Available at: www.researchpublications.org

Sleep-wake and anycast scheduling technique for Performance Enhancement of Wireless Sensor Network

Ms.Priyanka M. Lokhande
ME-CSE. (Scholar)
Sipna COET, Amravati (MS) INDIA
priyanka.20it@gmail.com

Prof.A.P.Thakare
Professor and Head of Electronics
& Telecommn.deptt
Sipna COET, Amravati (MS) INDIA

Abstract- **Every network system concentrates on the term improvement in the performance & reliability of Wireless sensor network. The number of nodes in a typical sensor network is much higher than in a typical ad hoc network, and dense deployments are often desired to ensure coverage and connectivity. In this paper, we are focusing on the aspect of minimizing the delay and maximizing the lifetime of event-driven wireless sensor networks for which events occur infrequently. Many of the energy is consumed when the radios are on, waiting for a packet to arrive. Sleep–wake scheduling is an effective mechanism to prolong the lifetime of these energy-constrained wireless sensor networks. "anycast"-based packet forwarding schemes, where each node opportunistically forwards a packet to the first neighboring node that wakes up among multiple candidate nodes. In this paper, we first study how to control the anycast forwarding schemes for minimizing the expected packet-delivery delays from the sensor nodes to the sink. Based on this result, we then provide a solution to the joint control problem of how to optimally control the system parameters of the sleep–wake scheduling protocol and the anycast packet-forwarding protocol to maximize the network lifetime, subject to a constraint on the expected end-to-end packet-delivery delay.**

***Index Terms*— sleep–wake scheduling, Lifetime maximization sensor network, Anycast, delay, energy-efficiency, network lifetime.**

I INTRODUCTION

A communication network is composed of nodes, each of which has computing power and can transmit and receive messages over communication links, wireless or cabled. The sensor nodes usually operate with batteries and are often deployed into a harsh environment. Once deployed, it is hard or even impossible to recharge or replace the batteries of the Sensor nodes. Therefore, extending the network Lifetime by efficient use of energy is a critical for the Routing. Since a distributed network has multiple requirements a WSN.nodes and services many messages, and each node is a shared resource, many decisions must be made. There may be multiple paths from the source to the destination. Therefore, message routing is an important topic. The main performance measures affected by the routing scheme are throughput (quantity of service) and average packet delay (quality of service). Routing schemes should also avoid both deadlock and livelock .Routing methods can be fixed (i.e. pre-planned), adaptive, centralized, distributed, broadcast, etc. Sensor networks are the key to gathering the information needed by smart environments. Wireless networks use some sort of radio frequencies in air to transmit and receive data instead of using some physical cables. The most admiring fact in these networks is that it eliminates the need for laying out expensive cables and maintenance costs.

Sensing, processing and communication are three key elements whose combination in one tiny device gives rise to a vast number of applications [30], [31]. Sensor networks provide endless opportunities, but at the same time pose formidable challenges, such as the fact that energy is a scarce and usually non-renewable resource. Energy-efficient routing should avoid the loss of a node due to battery depletion. Many proposed protocols tend to minimize energy consumption on forwarding paths, but if some nodes happen to be located on most forwarding paths (*e.g.*, close to the base station), their lifetime will be reduced. network the performance is the important and main focusing aspect ie is called as the performance metrics of the network including packet delivery ratio ,end to end delay ,network lifetime, packet loss ratio ,throughput etc .In this paper we are focusing on parameter of network life and delay and their enhancement towards the performance improvement for the WSN by using anycast and sleep wake scheduling concept .The wireless sensor network consists of large number of sensing nodes equipped with various sensing devices to observe different phenomenon changes in real world. Wireless sensor networks (WSN) are used to remotely Sense the environment. Wireless sensor networks consists of many sensing nodes that captures the changes in the environment enclose data in data packets and gives these packets to sink node present in the network. Such networks are present in hard to reach areas so they remain unattended for long duration. So key issue in such area is efficient use of node energy to extend the lifetime of network. We mainly focus here on event driven sensor networks for which events occur rarely. This is very important area of research and has many applications such as environment monitoring, intrusion detection etc.

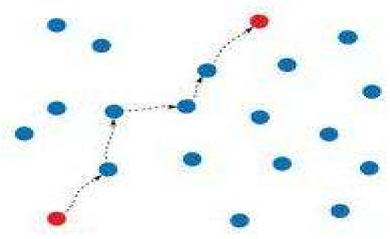

Fig.1. General Scenario of mobile nodes

In Fig.1 red nodes circles indicates the source and destination node. In example every node broadcast the message to the neighboring nodes & this process continues in operation when desired destination is encountered some node emerge gateways to the subsection of the network. In such systems, there are four sources of Synchronized sleep–wake scheduling protocols have been proposed in [1]-[5] these protocols, sensor nodes periodically or aperiodically exchange synchronization information with neighboring nodes. Energy consumption these sources are: communication radios, data transmission and reception, sensors and transmission and reception of control packets. Fraction of total energy consumption for data transmission and reception is small for such systems because events occur so rarely. To sense the event, constant energy is required and it cannot be controlled. Hence energy required to keep communication system on means for listening the medium and control packets is dominant component of energy consumption which can be controlled to extend network lifetime. So sleep-wake scheduling is used to increase the lifetime of event driven sensor networks. We intend to use asynchronous sleep wake scheduling where each node wakes up independent of its neighboring nodes in order to save energy. But due to this independence of wake-up processes, additional delays encounter at each node along path to sink node because each node has to wait for its next hop node to wake up before transmitting the packet. Anycast packet forwarding scheme is used to reduce this event reporting delay to sink node and thus minimization of delay is done. To sense the event, constant energy is required and it cannot be controlled. Hence energy required to keep communication system on means for listening the medium and control packets is dominant component of energy consumption which can be controlled to extend network lifetime. So sleep-wake scheduling [1]-[5] is used to increase the lifetime of event driven sensor networks. We intend to use asynchronous sleep wake scheduling where each node wakes up independent of its neighboring nodes in order to save energy. But due to this independence of wake-up processes, additional delays encounter at each node along path to sink node because each node has to wait for its next hop node to wake up before transmitting the packet.

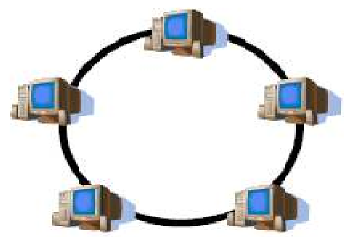

Fig.2. Ring topology Basic structure

In the ring topology all nodes perform the same function and there is no leader node. Messages generally travel around the ring in a single direction. However, if the ring is cut, all communication is lost. Anycast packet forwarding scheme is used to reduce this event reporting delay to sink node and thus minimization of delay is done. Sleep wake scheduling is the important method which is used to increase the network lifetime. Section I focuses on the basic idea about the wireless communication & key issue of the network lifetime as well as anycast packet forwarding scheme. Section II & III focuses on the different protocols used in networking & synchronized sleep wake scheduling concept. Delay minimization problem. Sections IV concentrate on the problem analysis of delay minimization and lifetime minimization for the wireless sensor network. Sleep-wake scheduling with any cast intend to solve these two main problems. proposed technology with objectives to resolve the problem related to the wireless sensor network basically performance parameter of the network. Section V deals with the conclusion & Future work so as to improve the performance of the WSN. Prior work in the literature has proposed the use of *anycast* packet-forwarding schemes (also called opportunistic forwarding schemes) to reduce this event reporting delay [11]-[15] working & synchronized sleep wake scheduling concept. Delay minimization problem.

Sections III concentrate on the problem definition & objectives related to the wireless sensor network. Section IV related to Simulation & result with objectives to resolve the problem related to the wireless sensor network basically performance parameter of the network. Section V deals with the conclusion & Future work so as to improve the performance of the WSN. Prior work in the literature has proposed the use of *anycast* packet-forwarding schemes (also called opportunistic forwarding schemes) to reduce this event reporting delay [11]- [15].

II WIRELESS & WIRED NETWORK

A Wired & Wireless Networks

1 In wired network, the connection is usually established with the help of physical devices like Switches and Hubs in between to increase the strength of the connection.

2 These networks are usually more efficient, less expensive and much faster than wireless networks.

3 Once the connection is set there is a very little chance of getting disconnected.

B Advantages of Wired Network

1 A wired network offer connection speeds of 100Mbps to 1000Mbps

2 Physical, fixed wired connections are not prone to interference and fluctuations in available bandwidth, which can affect some wireless networking connections.

C Disadvantages Over Wireless Network

1 Expensive to maintain the network due to many cables between computer systems and even if a failure in the cables occur then it will be very hard to replace that particular cable as it involved more and more costs.

2 When using a laptop which is required to be connected to the network, a wired network will limit the logical reason of purchasing a laptop in the first place.

D Wireless Networks

1 Wireless networks use some sort of radio frequencies in air to transmit and receive data instead of using some physical cables.

2 The most admiring fact in these networks is that it eliminates the need for laying out expensive cables and maintenance costs.

E Advantages of Wireless Networks

1 Mobile users are provided with access to real-time information even when they are away from their home or office.

2 Setting up a wireless system is easy and fast and it eliminates the need for pulling out the cables through walls and ceilings.

3Network can be extended to places which cannot be wired.

4Wireless networks offer more flexibility and adapt easily to changes in the configuration of the network.

F Disadvantages of Wireless Networks

1Interference due to weather, other radio frequency devices, or obstructions like walls.

2 The total Throughput is affected when multiple connections exists.

III RELATED WORK & CONTRIBUTIONS

Sensor networks should be scalable, and they should be able to dynamically adapt to changes in node density and topology, In traditional packet-forwarding schemes, every node has one designated next-hop relaying node in the neighborhood, and it has to wait for the next-hop node to wake up when forward a packet has to be done. In contrast, under anycast packet-forwarding schemes, each node has multiple next-hop relaying nodes in a candidate set (we call it as forwarding set) and forwards the packet to the first node that wakes up in the forwarding set. It is easy to see that, compared to the basic scheme; anycast clearly reduces the expected one-hop delay. But anycast does not necessarily lead to minimum end to end delay because packet has to relay through time consuming path. Therefore to reduce this expected end to end delay, one challenge is how each node chooses its anycast forwarding policy like forwarding set this is to be solved and another important concept here is that implementing anycast in isolation does not give good performance it has to be jointly controlled with parameters of sleep scheduling like wake up rate. Anycast addresses these challenges.

Sleep-wake scheduling protocol have been proposed in literature. In synchronized sleep–wake scheduling [1]-[5] protocols sensor nodes periodically or aperiodically exchange synchronization information with neighbouring nodes. However, such synchronization procedures could incur additional communication overhead and consume a considerable energy. On-demand sleep–wake scheduling protocols [6]-[7] is one scheduling where nodes turn off most of their circuitry and always turn on a secondary low-powered receiver to listen to "wake-up" calls from neighbouring nodes when to relay the packet. But this on-demand sleep–wake scheduling can significantly increases sensor nodes cost due to the additional receiver. In this, we are interested in asynchronous sleep–wake scheduling protocols [8]-[10] in which each node wakes up independently of neighbouring nodes for energy saving. However, this independence of the wake-up processes causes additional delays at each node along the path to the sink because each node needs to wait for its next-hop node to wake up before it can transmission of the packet. This delay could be unacceptable for delay-sensitive applications which require the event reporting delay to be very small. So for minimizing this event reporting delay, anycast packet forwarding technique is used.

This technique shows how to use the solution to the delay-minimization problem to construct an optimal solution to the lifetime-maximization problem for a specific definition of network lifetime. However, anycast does not necessarily lead to the minimum expected end-to-end delay because a packet can still be relayed through a time-consuming routing path. Therefore, the first challenge for minimizing the expected end-to-end delay is to determine how each node should choose its anycast forwarding policy (e.g., the forwarding set) carefully. Study of [12]–[14] proposes heuristic anycast protocols that exploit the geographical distance to the sink node. The work in [15] and [16] considers MAC-layer anycast protocols that work with the separate routing protocols in the network layer. However, these solutions are heuristic in nature and do not directly minimize the expected end-to-end delay. The algorithms in [17] use the hop-count information (i.e., the number of hops for each node to reach the sink) to minimize some state-dependent cost (delay) metric along the possible routing paths. However, these algorithms do not directly apply to asynchronous sleep–wake scheduling, where each node does not know the wake-up schedule of neighboring nodes when it has a packet to forward.

The second challenge step from the fact that good performance cannot be obtained by studying the anycast forwarding policy in isolation. Rather, it should be jointly controlled with the parameters of sleep–wake scheduling (e.g., the wake-up rate of each node). It will directly impact both network lifetime and the packet-delivery delay. Hence, to optimally trade off network lifetime and delay, both the wake-up rates and the anycast packet-forwarding policy should be jointly controlled. However, related work is studied in the literature [11]–[18] but it is not jointly controlled.

IV PROBLEM ANALYSIS & OBJECTIVES

In the analysis phase, we are highlighting on the two main important aspect related to the performance enhancement which affect the WSN. Anycast packet forwarding should be implemented along with sleep scheduling here in order to get good performance & reliability of the system.

Objectives work are summarized as follows

- Analysis of delay incurred during packet transmission in wireless sensor network.
- Analysis of network lifetime for wireless sensor network.
- Proposed technique for increasing energy efficiency to maximize lifetime of network & minimization of incurred packet transmission delay to sink node.
- Improve the performance of the event driven sensor network.

A. Delay Minimization

In this, with the wakeup rates of the sensor nodes, optimally choosing the anycast forwarding policy to reduce the expected.

B. Maximization of network lifetime

Lifetime is extremely critical for most applications, and its primary limiting factor is the energy consumption of the nodes, which need to be self-powering. In this, Wireless nodes self-organize into an infrastructure less network with a dynamic topology. Although it is often assumed that the transmit power associated with packet transmission accounts for the lion's share of power consumption, sensing, signal processing and even hardware operation in standby mode consume a consistent amount of power as well [28], [29].With constraint on the expected end-to-end delay, how to maximize the network lifetime by jointly controlling the wake-up rates and the anycast packet-forwarding policy.

Sleep-wake scheduling with anycast intend to solve these two main problems. The lifetime of event driven sensor network consists of two phases' configuration phase and operation phase. In configuration phase, node optimizes control parameters of anycast forwarding policy and their wakeup rate. After configuration phase, operation phase begins in which each node alternates between two sub phases sleeping sub phase and event

reporting sub phase. This Technique assume that the sensor network employs asynchronous sleep–wake scheduling to improve energy efficiency, and nodes choose the next-hop node and forward the packet to the chosen node using the following basic sleep–wake scheduling protocol. This basic protocol generalizes typical asynchronous sleep–wake scheduling protocols in to account for anycast. In this basic protocol, we assume that there is a single source that sends out event-reporting packets to the sink. This is the most likely operating mode because when nodes wake up asynchronously and with low duty-cycles, the chance of multiple sources generating event-reporting packets simultaneously is small. The sensor nodes sleep for most of the time and occasionally wake up for a short period of time T_{active}. When a node i has a packet for node j to relay, it will send a beacon signal and an ID signal (carrying the sender information) for time periods t_B and t_C , respectively, and then hear the medium for time period t_A . If the node does not hear any acknowledgment signal from neighboring nodes, it repeats this signaling procedure. When a neighboring node j wakes up and senses the beacon signal, it keeps awake, waiting for the following ID signal to recognize the sender. When node j wakes up in the middle of an ID signal, it keeps awake, waiting for the next ID signal. If node j successfully recognizes the sender, and it is a next-hop node of node i, it then communicates with node to receive the packet. Node j can then use a similar procedure to wake up its own next-hop node. If a node wakes up and does not sense a beacon signal or ID signal, it will then go back to sleep. Assumption is made that the time instants that a node j wakes up follow a Poisson random process with rate λ_j. It is also also assume that the wake-up processes of different nodes are independent. The independence assumption is suitable for the scenario in which the nodes do not synchronize their wake-up times, which is easier to implement than the schemes that require global synchronization [3]–[5].
Advantage of Poisson sleep–wake scheduling is that, due to its memory less property, sensor nodes are able to use a time-invariant optimal policy to maximize the network lifetime.

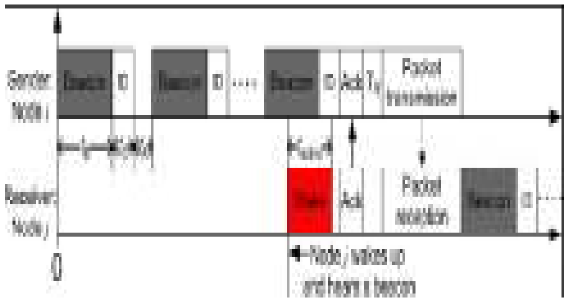

Fig.3.System Model [27]

A well-known problem of using sleep–wake scheduling in sensor networks is the additional delay incurred in transmitting a packet from source to sink because each node along the transmission path has to wait for its next-hop node to wake up. To reduce this delay, we use an anycast forwarding scheme as described in Fig 3 [27] Let Ći denote the set of nodes in the transmission range of node i . Suppose that node i has a packet, and it needs to pick up a node in its transmission range Ći to relay the packet. Each node i maintains a list of nodes that node i intends to use as a forwarder. We call the set of such nodes the forwarding set, which is denoted by *Fi* for node i .

In addition, each node j is also assumed to maintain a list of nodes i that use node j as a forwarder (i.e.*j* € *Fi*). As shown in Fig 3, node i starts sending a beacon signal and an ID signal successively. All nodes in Ći can hear these signals, regardless of whom these signals are intended for. A node j that wakes up during the beacon signal or the ID signal will check if it is in the forwarding set of node i. If it is, node j sends one acknowledgment after the ID signal ends. After each ID signal, node i checks whether there is any acknowledgment from the nodes in *Fi*. If no acknowledgment is detected, node I repeats the beacon-ID-signalling and acknowledgment-detection processes until it hears one. On the other hand, if there is an acknowledgment, it may take additional time for node i to identify which node acknowledge the beacon-ID signals, especially when there are multiple nodes that wake up at the same time. Let *Tr* denote the resolution period, during which time node i identifies which nodes have sent acknowledgments. If there are multiple awake nodes, node i chooses one node among them that will forward the packet. After the resolution period, the chosen node receives the packet from node I during the packet transmission period Tp, and then starts the beacon-ID-signalling and acknowledgment-detection processes to find the next forwarder. Since nodes consume energy when awake, Tactive should be as small as possible. However, if is too small, a node that wakes up right after an ID signal could return to sleep before the following beacon signal. In order to avoid this case, set

$$t_{active} = t_A + \epsilon_{detect},$$

Where ϵ_{detect} is a small amount of time required for a node to detect signal in the wireless medium.

V CONCLUSION & FUTURE WORK

This paper proposes a framework to maximize the lifetime of the wireless sensor networks (WSNs). Sensor networks offer a powerful combination of distributed sensing, computing and communication.
Performance of the WSN is the key issue of this paper ie maximization of network lifetime & minimization of delay for the improvement of WSN performance. Specifically, two optimization problems are focused. First, when the wake-up rates of the sensor nodes are given, we develop an efficient and distributed algorithm to minimize the expected event-reporting delay from all sensor nodes to the sink. Second, using a specific definition of the network lifetime, lifetime-maximization problem is handled to optimally control the sleep–wake scheduling policy and the anycast policy in order to maximize the network lifetime subject to an upper limit on the expected end-to-end delay.
Sleep-wake scheduling with anycast substantially gives better performance than heuristic solutions in the literature under practical scenarios where there are obstructions in the coverage area of the wireless sensor network. Future work will include strategy which will improve the performance of the wireless sensor network The results were validated by network simulations, which showed that the proposed schemes maintained the desired implication throughout the network. Future work will be conducted for improving the WSN performance is still is in processing phase.

REFERENCES

[1] J. Kim, X. Lin, N. B. Shroff, and P. Sinha, "On maximizing the lifetime of delay-sensitive wireless sensor networks with anycast," in *Proc. IEEE INFOCOM*, Pheonix, AZ, Apr. 2008, pp. 807–815.
[2] Y.-C. Tseng, C.-S. Hsu, and T.-Y. Hsieh, "Power-saving protocols for IEEE 802.11-based multi-hop ad hoc networks," *Comput. Netw.*, vol. 43, pp. 317–337, Oct. 2003.
[3] W. Ye, H. Heidemann, and D. Estrin, "Medium access control with coordinated adaptive sleeping for wireless sensor networks," *IEEE/ACM Trans. Netw.*, vol. 12, no. 3, pp. 493–506, Jun. 2004.
[4] T. van Dam and K. Langendoen, "An adaptive energy-efficient MAC protocol for wireless sensor networks," in *Proc. SenSys*, Nov. 2003, pp. 171–180.
[5] G. Lu, B. Krishnamachari, and C. S. Raghavendra, "An adaptive energy-efficient and low-latency MAC for data gathering in wireless sensor networks," in *Proc. IPDPS*, Apr. 2004, pp. 224–231.
[6] J. Elson, L. Girod, and D. Estrin, "Fine-grained network time synchronization using reference broadcasts," *SIGOPS Oper. Syst. Rev.*, vol. 36, no. SI, pp. 147–163, 2002.
[7] E. Shih, S.-H. Cho, N. Ickes, R. Min, A. Sinha, A.Wang, and A. Chandrakasan, "Physical layer driven protocol and algorithm design for energy- efficient wireless sensor networks," in *Proc. MobiCom*, 2001, pp. 272–287.
[8] M. Nosovic and T. Todd, "Low power rendezvous and RFID wakeup for embedded wireless networks," presented at the IEEE Comput. Commun. Workshop, 2000.
[9] C. Schurgers, V. Tsiatsis, S. Ganeriwal, and M. Srivastava, "Optimizing sensor networks in the energy-latency-density design space," *IEEE Trans. Mobile Comput.*, vol. 1, no. 1, pp. 70–80, Jan.–Mar. 2002.
[10] J. Polastre, J. Hill, and D. Culler, "Versatile low power media access for wireless sensor networks," in *Proc. SenSys*, Nov. 2004, pp. 95–107.
[11] J. Polastre, J. Hui, P. Levis, J. Zhao, D. Culler, S. Shenker, and I. Stoica, "A unifying link abstraction for wireless sensor networks," in *Proc. SenSys*, Nov. 2005, pp. 76–89.
[12] M. Zorzi and R. R. Rao, "Geographic Random Forwarding (GeRaF) for ad hoc and sensor networks: Energy and latency performance," *IEEE Trans. Mobile Comput.*, vol. 2, no. 4, pp. 349–365, Oct.–Dec. 2003.
[13] M. Zorzi and R. R. Rao, "Geographic Random Forwarding (GeRaF) for ad hoc and sensor networks: Multihop performance," *IEEE Trans. Mobile Comput.*, vol. 2, no. 4, pp. 337–348, Oct.–Dec. 2003.
[14] S. Liu, K.-W. Fan, and P. Sinha, "CMAC: An energy efficient MAC layer protocol using convergent packet forwarding for wireless sensor networks," in *Proc. SECON*, San Diego, CA, Jun. 2007, pp. 11–20.
[15] R. R. Choudhury and N. H. Vaidya, "MAC-layer anycasting in ad hoc networks,"*SIGCOMMComput. Commun. Rev.*, vol. 34, pp. 75–80, Jan. 2004.
[16] S. Jain and S. R. Das, "Exploiting path diversity in the link layer in wireless ad hoc networks," in *Proc. WoWMoM*, Jun. 2005, pp. 22–30.
[17] P. Larsson and N. Johansson, "Multiuser diversity forwarding in multihop packet radio networks," in *Proc. IEEE WCNC*, 2005, vol. 4, pp. 2188–2194.
[18] S. Biswas and R. Morris, "ExOR: Opportunistic multi-hop routing for wireless networks," in *Proc. ACM SIGCOMM*, Oct. 2005, vol. 35, pp. 133–144.
[19] M. Rossi and M. Zorzi, "Integrated cost-based MAC and routing techniques for hop count forwarding in wireless sensor networks," *IEEE Trans. Mobile Comput.*, vol. 6, no. 4, pp. 434–448, Apr. 2007.
[20] M. Rossi, M. Zorzi, and R. R. Rao, "Statistically Assisted Routing Algorithm (SARA) for hop count based forwarding in wireless sensor networks," *Wireless Netw.*, vol. 14, pp. 55–70, Feb. 2008.
[21] J. Kim, X. Lin, N. B. Shroff, and P. Sinha, "Minimizing delay and maximizing lifetime for wireless sensor networks with anycast," Purdue University, Tech. Rep., 2008 [Online]. Available: http://web.ics.purdue.edu/~kim309/Kim08tech2.pdf
[22] "IRIS OEM module datasheet," Crossbow Technology, Tech. Rep. [Online]. Available: http://www.xbow.com
[23] J.-H. Chang and L. Tassiulas, "Routing for maximum system lifetime in wireless ad-hoc networks," in *Proc. 37th Annu. Allerton Conf. Commun., Control, Comput.*, Monticello, IL, Oct. 1999, pp. 1191–1200.
[24] J.-H. Chang and L. Tassiulas, "Energy conserving routing in wireless ad-hoc networks," in *Proc. IEEE INFOCOM*, Mar. 2000, vol. 1, pp. 22–31.
[25] Y. T. Hou, Y. Shi, and H. D. Sherali, "Rate allocation in wireless sensor networks with network lifetime requirement," in *Proc. IEEE/ACM MobiHoc*, 2004, pp. 67–77.

[26] D. P. Bertsekas, *Dynamic Programming and Optimal Control Vol. 2*, 3rd ed. Belmont, MA: Athena Scientific, 2007.

[27] Joohwan Kim, Xiaojun Lin, Ness B. Shroff, Prasun Sinha," Minimizing Delay and Maximizing Lifetime for Wireless Sensor Networks With Anycast" IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 18, N

[28] A. Goldsmith and S. Wicker, "Design challenges for energy-constrained ad hoc wireless networks," *IEEE Wireless Communications Magazine*,
vol. 9, pp. 8–27, Aug. 2002.

[29] L. Yuan and G. Qu, "Energy-efficient Design of Distributed Sensor Networks," in *Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems*, M. Ilyas and I. Mahgoub, eds., Boca Raton, FL,pp. 38.1–38.19, CRC Press, 2004.

[30] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," in *IEEE Communications Magazine*,pp. 102–114, Aug. 2002.

[31] L.B. Ruiz, L.H.A. Correia, L.F.M. Vieira, D.F. Macedo, E.F. Nakamura,C.M.S. Figueiredo, M.A.M. Vieira, E.H.B. Maia, D. Câmara, A.A.F. Loureiro,J.M.S. Nogueira, D.C. da Silva Jr., and A.O. Fernandes, "Architectures for wireless sensor networks (In Portuguese)," in *Proceedings of the 22nd Brazilian Symposium on Computer Networks (SBRC'04)*, Gramado, Brazil,pp. 167–218, May 2004. Tutorial. ISBN: 85-88442-82-5.