Ain Shams University
Faculty of Engineering
Computer and Systems Engineering Department

Extending Network Lifetime under Constraints for Wireless Sensor Networks

A Thesis

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(Computer and Systems Engineering)

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Statement

This dissertation is submitted to Ain Shams University for the degree of Philosophy Doctor in Electrical Engineering (Computer and Systems Engineering).

The work is included in this thesis was carried out by the author at the Computer and Systems, Engineering department, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or qualification at other university or institution.

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ABSTRACT

Extending Network Lifetime under Constraints for Wireless Sensor Networks

In this thesis a Multilevel Minimized Delay Clustering Protocol (MMDCP) is proposed. MMDCP is proved to extend the lifetime of wireless sensor networks through leveling and through a better choice of cluster heads. The proposed algorithm assigns the number of the lower level cluster heads and the leaf nodes in the network so as to minimize the end-to-end delay. When comparing MMDCP to the well known LEACH-C protocol, MMDCP succeeds in extending the lifetime of the network more than LEACH-C and in minimizing the end-to-end delay of the data sending less than LEACH-C. MMDCP also shows significant increase in throughput values more than LEACH-C. In comparison to the recently proposed protocol THCHP which has competitive lifetime and delay optimizations, MMDCP shows significant minimization in end-to-end delay in high and medium density networks. Furthermore, it succeeds in extending the network lifetime more than THCHP in low density networks, whilst in throughput values MMDCP shows a noticeable increase more than THCHP. Also, MMDCP is compared to another recently proposed protocol, Delay-Aware, where it succeeds to show significant improvements in structure and results of lifetime, end-to-end delay and throughput as the network scales. The delay results are also compared in details of all delay sources including queuing, transmission and processing. Two radio models are used to evaluate MMDCP protocol performance, the First Order Radio Model and the Discrete Radio Model which is a realistic model with real mote specifications. The obtained results are proved analytically and via simulation. This significant minimization in delay makes the proposed protocol a very good candidate for use in crises management applications like pre-expectation of landslides and early control of slum fires.

List of Publications:

- Anar Abdel Hady, Hossam M.A. Fahmy, Sherine M. Abd El-kader, Hussein S. Eissa, and Ashraf Salem. “Multilevel Minimized Delay Protocol for Wireless Sensor Networks” International Journal of Communication Networks and Distributed Systems (IJCNDS)(under revising)
- Anar Abdel Hady, Sherine M. Abd El-kader, Hussein S. Eissa, Ashraf Salem, and Hossam M.A. Fahmy. "A Comparative Analysis of Hierarchical Routing Protocols in Wireless Sensor Networks." *Internet and Distributed Computing Advancements: Theoretical Frameworks and Practical Applications, JH Abawajy, M. Pathan, M. Rahman, A. K. Pathan, and MM Deris (eds.), IGI Global* (2012): 212-246.

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$E_{Tx-elec}$	Per-bit transmission energy
$E_{Rx-elec}$	Per-bit reception energy
E_{elec}	Electronics energy constant
$\varepsilon_{fs} d^2$	Amplifier energy
$\varepsilon_{mp} d^4$	Amplifier energy
$T_{Startup}$	Length of time needed to startup the radio oscillator
C_{PLEVEL}	Current usage in mA at power level *plevel*
T_{rate}	Transmission rate in bits per second
C_{Rx}	Current usage for receiving data
T_{frame}	Time Frame
T_{sl}	Time Slot
T_{Delay}	Delay Time
T_{trans}	Transmission Time
T_{queue}	Queuing Time
T_{agg}	Aggregation Time

List of Abbreviations

WSN	Wireless Sensor Networks
BS	Base Station
CH	Cluster Head
LL	Low Level
HL	High Level
MMDCP	Multilevel Minimized Delay Clustering Protocol
LEACH	Low-Energy Adaptive Clustering Hierarchy
LEACH-C	Low-Energy Adaptive Clustering Hierarchy Centralized
THCHP	Two-level Hierarchical Clustering Based Hybrid Routing Protocol
BA	Balancing Algorithm
MDA	Minimum Delay Algorithm
FOM	First Order Radio Model
DM	Discrete Radio Model
TDMA	Time Division Multiple Access
CSMA	Carrier Sense Multiple Access
TEEN	Threshold Sensitive Energy Efficient Sensor Network Protocol
APTEEN	Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol
PEGASIS	Power-Efficient GAthering in Sensor Information Systems
MECN	Minimum Energy Communication Network
SMECN	Small Minimum Energy Communication Network

SOP	Self Organizing Protocol
VGA	Virtual Grid Architecture Routing
HPAR	Hierarchical Power-Aware Routing
TTDD	Two-Tier Data Dissemination
BDCDP	Base-Station Controlled Dynamic Clustering Protocol
MICRO	Minimum Cost Routing with Optimized Data Fusion
MLC	Multi-Level Clustering
MEDC	Multi-layer Energy-efficient and Delay-reducing Chain-based data gathering protocol