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RESEARCH STUDY ON ENERGY CONSERVING ROUTING IN WIRELESS AD HOC NETWORKS

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ABSTRACT: In the last years, wireless networks have gained increasing attention from both the research community and actual users. As nodes are generally battery-powered devices, the critical aspects to face concern how to reduce the energy consumption of nodes, so that the network lifetime can be extended to reasonable times. An ad-hoc network of wireless static nodes is considered as it arises in a rapidly deployed, sensor based, monitoring system. Information is generated in certain nodes and needs to reach a set of designated gateway nodes. Each node may adjust its power within a certain range that determines the set of possible one hop away neighbors. Traffic forwarding through multiple hops is employed when the intended destination is not within immediate reach. The nodes have limited initial amounts of energy that is consumed in different rates depending on the power level and the intended receiver. It turns out that in order to maximize the lifetime; the traffic should be routed such that the energy consumption is balanced among the nodes in proportion to their energy reserves, instead of routing to minimize the absolute consumed power.

KEYWORDS: energy-sensitive routing, wireless ad-hoc networks, sensor networks

INTRODUCTION

Multiple adhoc networking has been the focus of the many recent research and development efforts it has wide application in military commercial and educational environments such as wireless office LAN connections, mobile phones PDA's or computers, sensors networks or other networks.

Current studies of adhoc networks routing protocols have focused primarily on protocol design and evaluation in terms of routing packet overheads and loss rates. The adhoc network typically consists of energy limited nodes, so designing power-conserving protocols deserves study. For some scenarios power is the important metric. for example in sensor networks, nodes are casually placed and remain unattended for long period of time, sensing and reporting objects until sensor nodes run out of power.

The problem of minimum energy routing has been addressed before in [1], [6], [16], [10], [8], [18], [17], and [7]. The approach in those works was to minimize the total consumed energy to reach the destination, which minimizes the energy consumed per unit flow or packet. If all the traffic is routed though through the minimum energy path to the destination the nodes in that path will be drain-out of batteries quickly while other nodes, which perhaps will be more power hungry if traffic is forwarded through them, will remain intact.

The paper has been organized in the following sections

I. Routing Problem
II. Algorithm for the Routing Problem for Less Energy consumption [FLOW AUGMENTATION]
III. Energy Conserving Algorithms

I. ROUTING FOR THE MAXIMUM SYSTEM LIFETIME

The wireless ad-hoc network in consideration is modeled as a directed graph G (N, A) where N is the set of all nodes and A is the set of all directed links (i j) where i, j € N . Let S_i be the set of all nodes that can be reached by node *i* with a certain power level in its dynamic range. We assume that link (i , j) exists if and only if j € S_i . Let each node *i* have the initial battery energy E_i, and let $Q_i^{(c)}$. be the rate at which information is generated at node *i* belonging to commodity $c \in C$, where C is the set of all commodities. Assume that the transmission energy required for node *i* to transmit an information unit to its neighboring node j is e_{ij} , and the rate at which information of commodity *c* is transmitted from node *i* to node *j* is called the flow $q_{ij}^{(c)}$ Further, let Q_i and q_{ij} be the aggregate flows of all commodities, i.e.,

$$Q_i = \sum_{c \in C} Q_i^{(c)},$$

and (1)

$$q_{ij} = \sum_{c \in C} q_{ij}^{(c)}.$$

(2)

We are given, for each commodity c, a set of origin nodes $O^{(c)}$ where the information is generated, i.e,

$$O^{(c)} = \{\, i \mid Q_i^{(c)} > 0,\ i \in N \}, \qquad (3)$$

and a set of destination nodes D(c) among which any node can be reached in order for the information transfer of commodity c be considered done.

The lifetime of node i under a given flow $q = \{q^{(ij)}\}$ is given by

$$T_i(\mathbf{q}) = \frac{E_i}{\sum_{j \in S_i} e_{ij} \sum_{c \in C} q_{ij}^{(c)}}. \qquad (4)$$

Now, let us define the system lifetime under flow q as the length of time until the first battery drain-out among all nodes in N, which is the same as the minimum lifetime over all nodes, i.e.,

$$\begin{aligned} T_{sys}(\mathbf{q}) &= \min_{i \in N} T_i(\mathbf{q}) \\ &= \min_{i \in N} \frac{E_i}{\sum_{j \in S_i} e_{ij} \sum_{c \in C} q_{ij}^{(c)}}. \end{aligned} \qquad (5)$$

Our goal is to find the flow that maximizes the system lifetime under the flow conservation condition. The problem can be written as follows:

$$\text{Maximize} \quad T_{sys}(\mathbf{q}) = \min_{i \in N} \frac{E_i}{\sum_{j \in S_i} e_{ij} \sum_{c \in C} q_{ij}^{(c)}}$$

$$\text{s.t.} \quad q_{ij}^{(c)} \geq 0, \qquad \forall i \in N, \forall j \in S_i, \forall c \in C,$$

$$\sum_{j:\, i \in S_j} q_{ji}^{(c)} + Q_i^{(c)} = \sum_{k \in S_i} q_{ik}^{(c)}, \quad \forall i \in N - D^{(c)}, \forall c \in C.$$

(6)

Fig.2 illustrates the flow conservation condition for commodity *c* at node *i*, and it should be noted that the condition applies to each commodity separately.

In the following we show that the problem is a linear programming problem [13]. The problem of maximizing the system lifetime, given the information generation rates $Q_i^{(c)}$ at the set of origin nodes $O^{(c)}$

and the set of destination nodes $D^{(c)}$ for each commodity c, is equivalent to the following linear programming problem:

$$\text{Maximize } T \quad (7)$$

$$\text{s.t.} \quad \hat{q}_{ij}^{(c)} \geq 0, \quad \forall i \in N, \forall j \in S_i, \forall c \in C, \quad (8)$$

$$\sum_{j \in S_i} e_{ij} \sum_{c \in C} \hat{q}_{ij}^{(c)} \leq E_i, \quad \forall i \in N, \quad (9)$$

$$\sum_{j:\, i \in S_j} \hat{q}_{ji}^{(c)} + TQ_i^{(c)} = \sum_{k \in S_i} \hat{q}_{ik}^{(c)}, \ \forall i \in N - D^{(c)}, \forall c \in C, (10)$$

Where $\hat{q}_{ij}^{(c)} = Tq_{ij}^{(c)}$ the amount of information of commodity c is transmitted from node *i* to node *j* until time T.

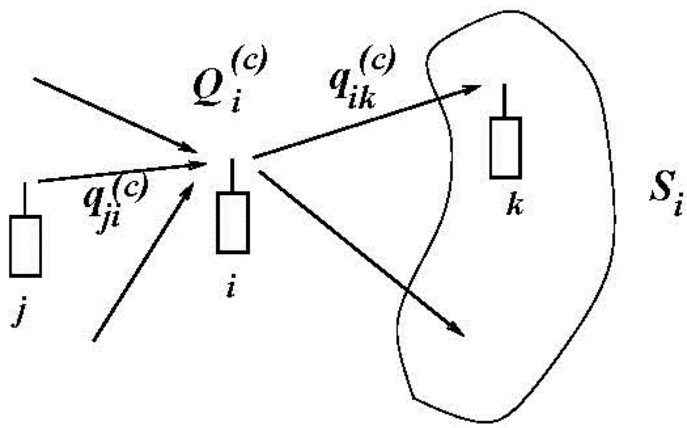

Fig. 1: The conservation of flow condition at node i for each commodity *c* requires that the sum of information generation rate and the total incoming flow must equal the total outgoing flow.

The linear program given above can be viewed as a variation of the conventional maximum flow problem with node capacities [5]. If the transmitted power level at each node is fixed regardless of its next hop node, i.e., if there is no power control,

$$e_{ij} = e_i, \ \forall j \in S_i, \quad (11)$$

and the problem is equivalent to the maximum flow problem with node capacities given by

$$\sum_{j \in S_i} \sum_{c \in C} \hat{q}_{ij}^{(c)} \leq E_i / e_i, \ \forall i \in N. \quad (12)$$

When the capacity of a a node is a fixed quantity as in (12) then the problem can be converted to a link capacity version by replacing the node with two nodes and a link having the same capacity[4], and the max-flow-min-cut theorem[5] can be used. However, in our problem, unlike the above, the amount of resource (or energy in this case) which a unit flow consumes depends on the energy expenditure to the next hop node. Therefore, it is not trivial to find the min-cut nodes, even if they were found the traffic split at the nodes must also be identified.

II. FLOW AUGMENTATION ALGORITHMS

In this section, we propose a class of flow augmentation (FA) algorithms which use the shortest cost path.

The general description of the algorithm is given in the following. At each iteration, each origin node o € $O^{(c)}$ of commodity *c* calculates the shortest cost path to its destination nodes in $D^{(c)}$. Then the flow is augmented by an amount of $\lambda Q_i^{(c)}$ on the shortest cost path, where λ is the augmentation step size.

After the flow augmentation, the shortest cost paths are recalculated and the procedures are repeated until any node *I* € N runs out of its initial total energy E_i. As a result of the algorithm, we obtain the flow which will be used at each node to properly split incoming traffic.

Our objective is to find the best link cost function which will lead to the maximization of the system lifetime. There are three parameters to consider in calculating the link cost c_{ij} for link(i , j). One is the energy expenditure for unit flow transmission over the link, e_{ij}, the second is the initial energy E_i, and the third is the residual energy at the transmitting node *i* which is denoted by E_i. A good candidate for the flow augmenting path should consume less energy and should avoid nodes with small residual energy since we would like to maximize the minimum lifetime of all nodes. In [18], each of these was separately considered which falls short of optimizing the system lifetime. Obviously, both of these can't be optimized at the same time, which means there is a tradeoff between the two. In the beginning when all the nodes have plenty of energy, the minimum total consumed energy path is better off, whereas towards the end avoiding the small residual energy node becomes more important. Therefore, the link cost function should be such that when the nodes have plenty of residual energy, the energy expenditure term is emphasized, while if the residual energy of a node becomes small the residual energy term should be more emphasized.

With the above in mind, the link cost cij is proposed to be

$$c_{ij} = e_{ij}^{x_1} \underline{E}_i^{-x_2} E_i^{x_3}, \qquad (13)$$

Where x1, x2 and x3 3 are nonnegative weighting factors for each item. Note that if {x1, x2; x3} = {0, 0, 0} then the shortest cost path is the minimum hop path, and if it is {1,0,0} then the shortest cost path is the minimum transmitted energy path.

If x2 = x3 then normalized residual energy is used, while if x3 = 0 then the absolute residual energy is used. Let's refer to the algorithm as FA(x1, x2;,x3) in the rest of the paper indicating the parameters, and the meanings of the parameters are summarized in Table I for reference.

The path cost is computed by the summation of the link costs on the path, and the algorithm can be implemented with any existing shortest path algorithms including the distributed Bellman-Ford algorithm [2], which will be used in our simulation.

CONCLUSIONS

The proposed algorithms are local and amenable to distributed implementation and showed close to the optimal performance most of the time. In power-controlled wireless ad-hoc networks, battery energy at network nodes is a very limited resource that needs to be utilized efficiently. One of the conventional routing objectives was to minimize the total consumed energy in reaching the destination. However, the conventional approach may drain out the batteries of certain paths which may disable further information delivery even though there are many nodes with plenty of energy. Therefore, we formulated the routing problem with the objective of maximizing the system lifetime given the sets of origin and destination nodes and the information generation rates at the origin nodes, and proposed a class of flow augmentation algorithms and a flow redirection algorithm which balance the energy consumption rates among the nodes in proportion to their energy reserves.

We also two approaches to energy conservation for adhoc routing. Power consumption in current wireless networks is idle time dominated, so both focus on turning the radio off as much as possible.

BECA, our basic algorithm, uses routing and application-layer information to achieve up to a 50% duty cycle. Although route setup latency increases, for sleep times of 10s we see energy savings of 40%.

Our second algorithm, AFECA, demonstrates *adaptive fidelity*. **It** adapts sleep times based on node density, sealing back node duty cycles (and so reducing routing "fidelity") when many inter- changeable nodes are present. We have shown that it performs at least as well as BECA for packet loss, route latency, and energy in typical conditions, and it can nearly double network lifetime as density rises.

REFERENCES

1. Dennis J. Baker and Anthony Ephremides, “The architectural organization of a mobile radio network via a distributed algorithm,” IEEE Transactionson Communications, vol. COM-29, no. 11, pp. 56–73, Jan. 1981.
2. Dimitri Bertsekas and Robert Gallager, Data Networks, Prentice-Hall, Inc., 2nd edition, 1987.
3. J.-H. Chang and L. Tassiulas, “Routing for maximum system lifetime in wireless ad-hoc networks,” in Proceedings of 37-th Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, Sept. 1999.
4. Wai-Kai Chen, Theory of Nets: Flows in Networks, Wiley, 1990.
5. T. Cormen, C. Leiserson, and R. Rivest, Introduction to Algorithms, McGraw-Hill and MIT Press, 1990.
6. Anthony Ephremides, Jeffrey E. Wieselthier, and Dennis J. Baker, “A design concept for reliable mobile radio networks with frequency hopping signaling,” Proceedings of the IEEE, vol. 75, no. 1, pp. 56–73, Jan. 1987.
7. M. Ettus, “System capacity, latency, and power consumption in multihoprouted SS-CDMA wireless networks,” in Proceedings of IEEE Radio and Wireless Conference (RAWCON) 98, Colorado Springs, CO, Aug. 1998, pp. 55–58.
8. R.G. Gallager, P.A. Humblet, and P.M. Spira, “A distributed algorithm for minimum weight spanning trees,” Tech. Rep. LIDS-P-906-A, Lab. Inform. Decision Syst., Massachusetts Inst. of Technol., Cambridge, MA, Oct. 1979.
9. D. Johnson and D. Maltz, “Dynamic source routing in ad hoc wireless networks,” Mobile Computing, 1996. August 1999. ACM.