Ni}) + R) \text{ x } N_i \text{ x } T \qquad (2)$$

Observe that the first term does not have a random component; thus If a node is running low on energy, its propensity to become a volunteer is guaranteed to diminish relative to other nodes in the neighborhood with similar neighbors.

In a network with uniform density and energy, our election algorithm rotates coordinators among all nodes of the network. It achieves fairness because the likelihood of becoming of a coordinator falls rule adapts to non-uniform topology: a node that connects network partitions together will always be elected a coordinator. This property preserves capacity over the lifetime of the network. Because of Span's emphasis on capacity-preservation to the extent possible, such critical nodes will unavoidably die before other less-critical ones. However, in a mobile Span network, a given node is rarely stuck in such a position, and this improves fairness dramatically.

3.2 Coordinator Withdrawal

Each coordinator at regular intervals checks if it has to withdraw as a coordinator. A node should remove if every pair of its neighbors can attain each other either directly or via one or two other controllers or coordinators. In order to also rotate the coordinators among all the nodes fairly, after a node has been a coordinator for some time, it marks itself as a tentative coordinator if every pair of neighbor nodes can reach each other via one or two other neighbors, even if those neighbors are not at present controllers. A tentative coordinator can still be used to forward packets. However, the coordinator announcement algorithm described above treats a tentative coordinator as a non-coordinator. Thus, by marking itself as tentative, a coordinator gives its neighbors a chance to become coordinators. A coordinator stays tentative for W_T of time, where W_T the maximum value of equation 2.

$$W_T = 3X \, N_i \, X \, T \qquad (3)$$

If a coordinator has not withdrawn after W_T, It clears its tentative bit. To prevent an unlucky low energy node from draining all of its energy once it becomes a coordinator, the amount of time a node stays as a coordinator before on its tentative bit is proportional to the amount of energy it has (E_r / E_m).

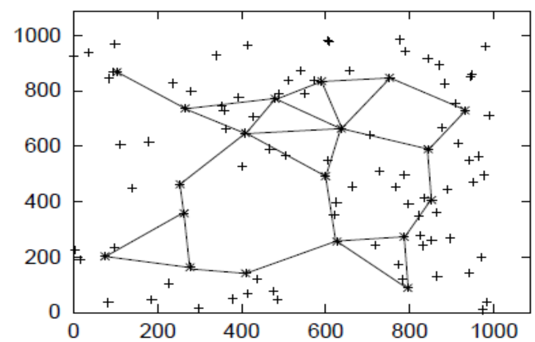

Figure.3: Election Algorithm At A Random Point In Time

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Figure.3: Shows a scenario with 100 nodes, 19 coordinators, and a radio range of 250 meters. The nodes marked "*" are coordinators; the nodes marked "+" are non coordinator nodes. Solid lines connect coordinators that are within radio range of each other.While Span uses local HELLO messages to propagate topology information, it does not depend on them for correctness. When HELLO messages are lost, Span elects more coordinators , but does not disconnect the backbone.

Figure 3 shows the election algorithm at a random point in time on a network of 100 nodes in a 1000 meters x 1000 meters area, where each radio has an isotropic circular range with a 250 meter radius. Solid lines connect coordinators that are within the radio range of each other.

4. SIMULATOR IMPLEMENTATION

This section describes the implementation of span, DSDV, the 802.11 power saving mode and the energy model used in my simulations. Span implementation is done in ns-2 network simulator environment 2.33.

4.1 Span and DSDV

Our implementation uses a DSDV routing agent. DSDV routing agent is primarily chosen because it proactive and simple; Span can be used with other routing protocols as well.

Span's election algorithm requires each node to advertise its coordinators, its neighbors, and if it is a coordinator, a tentative coordinator, or a non coordinator. To reduce protocol overhead, we piggyback Span HELLO information onto the broadcast updates required by DSDV.

Sequence#
Destination
Is coordinator
Is tentative
Coordinator List
Neighbor List

Figure.4 : HELLO Packet For Span And DSDV. Italized Fields Are Span Specific Information.

The coordinators chosen by Span are used by routing protocols to forward packets to the destinations. See fig 4. Each node enters all the information it receives in broadcast updates into a neighbor table Consequently, this neighbor table contains a list of neighbors and coordinators, and for each neighbor, a list of its neighbors and coordinators. Here in the above implemented routing protocol routing messages are exchanged among neighboring mobile nodes (i.e mobile nodes that are within choice of one another). The Routing updates are possibly triggered or schedule. Updates are triggered in case routing information from one of the neighbors sevices a change in the routing table. In the routing table next hops for a particular destination are going to be nodes in the coordinator list with the better metric. Upon receiving a packet for a node not in radio range, a coordinator forwards the packet to a neighboring coordinator that is closest to the destination. If no such coordinator exists, the packet is forwarded to a non-coordinator that is closer to the destination. Otherwise, that packet is dropped.

4.2 Coordinator Election

node uses information from its neighbor table to determine if it should announce or withdraw itself as a coordinator. A non-coordinator node periodically calls check-announce-coordinator to decide if it should turn into a coordinator or not. Check-announce-coordinator first computes C, the number of additional neighbor pairs that would be connected if the node becomes a coordinator, using connect-pair.

If C >0, the node computes delay using equation 2 and waits for delay seconds before recomputing C. If C continues to be greater than 0 after delay seconds, the node announces itself as a coordinator.

5. SIMULATIONS AND RESULTS

5.1 Performance Evaluation

To measure the effectiveness of Span, it is simulated on various scenarios of different node densities ranging from 50 nodes to 300 nodes. Simulation results show that Span reduces energy consumption and increases the network lifetime significantly when compared to protocols without Span.

Journal of Theoretical and Applied Information Technology
20th August 2013. Vol. 54 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5.2 Simulation Environment

Span is simulated in the ns-2 [5] network simulator of version ns2.33 using the CMU wireless extensions [9]. DSDV is used as the routing protocol for routing packets from source to destination. Span runs on top of the 802.11 MAC layer with power saving support.

5.3 Energy Remaining

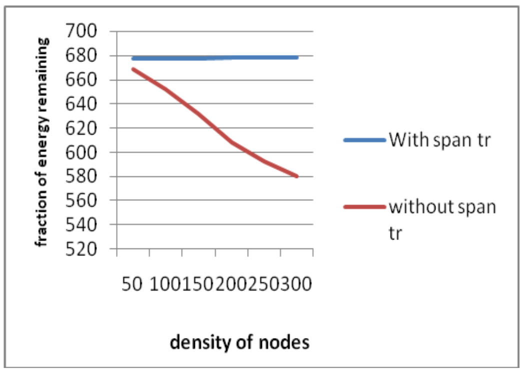

Figure.5: Density Of Nodes Vs Fraction Of Energy Remaining With And Without Span

Figure.5: Graph showing density of nodes Vs fraction of energy remaining with and without Span. From the above graph it is obvious that Span performs better as the density of nodes increases. Energy remaining after simulation goes on decreasing for Protocol without span as the density of nodes goes on increasing where as for the protocol with span the energy remaining remains to be nearly same on the same scenario for the same simulation time.

5.4 Network Lifetime

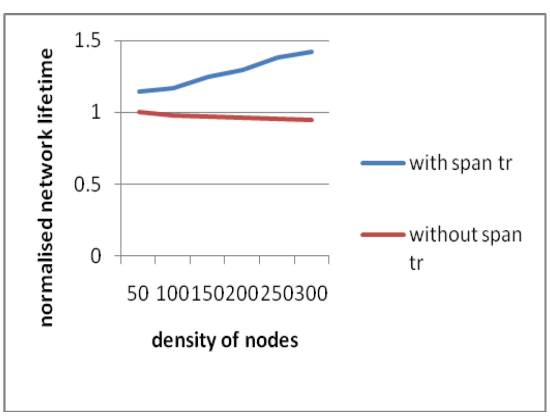

Figure.6: Density Of Nodes Vs Normalized Network Lifetime With And Without Span.

Figure.6: Graph showing density of nodes Vs normalized network lifetime with and without span.As the density of nodes goes on increasing Span is going to going to consume less amount of energy and hence energy remaining is going to be more when compared without spanSo this is reflected in increasing in lifetime of the network. But for protocol without span as the energy consumption goes on increasing with the density of nodes, the energy remaining is going to be less and the network lifetime is reflected in the corresponding way. Normalization is done to better compare the performance of span in terms of without span.

5.5 Capacity Preservation (throughput)

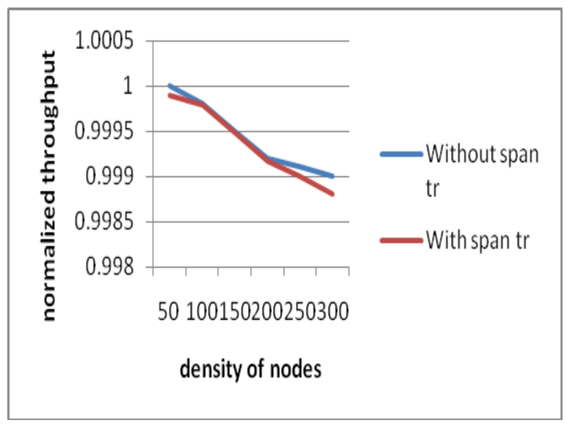

Figure.7: Density Of Nodes Vs Normalized Throughput With And Without Span.

Even though Span is reducing the energy consumption and thus saving the energy and increasing the network lifetime of the network, it is not affecting the system capacity. This is obvious from the throughput which is the ratio of number of packets received to the number of packets sent in the network at different density of nodes. Throughput with Span is found to be approximately equal to the throughput without Span and by this it is obvious that Span functionality is efficient by not affecting the throughput and thus preserving capacity of the network. Normalization of throughput is done to better compare the performance of the Span in terms of without span.

6. CONCLUSION

The proposed Span protocol reduces the energy consumption by turning off the nodes which are

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

idle. As a node consumes significant amount of energy when it is idle, that node is made to go to sleep mode and the difference of energies consumed in idle and sleep mode is saved. Simulation results show a significant reduction in energy consumption and increase in network lifetime without affecting the throughput. It is also observed that Span performs better as the density of nodes increases.

REFERENCES:

[1] Benjie Chen, Kylie Jamieson, Hari Balakrishnan and Robert Morris “Span: An Energy-Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks” , ACM SIGMOBILE Sep-2001 Rome, Italy.

[2] Feeney, L., and Nilsson, ”Investigating the energy consumption of a wireless Network Interface in an Ad hoc Networking Environment”, In proceedings of IEEE INFOCOM ,Anchorage, AK ,2001.pp 5-26.

[3] Chang, j.,and Tassiulas, L. “ Energy Conserving Routing in Wireless Ad hoc networks”, In proceedings of IEEE INFOCOM ,Tel Aviv, Israel, 2000. pp 626-632.

[4] Heinzelman, Chandrakasan, Balakrishnan,. “ Energy-efficient Communication Protocols for ireless Microsensor Networks”. In proceedings of the Hawaaian international Conference on Systems science ,jan2000. Pp.1633-1639.

[5] ns Notes and Documentation http://www.isi.edu/vint/nsnam/,2000.

[6] Feeney, W. Internet Group Management protocol , Version2 , Nov 1997. RFC-2236.

[7] Das and Bhargavan, ”Routing in Ad-Hoc Networks using Minimum Connected Dominating Sets” , In proceedings of the IEEE International Conference on Communications ICC ’1997.

[8] CMU Monarch Extensions to ns http://www.monarch.cs.cmu.edu/.

[9] Mangione-Smith,for Ghang, Nazareth, Lettieri, Boring and Jain, “A Low Power Architecture for Wireless Multimedia Systems: Lessons Learned From Building a Power Hog”. In 1996 International Symposium on low Power Electronics and Design Digest of Technical Papers ,Monterey, C.A, Aug 1996.pp 219-230.

[10] Floyd, Jacobson, McCanne, Liu and Zhang. “A Reliable Multicast Framework for Lightweight Sessions and Application Level Framing”. In proceedings of ACM SIGCOMM ,Boston, M.A, Sept 1995), pp-342-356.