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Energy Efficient Distributed Topology Control Technique in Wireless Sensor Networks

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Abstract— Topology control mechanism is crucial when designing wireless sensor network and mobile ad-hoc control. Topology control mechanism should create topology with sparser connectivity, lower transmission power and smaller node degree. Proposed paper presents analysis of different topology control mechanisms at present. This paper proposes distributes topology control mechanism which reduces computational complexity and results into improvement in crucial parameter like sparser connectivity, lower transmission power and smaller node degree.

Keywords— SBYaoGG, WSN, Topology Control, Energy Efficient, MANET

I. INTRODUCTION

Recent advances in wireless communications and electronics have enabled the development of low cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks. Sensor networks represent a significant improvement over traditional sensors. The position of sensor nodes need not be engineered or predetermined. This allows random deployment in inaccessible terrains or disaster relief operations. WSNs are powerful in that they are amenable to support a lot of real world applications that vary considerably in terms of their requirements and characteristics. Networks of sensors exist in many industrial applications providing the ability to monitor and control the environment in real time. Most of these networks, however, are wired and as a result are costly to install and maintain. To lower the system and infrastructure costs wireless solutions can be used. Wireless solutions have other benefits in industrial applications such as enhanced physical mobility, reduced danger of breaking wireless hassle with connectors and ease of upgrading.

Recent advancement in wireless communications and electronics has enabled the development of low-cost sensor networks. The sensor networks can be used for various application areas (e.g., health, military, home). For different application areas, there are different technical issues that researchers are currently resolving. The current state of the art of sensor networks is captured in[1], where solutions are discussed under their related protocol stack layer sections. [1] Also points out the open research issues and intends to spark new interests and developments in this field.

II. LITERATURE SURVEY

[2] Presents the design and optimization of the coupling beam of wineglass-mode micromechanical disk filters using simulated annealing. [3] Discusses a selection of promising and interesting research areas in the design of protocols and systems for wireless industrial communications. Given the increasing age of many industrial systems and the dynamic industrial manufacturing market, intelligent and low-cost industrial automation systems are required to improve the productivity and efficiency of such systems. The collaborative nature of industrial wireless sensor networks brings several advantages over traditional wired industrial monitoring and control systems, including self-organization, rapid deployment, flexibility, and inherent intelligent-processing capability. In this regard, IWSN plays a vital role in creating a highly reliable and self-healing industrial system that rapidly responds to real-time events with appropriate actions. In [4] technical challenges and design principles are introduced in terms of hardware development, system architectures and protocols, and software development. Specifically, radio technologies, energyharvesting techniques, and cross-layer design for IWSNs havebeen discussed.

In [5] the opportunities and challenges of hybrid network architecture are discussed. More specifically, Internet based Virtual Private Networks, power line communications, satellite communications and wireless communications are described in detail. The motivation of [5] is to provide a better understanding of the hybrid network architecture that can provide heterogeneous electric system automation application requirements. [6] starts with an overview of the application of WSNs for electric power systems along with their opportunities and challenges and opens up future work in many unexploited research areas in diverse smart-grid applications. Then, it presents a comprehensive experimental study on the statistical characterization of the wireless channel in different electric-power-system environments, including a 500-kV substation, an industrial power control room, and an underground network transformer vault. Field tests have been performed on IEEE 802.15.4-compliant wireless sensor nodes in real-world power delivery and distribution systems to measure background noise, channel characteristics, and attenuation in the 2.4-GHz frequency band. Overall, the empirical measurements and experimental results provide valuable insights about IEEE 802.15.4-compliant sensor network platforms and guide design decisions and tradeoffs for WSN-based smart-grid applications. In [7], the state of the art in algorithms, protocols, and hardware for wireless multimedia sensor networks is surveyed, and open research issues are discussed in detail. Architectures for WMSNs are explored, along with their advantages and drawbacks. Currently off-the-shelf hardware as well as available research prototypes for WMSNs are listed and classified. Existing solutions and open research issues at the application, transport, network, link, and physical layers of the communication protocol stack are investigated, along with possible cross-layer synergies and optimizations. [8] proposes H-NAMe, a very simple yet extremely efficient hidden-node avoidance mechanism for WSNs. H-NAMe relies on a grouping strategy that splits each cluster of a WSN into disjoint groups of non-hidden nodes that scales to multiple clusters via a cluster grouping strategy that guarantees no interference between overlapping clusters. Importantly, H-NAMe is instantiated in IEEE 802.15.4/ZigBee, which currently are the most widespread communication technologies for WSNs, with only minor add-ons and ensuring backward compatibility with their protocols standards. H-NAMe was implemented and exhaustively tested using an experimental test-bed[[9].

[10] Presents a dynamic topology management protocol that surpasses the static approach introducing support for event-driven data transmissions and node joining at runtime and providing a novel adaptive technique for energy balancing among nodes to further increase network lifetime. This paper provides a detailed description of the dynamic protocol and simulation results on network lifetime and routing performance with comparative assessments. [11] states several problems related to topology control in wireless ad hoc and sensor networks, and we survey state-of-the-art solutions which have been proposed to tackle them. We also outline several directions for further research which we hope will motivate researchers to undertake additional studies in this field. [12] presents a minimum spanning tree (MST)-based algorithm, called local minimum spanning tree (LMST), for topology control in wireless multi hop networks. In this algorithm, each node builds its LMST independently and only keeps on-tree nodes that are one-hop away as its neighbors in the final topology. We analytically prove several important properties of LMST. Simulation results show that LMST can increase the network capacity as well as reduce the energy consumption.

In [13] a detailed analysis of a cone-based distributed topology-control (CBTC) algorithm. This algorithm does not assume that nodes have GPS information available; rather it depends only on directional information. Roughly speaking, the basic idea of the algorithm is that a node transmits with the minimum power required to ensure that in every cone of around, there is some node that can reach with degree power. [13] Also propose a set of optimizations that further reduce power consumption and prove that they retain network connectivity. Dynamic reconfiguration in the presence of failures and mobility is also discussed. Simulation results are presented to demonstrate the effectiveness of the algorithm and the optimizations. [14] Propose an approach to topology control based on the principle of maintaining the number of neighbors of every node equal to or slightly below a specific value k. The approach enforces symmetry on the resulting communication graph, thereby easing the operation of higher layer protocols [15] propose a novel localized topology-control algorithm for each wireless node to locally select communication neighbours and adjust its transmission power accordingly such that all nodes together self-form a topology that is energy efficient simultaneously for both unicast and broadcast communications. We theoretically prove that the proposed topology is planar, which meets the requirement of certain localized routing methods to guarantee packet delivery; it is power-efficient for unicas the energy needed to connect any pair of nodes is within a small constant factor of the minimum; it is also asymptotically optimum for broadcast the energy consumption for broadcasting data on top of it is asymptotically the best among all structures constructed using only local information; it has a constant bounded logical degree, which will potentially save the cost of updating routing tables if used. [15] further prove that the expected average physical degree of all nodes is a small constant.

In [16] analyse the critical transmitting range for connectivity in wireless ad hoc networks, considering the following problem: Assume n nodes, each capable of communicating with nodes within a radius of r, are randomly and uniformly distributed in a d-dimensional region with a side of length l; how large must the transmitting range r be to ensure that the resulting network is connected with high probability? First, we consider this problem for stationary networks, and we provide tight upper and lower bounds on the critical transmitting range for one-dimensional networks and non tight bounds for two and three-dimensional networks. Due to the presence of the geometric parameter l in the model, our results can be applied to dense as well as sparse ad hoc networks, contrary to existing theoretical results that apply only to dense networks. We also investigate several related questions through extensive simulations.

[17] proposes a stable, dynamic, distributed clustering for energy efficient networking. Via simulation, evaluated the impacts of mobility and transmission power variation on network stability. [18] define as network lifetime the time period from the instant when the network starts functioning to the instant when the first network node runs out of energy. objective is to devise techniques to maximize the network lifetime in the case of cluster-based systems, which represent a significant sub-set of ad hoc networks. Cluster-based ad hoc networks comprise two types of nodes: cluster-heads and ordinary nodes. Cluster-heads coordinate all transmissions from/to ordinary nodes and forward all traffic in a cluster, either to other nodes in the cluster or to other cluster-heads. In this case, to prolong the network lifetime we must maximize the lifetime of the cluster-heads because they are the critical network element from the energy viewpoint. [18] propose an original approach to maximize the network lifetime by determining the optimal assignment of nodes to cluster-heads. Given the number of cluster-heads, the complexity of the proposed solution grows linearly with the number of network nodes. The network topology is assumed to be either static or slowly changing. Two working scenarios are considered. In the former, the optimal network configuration from the energy viewpoint is computed only once; in the latter, the network configuration can be periodically updated to adapt to the evolution of the cluster-heads

energy status. In both scenarios, the presented solution greatly outperforms the standard assignment of nodes to cluster-heads, based on the minimum transmission power criterion.

Transmit power control is a prototypical example of a cross-layer design problem. The transmit power level affects signal quality and, thus, impacts the physical layer, determines the neighbouring nodes that can hear the packet and, thus, the network layer affects interference which causes congestion and, thus, affects the transport layer. It is also means to several performance measures such as throughput, delay, and energy consumption. The challenge is to determine where in the architecture the power control problem is to be situated, to determine the appropriate power level by studying its impact on several performance issues, to provide a solution which deals properly with the multiple effects of transmit power control, and finally, to provide a software architecture for realizing the solution [19]. Some basic principles on power control, which inform the subsequent design process, detail the design of a sequence of increasingly complex protocols, which address the multidimensional ramifications of the power control problem. Many of these protocols have been implemented, and may be the only implementations for power control in a real system. It is hoped that the approach in this paper may also be of use in other topical problems in cross-layer design[19].

[20] Introduce a geographical adaptive fidelity (GAF) algorithm that reduces energy consumption in ad hoc wireless networks. GAF conserves energy by identifying nodes that are equivalent from a routing perspective and turning off unnecessary nodes, keeping a constant level of routing fidelity. GAF moderates this policy using application- and system-level information; nodes that source or sink data remain on and intermediate nodes monitor and balance energy use. GAF is independent of the underlying ad hoc routing protocol; we simulate GAF over unmodified AODV and DSR. Analysis and simulation studies of GAF show that it can consume 40% to 60% less energy than an unmodified ad hoc routing protocol. Moreover, simulations of GAF suggest that network lifetime increases proportionally to node density; in one example, a four-fold increase in node density leads to network lifetime increase for 3 to 6 times (depending on the mobility pattern). More generally, GAF is an example of adaptive fidelity, a technique proposed for extending the lifetime of self configuring systems by exploiting redundancy to conserve energy while maintaining application fidelity [20].

The nodes can also coordinate to exploit the redundancy provided by high density so as to extend overall system lifetime[21]. The large number of nodes deployed in these systems will preclude manual configuration, and the environmental dynamics will preclude design-time pre configuration. Therefore, nodes will have to self-configure to establish a topology that provides communication under stringent energy constraints. ASCENT builds on the notion that, as density increases, only a subset of the nodes are necessary to establish a routing forwarding backbone[21]. In ASCENT, each node assesses its connectivity and adapts its participation in the multi hop network topology based on the measured operating region. This paper motivates and describes the ASCENT algorithm and presents analysis, simulation, and experimental measurements. We show that the system achieves linear increase in energy savings as a function of the density and the convergence time required in case of node failures while still providing adequate connectivity[22].

III. PROPOSED METHOD

In proposed method network topology is modelled as Graph. Original Graph G(S,E) where set S of Vertex(nodes) , E is set of edges(communication links), Gabriel graph GG(s',e') is a graph such that $s' \subseteq S$, $e' \subseteq E$, and Edge $PQ \subseteq e'$ only when disc of which PQ is a diameter contains no other elements of S.

$$\text{Average Remaining energy} = 1/|GG| \ast \sum \text{remaining energy } (i) \quad \text{for } i=0 \text{ to } |GG| \qquad (1)$$

Where |GG| is number of nodes in GG.

Final Topology graph FTG (N, C) is graph such that

$N \subseteq s'$ and remaining energy of $N >=$ average remaining energy

$C \subseteq e'$ and Edge $PQ \subseteq C$ only when $\{P,Q\} \subseteq N$.

Following are major steps in proposed method:

- The node discovers its neighbour nodes by broadcasting HELLO message along with remaining energy of itself.
- The Gabriel graph is constructed locally by each node.
- The unit direction vectors of neighbour nodes in the Gabriel graph are computed.
- The average remaining energy is computed locally.
- Nodes with remaining energy less than average remaining energy are dropped from topology, producing the reduced topology.
- Above process is repeated periodically to replace low energy nodes with better energy nodes.

In proposed method, use of Gabriel graph results into low interference. Proposed system will result into equal utilization of energy as Low energy nodes are avoided from being on path and topology is changed periodically. This will result into prolonged network lifetime. But in some cases end to end delay in communication may be little higher as nodes belong to shortest path might be dropped from topology due to lesser energy.

IV. CONCLUSIONS

Computational complexity of Gabriel Graph and Yao graph is very high and optimization is NP hard. Our proposed model is computationally less complex. Also proposed model provides topology control at local level in distributed manner. Proposed algorithm also proved to be energy efficient and helps in prolong network lifetime. Our future work includes implementation of proposed method and evaluating performance.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, A survey on sensor networks, • IEEE Commun. Mag., vol. 40, no. 8, pp. 102-110, 2002.
[2] M. M. Shalaby, M. A. Abdelmoneum, and K. Saitou, Design of spring coupling for high-Q high-frequency MEMS filters for wireless applica- tions, • IEEE Trans. Ind. Electron., vol. 56, no. 4, pp. 1022-1030, Apr. 2009.
[3] A. Willig, Recent and emerging topics in wireless industrial commu- nications: A selection, • IEEE Trans. Ind. Inform., vol. 4, no. 2, pp. 102-122, May 2008.
[4] S.-E. Yoo et al., Guaranteeing real-time services for industrial wireless sensor networks with IEEE 802.15.4, • IEEE Trans. Ind. Electron., vol. 57, no. 11, pp. 3868-3876, Nov. 2010.
[5] V. C. Gungor and F. C. Lambert, A survey on communication networks for electric system automation, • Comput. Networks, vol. 50, no. 7, pp. 877-897, 2006.
[6] V. C. Gungor, B. Lu, and G. P. Hancke, Opportunities and challenges of wireless sensor networks in smart grid, • IEEE Trans. Ind. Electron.,vol. 57, no. 10, pp. 3557-3564, Oct. 2010.
[7] I. F. Akyildiz, T. Melodia, and K. R. Chowdhury, A survey on wireless multimedia sensor networks, • Comput. Networks, vol. 51, no. 4, pp. 921-960, 2007.
[8] A. KoubÃ¢a, R. Severino, M. Alves, and E. Tovar, Improving quality-of-service in wireless sensor networks by mitigating hidden-node collisions, • IEEE Trans. Ind. Inform., vol. 5, no. 3, pp. 299-313, Aug. 2009.
[9] S. Adee, IEEE Spectrum 2010. [Online]. Available: http://spectrum.ieee.org/semiconductors/devices/wireless-sensors-that-live-forever
[10] L. Lobello and E. Toscano, An adaptive approach to topology management in large and dense real-time wireless sensor networks, • IEEE Trans. Ind. Inform., vol. 5, no. 3, pp. 314-324, Aug. 2009.
[11] P. Santi, Topology control in wireless ad hoc and sensor networks,ACM Comput. Surveys, vol. 37, no. 2, pp. 164-194, 2005.
[12] N. Li, J. C. Hou, and L. Sha, Design and analysis of an MST-based topology control algorithm, • IEEE Trans. Wireless Commun., vol. 4, no. 3, pp. 1195-1206, 2005.
[13] L. Li, J. Y. Halpern, P. Bahl, Y.-M. Wang, and R. Wattenhofer,A cone-based distributed topology-control algorithm for wireless multi-hop networks, • IEEE/ACM Trans. Networking, vol. 13, no. 1, pp. 147-159, Feb. 2005.
[14] D. M. Blough, M. Leoncini, G. Resta, and P. Santi, The K-Neigh protocol for symmetric topology control in ad hoc networks, • in Proc. Int. Symp. Mobile Ad Hoc Networking and Computing (MobiHoc), 2003, pp. 141-152.
[15] W.-Z. Li, X.-Y. Frieder, O. Wang, and W. Z. Song, Localized topology control for unicast and broadcast in wireless ad hoc networks, • IEEE Trans. Parallel Distrib. Syst., vol. 17, no. 4, pp. 321-334, 2006.
[16] P. von Rickenbach, R. Wattenhofer, and A. Zollinger, Algorithmic models of interference in wireless ad hoc and sensor networks,IEEE/ACM Trans. Networking, vol. 17, no. 1, pp. 172-185, Feb. 2009.
[17] P. Santi and D. M. Blough, The critical transmitting range for connectivity in sparse wireless ad hoc networks, • IEEE Trans. Mobile Computing, vol. 2, no. 1, pp. 25-39, Jan.-Mar. 2003.
[18] T. J. Kwon and M. Gerla, Clustering with power control, • in Proc, IEEE Military Commun. Conf. MILCOM 2, 1999, pp. 1424-1428.
[19] C.-F. Chiasserini, I. Chlamtac, P. Nucci, and A. Monti, An energy efficient method for nodes assignment in cluster-based ad hoc networks, Wireless Networks, vol. 10, no. 3, pp. 223-231, 2004.
[20] V. Kawadia and P. R. Kumar, Principles and protocols for power control in wireless ad hoc networks, • IEEE J. Sel. Areas Commun., vol. 23, no. 1, pp. 76-88, Jan. 2005.
[21] Y. Xu, J. Heidemann, and D. Estrin, Geography-informed energy conservation for ad hoc routing, • in Proc. Annu. Int. Conf. Mobile Comput. Networking (MOBICOM), 2001, pp. 70-84.
[22] A. Cerpa and D. Estrin, ASCENT: Adaptive self-configuring sensor networks topologies, • IEEE Trans. Mobile Comput., vol. 3, no. 3, pp. 272-285, Jul.-Aug. 2004.