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Wireless Sensor Networks Localization Algorithms: A Comprehensive Survey

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ABSTRACT

Wireless sensor networks (WSNs) have recently gained a lot of attention by scientific community. Small and inexpensive devices with low energy consumption and limited computing resources are increasingly being adopted in different application scenarios including environmental monitoring, target tracking and biomedical health monitoring. In many such applications, node localization is inherently one of the system parameters. Localization process is necessary to report the origin of events, routing and to answer questions on the network coverage, assist group querying of sensors. In general, localization schemes are classified into two broad categories: range-based and range-free. However, it is difficult to classify hybrid solutions as range-based or range-free. In this paper we make this classification easy, where range-based schemes and range-free schemes are divided into two types: fully schemes and hybrid schemes. Moreover, we compare the most relevant localization algorithms and discuss the future research directions for wireless sensor networks localization schemes.

KEYWORDS

Localization, WSN, anchor node, range-based methods, range-free methods, hybrid-based methods.

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REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam & E. Cayirci, (2002) “Wireless sensor networks: A survey”, ELSEVIER Computer Networks Journal, vol. 38,No.4, pp 393–422.

[2] B.H. Wellenhof, H. Lichtenegger & J. Collins, (1997) Global Positioning System: Theory and Practice, 4th ed. Springer.

[3] N. Labraoui, M. Gueroui & M. Aliouat, (2012) “Secure DV-hop Localization scheme against wormhole attacks in wireless sensor networks”, Transactions on Emerging Telecommunication Technologies, vol.23, No.4, pp 303–316.

[4] A. Savvides, C. Han & M.B Strivastava, (2001) “Dynamic fine-grained localization in ad-hoc networks of sensors”, ACM MOBICOM, pp 166-79.

[5] L.N Donggang, N. Peng & D. Wenliang, (2005) “detecting malicious beacon nodes for secure location discovery in wireless sensor networks”, 25th IEEE International Conference on Distributed Computing Systems, pp 609-619.

[6] M. Pirretti, N. Vijaykrishnan, P. McDaniel & B Madan, (2005) “SLAT: secure localization with attack tolerance.” Technical report: NAS-TR-0024-2005, Pennsylvania State Univ.

[7] Nazir, U.; Arshad, M.A.; Shahid, N.; Raza, S.H.(2012) “Classification of localization algorithms for wireless sensor network: A survey,” IEEE International Conference on Open Source Systems and Technologies (ICOSST),pp1 - 5, Lahore.

[8] J. Wang, R.K. Ghosh & S.K. Das, (2010) “A survey on sensor localization”. Journal of Control Theory and Applications,vol. 8,No.1,pp2-11.

[9] G. Mao, B. Fidan & B. Anderson, (2007) “Wireless sensor network localization techniques”, Elsevier/ACM Computer Networks, vol. 51,pp2529–2553.

[10] H. Cui, Y. Wang, J. Ly & Y. Mao (2011) “Three-mobile-beacon assisted weighted centroid localization method in wireless sensor networks”, IEEE 2nd International Conference on Software Engineering and Service Science, pp 308 - 311, Beijing.

[11] N. Bulusu, J. Heidemann & D. Estrin. (2000) “GPS-less low-cost outdoor localization for very small devices”, IEEE Personal Communications, vol. 7,pp 28-34.

[12] H. Chen, P. Huang, M. Martins, H.C. So & K. Sezaki. (2008) “Novel centroid localization algorithm for three-dimensional wireless sensor networks”, International Conference on Wireless Communications, Networking and Mobile Computing, pp 1 – 4, Dalian.

[13] L.M. Blumenthal (1959) Theory and Applications of Distance Geometry (2nd edition) , Chelsea.
[14] Q. Wan, Y. Peng (2002) “An Improved 3-Dimensional Mobile Location Method Using Volume Measurements of Tetrahedron”, 4th World Congress on intelligent Control and Automation, vol. 3, pp 2181 – 2185.

[15] D. Niculescu, B. Nath (2001) “Ad-hoc Positioning System”, IEEE Global Telecommunications Conference, vol. 5, pp 2926 – 2931, San Antonio.

[16] D. Niculescu, B. Nath (2003) “DV Based Positioning in Ad hoc Networks”, Journal of Telecommunication Systems, vol. 22, pp 267–280.

[17] W.W. Ji, Z. Liu (2006) “An Improvement of DV-Hop Algorithm in Wireless Sensor Networks”, International Conference on Wireless Communications, Networking and Mobile Computing, pp 1-4, Wuhan.

[18] S. Tian, X. Zhang, X. Wang, P. Sun & H. Zhang (2007) “A Selective Anchor Node Localization Algorithm for Wireless Sensor Networks”, International Conference on Convergence Information Technology, pp 358 – 362, Gyeongju.

[19] J. Li, J. Zhang & L. Xiande (2009) “A Weighted DV-Hop Localization Scheme for Wireless Sensor Networks”, International Conference on Scalable Computing and Communications / Eighth International Conference on Embedded Computing, pp 269 – 272, Dalian.

[20] W. Yu, H. Li (2012) “An improved DV-Hop localization method in Wireless Sensor Networks”, IEEE International Conference on Computer Science and Automation Engineering, pp 199 - 202, Zhangjiajie.

[21] T. He, C. Huang & B.M. Blum, J.A. Stankovic, T. Abdelzaher (2003) “Range-free localization schemes for large scale sensor networks”, 9th annual international conference on mobile computing and networking, pp 81-95, San Diego.

[22] J. Wang, H. Jin (2009) “Improvement on APIT Localization Algorithms for Wireless Sensor Networks”, International Conference on Networks Security / Wireless Communications and Trusted Computing, vol. 1, pp 719 – 723.

[23] J. Shu, C. Yan & L. Liu (2012) “Improved three-dimensional localization algorithm based on volume-test scan for wireless sensor networks”, The Journal of China Universities of Posts and Telecommunications of Elsevier, vol. 19, pp 1 – 6.

[24] L. Lazos, R. Poovendran (2004) “SeRLoc: Secure range-independent localization for wireless sensor networks”, ACM Workshop on Wireless Security, pp 21-30, Philadelphia.

[25] R. Stoleru, T. He & A. Stankovic (2007) “Range-free Localization”, Secure Localization and Time Synchronization for Wireless Sensor and Ad Hoc Networks”, vol. 30, pp 3-31.

[26] E. Guerrero, H.G. Xiong, Q. Gao, R. Ricardo & J. Estévez (2009) “ADAL: A Distributed Range-free Localization Algorithm Based on a Mobile Beacon for Wireless
Sensor Networks”, International Conference on Ultra Modern Telecommunications & Workshops, pp 1-7, St. Petersburg.

[27] Y. Shang, W. Ruml, Y. Zhang & M.P.J. Fromherz (2003) “Localization from mere connectivity”, Fourth International ACM Symposium on Mobile Ad Hoc

[29] H. Junfeng, C. Jun, Z. Yafeng & M. Xue (2010) “A MDS-based localization algorithm for large-scale wireless sensor network”, International Conference on Computer Design and Applications, pp 566 - 570, Qinhuangdao

[30] X.H. Nie, Z.M. Pan (2012) “Iterated Hybrid Localization Algorithm for Random Wireless Sensor Networks based on Centroid and DV-Hop Algorithm”, Applied Mechanics and Materials, pp 1854-1857.

[31] P. Motter, R. Allgayer, Müller I & Freitas E (2011) “Practical issues in wireless sensor network localization systems using received signal strength indication”, IEEE Sensors Applications Symposium, pp 227-232, San Antonio.

[32] C.Y. Shih, P.J. Marrón (2010) “COLA: Complexity-Reduced Trilateration Approach for 3D Localization in Wireless Sensor Networks”, Fourth International Conference Sensor Technologies and Applications, pp 24 – 32, Venice

[33] M. Sugano, T. Kawazoe, Y. Ohta & M. Murata (2006) “Indoor localization system using RSSI measurement of wireless sensor network based on ZigBee standard”, IASTED International MultiConference on Wireless and Optical Communication.

[34] K. Whitehouse, C. Karlof & D. Culler (2007) “A practical evaluation of radio signal strength for ranging-based localization”, ACM SIGMOBILE Mobile Computing and Communications Review, vol. 11, pp 41–52.

[35] M. BAL, M. Liu, W. Shen & H. Ghenniwa (2009) “Localization in cooperative Wireless Sensor Networks: A review”, 13th International Conference on Computers Supported Cooperative Work in Design, pp 438 – 443, Santiago, Chile.

[36] E. Elnahrawy, X. Li & R.P. Martin (2004) “The Limits of Localization Using Signal Strength: A Comparative Study”, First Annual IEEE Communications Society Conference on Sensor and Ad Hoc Communications and Networks, pp 406-414, California.

[37] A. Awad, T. Frunzke & F. Dressler (2007) “Adaptive Distance Estimation and Localization in WSN using RSSI Measures”, 10th EUROMICRO Conference on Digital System Design Architectures/ Methods and Tools, pp 471-478, Lübeck

[38] Y. Gwon, R. Jain & T. Kawahara (2004) “Robust indoor location estimation of stationary and mobile users”, IEEE INFOCOM, vol.2, pp 1032 - 1043.
[39] T.S. Rappaport, J.Reed & B.D. Woerner (1996) “Position location using wireless communications on highways of the future”, IEEE Communications Magazine, vol. 34, pp 33 – 42.

[40] D. Niculescu, B. Nath (2003) “Ad hoc positioning system (APS) using AOA”, IEEE INFOCOM, vol. 3, pp 1734 – 1743.

[41] A. Nasipuri, K. Li (2002) “A directionality based location discovery scheme for wireless sensor networks”, 1st ACM international workshop on Wireless sensor networks and applications, pp 105–111, Atlanta.

[42] P. Kulakowski, J. Vales-Alonso, E. Egea-López, W. Ludwin & J. Garcia-Haro (2010) “Angle-of-arrival localization based on antenna arrays for wireless sensor networks”, Computer & Electrical Engineering, vol. 36, pp 1181–1186.

[43] P. Rong, M.L. Sichitiu (2006) “Angle of arrival localization for wireless sensor networks”, IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, pp 374–82, Reston.

[44] I. Amundson, J. Sallai, X. Koutsoukos, A. Ledeczi & M. Maroti (2011) “RF Angle of Arrival-based Node Localization”, International Journal of Sensor Networks, vol. 9, pp 209-224.

[45] N.B. Priyantha, A.K.L. Miu, H. Balakrishnan & S. teller. (2001) “The Cricket Compass for ContextAware Mobile Applications”, 7th annual international conference on mobile computing and networking, pp1-14, Rome.

[46] K.H. Lee, C.H. Yu, J.W. Choi & Y.B. Seo (2008) “ToA based sensor localization in underwater wireless sensor networks”, SICE Annual Conference, pp1357 – 1361, Tokyo.

[47] H. Chen, B. Liu, P. Huang, J. Liang & Y. Gu (2012) “Mobility-Assisted Node Localization Based on TOA Measurements Without Time Synchronization in Wireless Sensor Networks”, Mobile Networks and Applications, vol. 17, pp90-99.

[48] L. Girod, D. Estrin (2001) “Robust range estimation using acoustic and multimodal sensing”, IEEE/RSJ International Conference on Intelligent Robots and Systems, pp1312 – 1320, Hawaii.

[49] M. Youssef, A. Youssef, C. Rieger, U. Shankar & A. Agrawala (2006) “Pinpoint: An asynchronous determination time-based location determination system”, 4th International Conference on Mobile Systems/ Applications and Services, pp165 – 176, New York.

[50] B. Thorbjornsen, N.M. White, A.D. Brown & J.S. Reeve (2010) “Radio frequency (RF) time-of-flight ranging for wireless sensor networks”, Measurement Science and Technology, vol. 21, pp 1-12.
[51] B. Parkinson, J. Spilker (1996) “Global positioning system: Theory and application”, Progress in Astronomics and Aeronotics.

[52] L. Hu, D. Evans (2004) “Localization for Mobile Sensor Networks”, 10th International Conference on Mobile Computing and Networking, pp 45–47, Philadelphia.

[53] N. Patwari, J.N. Ash, S. Kyperountas, A.O. Hero, R.L. Moses & N.S Correal (2005) “Locating the nodes: cooperative localization in wireless sensor networks”, IEEE signal processing magazine, vol. 22, pp 1053–5888.

[54] A. Boukerche, H.A.B Oliveira, E.F.Nakamura & A.A.F Loureiro (2007) “Localization systems for wireless sensor networks”, IEEE Wireless Communications, vol.14, pp 6 – 12.

[55] J. Xiao, L. Ren, J. Tan (2006) “Research of TDOA Based Self-Localization Approach in Wireless Sensor Network”, IEEE/RSJ International Conference on Intelligent Robots and Systems, pp 2035 – 2040, Beijing.

[56] S. Zhang, L. Ren, J. Xiao & J.Tan (2006) “A High Precision Localization Algorithm in Wireless Sensor Network”, 9th International Conference on Control, Automation, Robotics and Vision, pp 1 – 6. Singapore

[57] F. Gustafsson, F.Gunnarsson (2003) “Positioning using time-difference of arrival measurements”, IEEE International Conference on Acoustics, Speech and Signal Processing, vol. 6, pp 553–556.

[58] A.R. Kulaib, R.M. Shubair, M.A. Al-Quatayri & N.g, JWP (2011) “An overview of localization techniques for Wireless Sensor Networks”, International Conference on Innovations in Information Technology, pp 167–172, Abu Dhabi.

[59] C. Savarese, J. Rabaey & J. Beutel (2001) “Locationing in distributed ad-hoc wireless sensor networks”, IEEE International Conference on Acoustics, Speech, and Signal Processing, vol. 4, pp 2037 – 2040.

[60] D. Moore, J. Leonard, D. Rus & S. Teller (2004) “Robust distributed network localization with noisy range measurements”, 2nd ACM Conference on Embedded Networking Sensor Systems, pp 50-61, Baltimore

[61] F. Sottile, M. Spirito (2006) “Enhanced Quadrilateral-based Localization for Wireless Ad-hoc Networks”, Fifth Annual Mediterranean Ad Hoc Networking Workshop, Lipari.

[62] C.Y. Wen, F.K. Chan (2010) “Adaptive AOA-aided TOA self-positioning for mobile wireless sensor networks”, Sensors, vol. 10, pp 9742–9770.

[63] N.J. Gordon, D.J. Salmond & A.F.M Smith (1993) “Novel approach to nonlinear/non-gaussian Bayesian state estimation”, IEE Proceedings F, vol. 140, pp 107-113.
[64] Y. Shi, M. Mizumoto, N. Yubazak & M. Otani (1996) “A learning algorithm for tuning fuzzy rules based on the gradient descent method”, 5th IEEE International Conference on Fuzzy Systems, pp55-61, New Orleans.

[65] A.N Bishop, B. Fidan, K. Dogancay, B.D.O. Anderson & P.N. Pathirana (2008) “Exploiting geometry for improved hybrid AOA/TDOA based localization”, Signal Processing, vol.88, pp1775–1791.

[66] P. Desai, N. Baine & K. Rattan (2011) “Fusion of RSSI and TDoA Measurements from Wireless Sensor Network for Robust and Accurate Indoor Localization”, International Technical Meeting of the Institute of Navigation, pp223-230, San Diego.

[67] C.D. Wann, H.C. Chin (2007) “Hybrid TOA /RSSI Wireless Location with Unconstrained Nonlinear Optimization for Indoor UWB Channels”, IEEE Wireless Communications and Networking Conference, pp 3940–3945, Kowloon.

[68] J. Blumenthal, R. Grossmann, F. Golatowski & D. Timmermann (2007) “Weighted Centroid Localization in Zigbee-Based Sensor Networks”, IEEE International Symposium on Intelligent Signal Processing, pp 1-6, Alcala de Henares.

[69] S. Tian, X. Zhang, P. Liu, P. Sun & X. Wang (2007) “A RSSI-based DV-hop Algorithm for Wireless Sensor Networks”, International Conference on Wireless Communications, Networking and Mobile Computing, pp 2555 – 2558, Shanghai.

[70] A. Magnani, K.K. Leung (2007) “Self-Organized, Scalable GPS-free Localization of Wireless Sensors”, IEEE Wireless Communications and Networking Conference, pp3798-3803, Kowloon.

[71] N. Priyantha, H. Balakrishnan, E. Demaine & S. Teller (2003) “Anchor-free distributed localization in sensor networks”, 1st International Conference on Embedded Networked Sensor Systems, pp 340-341.

[72] L.M.P.L. Brito, L.M.R. Peralta (2008) “An analysis of localization problems and solutions in wireless sensor networks”, Revista de Estudios Politécnicos Politecnical Studies Review, Vol.6, No.9.

[73] D.L. Hall (2004) “Mathematical Techniques in Multisensor Data Fusion”, Artech House Publishers.

[74] C. Wang, L. Xiao (2006) “Locating Sensors in Concave Areas”, In 25th Annual Conference of IEEE INFOCOM, Barcelona, Spain.

[75] T. Kubo, A. Tagami & T. Hasegawa, T. Hasegawa and J Walrand (2012) “Range-free localization using grid graph extraction”, Network Protocols (ICNP), 20th IEEE International Conference, pp1-11, Austin.
Towards Internet of Things (IOTS): Integration of Wireless Sensor Network to Cloud Services for Data Collection and Sharing

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ABSTRACT

Cloud computing provides great benefits for applications hosted on the Web that also have special computational and storage requirements. This paper proposes an extensible and flexible architecture for integrating Wireless Sensor Networks with the Cloud. We have used REST based Web services as an interoperable application layer that can be directly integrated into other application domains for remote monitoring such as e-health care services, smart homes, or even vehicular area networks (VAN). For proof of concept, we have implemented a REST based Web services on an IP based low power WSN test bed, which enables data access from anywhere. The alert feature has also been implemented to notify users via email or tweets for monitoring data when they exceed values and events of interest.

KEYWORDS

Internet of Things, Cloud computing, REST, Wireless Sensor Network, XBee

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REFERENCES

[1] M. Swan, "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0," Journal of Sensor and Actuator Networks, vol. 1, pp. 217-253, 2012.

[2] W. Wei, K. Lee, and D. Murray, "Integrating sensors with the cloud using dynamic proxies," in Personal Indoor and Mobile Radio Communications (PIMRC), 2012 IEEE 23rd International Symposium on,, 2012, pp. 1466-1471.

[3] Perumal.B, P. Rajasekaran.M, and Ramalingam.H.M, "WSN INTEGRATED CLOUD FOR AUTOMATED TELEMEDICINE (ATM) BASED e-HEALTHCARE APPLICATIONS," in 4th International Conference on Bioinformatics and Biomedical Technology, Singapore, 2012, pp. 166-170.

[4] C. Alcaraz, P. Najera, J. Lopez, and R. Roman, "Wireless Sensor Networks and the Internet of Things: Do We Need a Complete Integration?," presented at the 1st International Workshop on the Security of the Internet of Things (SecIoT'10), Tokyo, Japan, 2010.

[5] (2012, 20th December, 2012). Open.Sen.se. Available: http://open.sen.se/sensemeters/tab/3114/

[6] A. Wood, G. Virone, T. Doan, Q. Cao, L. Selavo, Y. Wu, et al., "ALARM-NET: Wireless sensor networks for assisted-living and residential monitoring," University of Virginia Computer Science Department Technical Report, 2006.

[7] D. Malan, T. Fulford-Jones, M. Welsh, and S. Moulton, "Codeblue: An ad hoc sensor network infrastructure for emergency medical care," in International workshop on wearable and implantable body sensor networks, 2004.

[8] G. Werner-Allen, K. Lorincz, M. Ruiz, O. Marcillo, J. Johnson, J. Lees, et al., "Deploying a wireless sensor network on an active volcano," Internet Computing, IEEE, vol. 10, pp. 18-25, 2006.

[9] J. Tooker, X. Dong, M. C. Vuran, and S. Irmak, "Connecting soil to the cloud: A wireless underground sensor network testbed," in Sensor, Mesh and Ad Hoc Communications and Networks (SECON), 2012 9th Annual IEEE Communications Society Conference on, 2012, pp. 79-81.

[10] F. Kausar, E. Al Eisa, and I. Bakhsh, "Intelligent Home Monitoring Using RSSI in Wireless Sensor Networks," International Journal of Computer Networks & Communications (IJCNC), vol. 4, pp. 33-46, 2012.

[11] H. ElAarag, D. Bauschlicher, and S. Bauschlicher, "System Architecture of HatterHealthConnect: An Integration of Body Sensor Networks and Social Networks to Improve Health Awareness,"
[12] P. A. C. d. S. Neves and J. J. P. C. Rodrigues, "Internet Protocol over Wireless Sensor Networks, from Myth to Reality," JOURNAL OF COMMUNICATIONS, vol. 5, pp. 189-195, 2010.

[13] M. R. Kosanović and M. K. Stojčev, "CONNECTING WIRELESS SENSOR NETWORKS TO INTERNET," FACTA UNIVERSITATIS, Mechanical Engineering, vol. 9, pp. 169-182, 2011.

[14] A. E. Kouche, "Towards a wireless sensor network platform for the Internet of Things: Sprouts WSN platform," in Communications (ICC), 2012 IEEE International Conference on, 2012, pp. 632-636.

[15] B. Li and J. Yu, "Research and Application on the Smart Home Based on Component Technologies and Internet of Things," Procedia Engineering, vol. 15, pp. 2087-2092, // 2011.

[16] N. Mitton, S. Papavassiliou, A. Puliafito, and K. S. Trivedi, "Combining Cloud and sensors in a smart city environment," EURASIP Journal on Wireless Communications and Networking, vol. 2012, p. 247, 2012.

[17] D. Guinard and V. Trifa, "Towards the web of things: Web mashups for embedded devices," in Workshop on Mashups, Enterprise Mashups and Lightweight Composition on the Web (MEM 2009), in proceedings of WWW (International World Wide Web Conferences), Madrid, Spain, 2009.

[18] N. B. Priyantha, A. Kansal, M. Goraczko, and F. Zhao, "Tiny web services: design and implementation of interoperable and evolvable sensor networks," in Proceedings of the 6th ACM conference on Embedded network sensor systems, 2008, pp. 253-266.

[19] A. Kansal, S. Nath, J. Liu, and F. Zhao, "SenseWeb: An Infrastructure for Shared Sensing," IEEE MultiMedia, vol. 14, pp. 8-13, 2007.

[20] D. International, "XBee User Manual," ed: Digi International, 2012, pp. 1-155.

[21] C. Chiu-Chiao, H. Ching Yuan, W. Shiau-Chin, and L. Cheng-Min, "Bluetooth-Based Android Interactive Applications for Smart Living," in Innovations in Bio-inspired Computing and Applications (IBICA), 2011 Second International Conference on, 2011, pp. 309-312.

[22] C.-H. Chen, C.-C. Gao, and J.-J. Chen, "Intelligent Home Energy Conservation System Based On WSN," presented at the International Conference on Electrical, Electronics and Civil Engineering, Pattaya, 2011.

[23] S. Hilton. (2012, 14 January). Progression from M2M to the Internet of Things: an introductory blog. Available: http://blog.bosch-si.com/progression-from-m2m-to-internet-of-things-an-introductoryblog/
[24] Z. Alliance. (2012, accessed on 6 October). ZigBee Specification. Available: http://www.zigbee.org

[25] Y. A. Alqudah, "VITAL SIGNS REMOTE MONITORING AND ANALYSIS: SEAMLESS INTEGRATION WITH A SMART PHONE," Biomedical Engineering: Applications, Basis and Communications, vol. 0, p. 1350003.

[26] C. Doukas, Building Internet of Things with the Arduino vol. 1, 2012.
A Reliable and Energy Efficient Transport Protocol for Wireless Sensor Networks

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ABSTRACT

In wireless sensor networks (WSN), an ideal transport layer needs to support reliable message delivery and provide congestion control in an efficient manner in order to extend the lifetime of a WSN. The main use of transport protocol in WSN is to overcome the congestion and the reliability with energy efficiency. In this paper, we develop a reliable and energy efficient transport protocol (REETP), which mainly focuses on the reliability and energy efficiency. Our proposed protocol consist of an Efficient Node Selection Algorithm to determine a set of efficient nodes called E-Nodes which form a near optimal coverage set with largest area and highest residual energy level. The key idea of REETP is to transfer encoded packets using LT codes from the source to the sink block by block and each block is forwarded to an E-node. After receiving encoded packets, the E-node tries to reconstruct the original data packets and it encodes the original data packets again and relays them to the next E-node until it reaches the sink. By simulation results, we show that our proposed protocol has more packet delivery ratio with reduced packet loss and energy consumption.

KEYWORDS

Wireless sensor networks, Congestion, Contention, Energy Efficient, Transmission rate, Data flow

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REFERENCES

1. Paulo Rogerio Pereira, Antonio Grilo, Francisco Rocha, Mario Serafim Nunes, Augusto Casaca, Claude Chaudet, Peter Almström and Mikael Johansson, “End-To-End Reliability in Wireless Sensor Networks: Survey and Research Challenges”, Euro FGI Workshop on IP QoS and Traffic Control, 2007.

2. Sandip Dalvi, Anirudha Sahoo and Ashutosh Deo, “A MAC-aware Energy Efficient Reliable Transport Protocol for Wireless Sensor Networks”, In the Proceedings of the IEEE conference on Wireless Communications & Networking Conference, 2009.

3. Chonggang Wang, Kazem Sohraby, Bo Li and Weiwen Tang, “Issues of Transport Control Protocols for Wireless Sensor Networks”, In the Proceedings of International Conference on Communications, Circuits and Systems (ICCCAS), 2005.

4. Justin Jones and Mohammed Atiquzzaman, “Transport Protocols for Wireless Sensor Networks: State-of-the-Art and Future Directions”, International Journal of Distributed Sensor Networks, 2007.

5. Chonggang Wang, Kazem Sohraby, Bo Li, Mahmoud Daneshmand and Yueming Hu, “A Survey of Transport Protocols for Wireless Sensor Networks”, IEEE Networks, 2006

6. Yogesh G. Iyer, Shashidhar Gandham and S. Venkatesan, “STCP: A Generic Transport Layer Protocol for Wireless Sensor Networks”, In the Proc. of IEEE Intl. Conf. on Computer Communications and Networks (ICCCN), 2005.

7. Urs Hunkeler, Hong Linh Truong and Andy Stanford-Clark, “MQTT-S – A Publish/Subscribe Protocol For Wireless Sensor Networks”, In the Proc. of 2nd Workshop on Information Assurance for Middleware Communications, (IAMCOM), 2008.

8. Yangfan Zhou, Michael R. Lyu, Jiangchuan Liu and Hui Wang, “PORT: A Price-Oriented Reliable Transport Protocol for Wireless Sensor Networks”, Proceedings of the 16th IEEE International Symposium on Software Reliability Engineering, 2005.

9. Chieh-Yih Wan, Andrew T. Campbell and Lakshman Krishnamurthy, “PSFQ: A Reliable Transport Protocol for Wireless Sensor Networks”, In the Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications, 2002.

10. Fred Stann and John Heidemann, “RMST: Reliable Data Transport in Sensor Networks”, In the 1st IEEE International Workshop on Sensor Net Protocols and Applications (SNPA), 2003.

11. Yogesh Sankarasubramaniam, Ozgur B. Akan and Ian F. Akyildiz, “ESRT: EventoSink Reliable Transport in Wireless Sensor Networks”, Proceedings of 4th ACM International symposium on Mobile ad hoc networking & computing, 2003.
12. Nurcan Tezcan and Wenye Wang, “ART: An Asymmetric and Reliable Transport Mechanism for Wireless Sensor Networks”, International Journal of Sensor Networks, 2007.

13. Yao-Nan Lien, “Hop-by-Hop TCP for Sensor Networks”, International Journal of Computer Networks & Communications (IJCNC), 2009.

14. Sunil Kumar, Zhenhua Feng, Fei Hu and Yang Xiao, “E2SRT: enhanced event-to-sink reliable transport for wireless sensor networks”, Wireless Communications and Mobile Computing, 2008.

15. Damayanti Datta and Sukhamay Kundu, “An Application-Specific Reliable Data Transfer Protocol in Wireless Sensor Networks”, Journal of Networks, 2008.

16. Michael Luby, “LT Codes”, Proceedings of the 43rd Symposium on Foundations of Computer Science, 2002.

17. Dunkels, A., Alonso, J. and Voigt, T., “Making TCP/IP Viable for Wireless Sensor Networks”. First European Workshop on Wireless Sensor Networks (EWSN’04), work-in-progress session, Berlin, Germany 2004.

18. N. Riga, I. Matta, A. Medina, C. Partridge, J. Redi, “An energy-conscious transport protocol for multi-hop wireless networks”, Proceedings of the 2007 ACM CoNEXT conference, New Work, 2007.

19. Network Simulator: www.isi.edu/nsnam/ns
Concepts and Evolution of Research in the Field Of Wireless Sensor Networks

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ABSTRACT

The field of Wireless Sensor Networks (WSNs) is experiencing a resurgence of interest and a continuous evolution in the scientific and industrial community. The use of this particular type of ad hoc network is becoming increasingly important in many contexts, regardless of geographical position and so, according to a set of possible application. WSNs offer interesting low cost and easily deployable solutions to perform a remote real time monitoring, target tracking and recognition of physical phenomenon. The uses of these sensors organized into a network continue to reveal a set of research questions according to particularities target applications. Despite difficulties introduced by sensor resources constraints, research contributions in this field are growing day by day. In this paper, we present a comprehensive review of most recent literature of WSNs and outline open research issues in this field.

KEYWORDS

WSNs, protocols, sensor, applications, routing, services, survey, bio-inspired.

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REFERENCES

[1] Warneke, B. A., and Pister, K. S. (2002). MEMS for distributed wireless sensor networks. In Electronics, Circuits and Systems, 2002. 9th International Conference on (Vol. 1, pp. 291-294). IEEE.

[2] Labraoui, N., Gueroui, M., Aliouat, M., and Petit, J. (2011). RAHIM: Robust Adaptive Approach Based on Hierarchical Monitoring Providing Trust Aggregation for Wireless Sensor Networks. J. UCS, 17(11), 1550-1571.

[3] Arampatzis, T., Lygeros, J., and Manesis, S. (2005, June). A survey of applications of wireless sensors and wireless sensor networks. In Intelligent Control, 2005. Proceedings of the 2005 IEEE International Symposium on, Mediterranean Conference on Control and Automation (pp. 719-724). IEEE.

[4] Potdar, V., Sharif, A., and Chang, E. (2009, May). Wireless sensor networks: A survey. In Advanced Information Networking and Applications Workshops, 2009. WAINA'09. International Conference on (pp. 636-641). IEEE.

[5] Mainwaring, A., Culler, D., Polastre, J., Szewczyk, R., and Anderson, J. (2002, September). Wireless sensor networks for habitat monitoring. In Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications (pp. 88-97). ACM.

[6] Lédeczi, Á., Nádas, A., Völgyesi, P., Balogh, G., Kusy, B., Sallai, J., ... and Simon, G. (2005). Countersniper system for urban warfare. ACM Transactions on Sensor Networks (TOSN), 1(2), 153-177.

[7] Palumbo, F., Ullberg, J., Štimec, A., Furfari, F., Karlsson, L., and Coradeschi, S. (2014). Sensor network infrastructure for a home care monitoring system. Sensors, 14(3), 3833-3860, International Journal of Computer Networks & Communications (IJCNC) Vol.7, No.1, January 2015 95

[8] Tsai, T. H., Yang, C. Y., and Chen, S. M. (2013). Development of a Dissolved Oxygen Sensor for Commercial Applications. Int. J. Electrochem. Sci, 8, 5250-5261.

[9] Sarafi, A., Tsiropoulos, G. I., and Cottis, P. G. (2009). Hybrid wireless-broadband over power lines: A promising broadband solution in rural areas. Communications Magazine, IEEE, 47(11), 140-147.

[10] Malinowski, J., and Geiger, E. J. (2014). Development of a wireless sensor network for algae cultivation using ISFET pH probes. Algal Research, 4, 19-22.

[11] Sakshat Virtual Labs: Simulating a Wireless Sensor Network. http://virtuallabs.ac.in/cse28/ant/ant/8/theory/ acceded on december 2014.
[12] Levis, P., Madden, S., Polastre, J., Szewczyk, R., Whitehouse, K., Woo, A., and Culler, D. (2005). TinyOS: An operating system for sensor networks. In Ambient intelligence (pp. 115-148). Springer Berlin Heidelberg.

[13] Jihua, Y., and Wen, W. A. N. G. (2014, August). Research and Design of Solar Photovoltaic Power Generation Monitoring System Based on TinyOS. In Computer Science & Education (ICCSE), 2014 9th International Conference on (pp. 1020-1023). IEEE.

[14] Phani, A. M. R. V. A., Kumar, D. J., and Kumar, G. A. (2007). Operating Systems for Wireless Sensor Networks: A Survey Technical Report.

[15] Basagni, S., Conti, M., Giordano, S., and Stoimenovic, I. (Eds.). (2013). Mobile Ad Hoc Networking: The Cutting Edge Directions (Vol. 35). John Wiley and Sons.

[16] Jiang, F., Frater, M., and Ling, S. S. (2011, June). A distributed smart routing scheme for terrestrial sensor networks with hybrid Neural Rough Sets. In Fuzzy Systems (FUZZ), 2011 IEEE International Conference on (pp. 2238-2244). IEEE.

[17] Yu, X., Wu, P., Han, W., and Zhang, Z. (2014). Overview of wireless underground sensor networks for agriculture. African Journal of Biotechnology, 11(17), 3942-3948.

[18] Kim, D., Noel, E., and Tang, K. W. (2014, January). WSN communication topology construction with collision avoidance and energy saving. In Consumer Communications and Networking Conference (CCNC), 2014 IEEE 11th (pp. 398-404). IEEE.

[19] Jiang, J. A., Yang, Y. C., Su, W. S., Chuang, C. L., and Lin, T. S. (2013). U.S. Patent No. 8,576,665. Washington, DC: U.S. Patent and Trademark Office.

[20] Misra, S., Reisslein, M., and Xue, G. (2008). A survey of multimedia streaming in wireless sensor networks. Communications Surveys & Tutorials, IEEE, 10(4), 18-39.

[21] Tagne-Fute, E. (2013). Une approche de patrouille multi-agents pour la détection d'évènements (Doctoral dissertation, Université de Technologie de Belfort-Montbéliard, France).

[22] Kumar, M., and Dutta, K. (2015). A Survey of Security Concerns in Various Data Aggregation Techniques in Wireless Sensor Networks. In Intelligent Computing, Communication and Devices (pp. 1-15). Springer India.

[23] N. Labraoui, M. Guerroui, M. Aliouat, and T. Zia. (2011). Data aggregation security challenge in wireless sensor networks. Ad Hoc & Sensor Wireless Networks, 12(3-4):295–324.

[24] Incebacak, D., Zilan, R., Tavli, B., Barcelo-Ordinas, J. M., and Garcia-Vidal, J. (2014). Optimal data compression for lifetime maximization in wireless sensor networks operating in stealth mode. Ad Hoc Networks.
[25] Labraoui, N., Gueroui, M., Aliouat, M., and Petit, J. (2010, May). Adaptive security level for data aggregation in wireless sensor networks. In Wireless Pervasive Computing (ISWPC), 2010 5th IEEE International Symposium on (pp. 325-330). IEEE.

[26] Madaan, S., Kumar, D., and Khurana, R. (2014). An Enhanced Approach for Synchronization in WSN. International Journal of Computer Applications, 94(17), 51-56.

[27] Labraoui, N., Gueroui, M., and Aliouat, M. (2012). Secure DV-Hop localization scheme against wormhole attacks in wireless sensor networks. Transactions on Emerging Telecommunications Technologies, 23(1), 303-316.

[28] Torkestani, J. A. (2013). An adaptive energy-efficient area coverage algorithm for wireless sensor networks. Ad hoc networks, 11(6), 1655-1666.

[29] Buratti, C., Conti, A., Dardari, D., and Verdone, R. (2009). An overview on wireless sensor networks technology and evolution. Sensors, 9(9), 6869-6896.

[30] Mancuso, M., and Bustaffa, F. (2006, June). A wireless sensors network for monitoring environmental variables in a tomato greenhouse. In IEEE International Workshop on Factory Communication Systems (pp. 107-110).

[31] Sensicast systems. http://www.crunchbase.com/organization/sensicast-systems (accessed on July 2014.)

[32] Jedermann, R., Behrens, C., Westphal, D., and Lang, W. (2006). Applying autonomous sensor systems in logistics—Combining sensor networks, RFIDs and software agents. Sensors and Actuators A: Physical, 132(1), 370-375.

[33] Dada, A., and Thiesse, F. (2008). Sensor applications in the supply chain: the example of quality based issuing of perishables. In The Internet of Things (pp. 140-154). Springer Berlin Heidelberg.

[34] Wang, J., Wang, H., He, J., Li, L., Shen, M., Tan, X., and Zheng, L. (2015). Wireless sensor network for real-time perishable food supply chain management. Computers and Electronics in Agriculture, 110, 196-207.

[35] Ko, J., Gao, T., and Terzis, A. (2009, April). Empirical study of a medical sensor application in an urban emergency department. In Proceedings of the Fourth International Conference on Body Area Networks (p. 10). ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering).

[36] Obinaju, B. E., Alaoma, A., and Martin, F. L. (2014). Novel sensor technologies towards environmental health monitoring in urban environments: A case study in the Niger Delta (Nigeria). Environmental Pollution.

[37] Du, W., Xing, Z., Li, M., He, B., Chua, L. H. C., and Miao, H. (2014, April). Optimal sensor placement and measurement of wind for water quality studies in urban
reservoirs. In Proceedings of the 13th international symposium on Information processing in sensor networks (pp. 167-178). IEEE Press.

[38] Gupta, G., and Younis, M. (2003, March). Fault-tolerant clustering of wireless sensor networks. In Wireless Communications and Networking, 2003. WCNC 2003. 2003 IEEE (Vol. 3, pp. 1579-1584). IEEE.

[39] Zhang, W., Xue, G., and Misra, S. (2007, May). Fault-tolerant relay node placement in wireless sensor networks: Problems and algorithms. In INFOCOM 2007. 26th IEEE International Conference on Computer Communications. IEEE (pp. 1649-1657). IEEE.

[40] Acharya, S., and Tripathy, C. R. (2015, January). An ANN Approach for Fault Tolerant Wireless Sensor Networks. In Emerging ICT for Bridging the Future-Proceedings of the 49th Annual Convention of the Computer Society of India CSI Volume 2 (pp. 475-483). Springer International Publishing.

[41] Prakash, T. S., Raja, K. B., Venugopal, K. R., Iyengar, S. S., and Patnaik, L. M. (2014, January). Fault Tolerant QoS Adaptive Clustering for Wireless Sensor Networks. In Proceedings of Ninth International Conference on Wireless Communication and Sensor Networks (pp. 167-175). Springer India.

[42] Nesrine, K., and Ben Jemaa, M. (2012, June). HEERP: Hierarchical energy efficient routing protocol for Wireless Sensor Networks. In Communications and Information Technology (ICCIT), 2012 International Conference on (pp. 308-313). IEEE.

[43] Yu, J., Qi, Y., Wang, G., and Gu, X. (2012). A cluster-based routing protocol for wireless sensor networks with nonuniform node distribution. AEU-International Journal of Electronics and Communications, 66(1), 54-61.

[44] Kumar, N., Bhutani, P., and Mishra, P. (2012, October). U-LEACH: A novel routing protocol for heterogeneous Wireless Sensor Networks. In Communication, Information & Computing Technology (ICCICT), 2012 International Conference on (pp. 1-4). IEEE.

[45] Zhang, R., Zhao, H., and Labrador, M. A. (2006, May). The anchor location service (ALS) protocol for large-scale wireless sensor networks. In Proceedings of the first international conference on integrated internet ad hoc and sensor networks (p. 18). ACM.

[46] Seada, K., Zuniga, M., Helmy, A., and Krishnamachari, B. (2004, November). Energy-efficient forwarding strategies for geographic routing in lossy wireless sensor networks. In Proceedings of the 2nd international conference on Embedded networked sensor systems (pp. 108-121). ACM.

[47] Lajevardi, A., Haghighat, A. T., and Eghbali, A. N. (2009, December). Extending directed diffusion routing algorithm to support sink mobility in wireless sensor networks. In Communications (MICC), 2009 IEEE 9th Malaysia International Conference on (pp. 541-546). IEEE.
[48] AlShawi, I.S., Lianshan Yan, Wei Pan and Bin Luo, (2012, October). A Fuzzy-Gossip routing protocol for an energy efficient wireless sensor networks, Sensors, 2012 IEEE, 1-4.

[49] Zhang, Y., and Fromherz, M. (2006, April). Constrained flooding: a robust and efficient routing framework for wireless sensor networks. In Advanced Information Networking and Applications, 2006. AINA 2006. 20th International Conference on (Vol. 1, pp. 6-pp). IEEE.

[50] Karaboga, D., Okdem, S., and Ozturk, C. (2012). Cluster based wireless sensor network routing using artificial bee colony algorithm. Wireless Networks, 18(7), 847-860.

[51] Zungeru, A. M., Seng, K. P., Ang, L. M., and Chong Chia, W. (2013). Energy Efficiency Performance Improvements for Ant-Based Routing Algorithm in Wireless Sensor Networks. Journal of Sensors, 2013.

[52] Kulkarni, R. V., Venayagamoorthy, G. K., and Cheng, M. X. (2009, October). Bio-inspired node localization in wireless sensor networks. In Systems, Man and Cybernetics, 2009. SMC 2009. IEEE International Conference on (pp. 205-210). IEEE.

[53] Zhou, Z., Peng, Z., Cui, J. H., Shi, Z., and Bagtzoglou, A. C. (2011). Scalable localization with mobility prediction for underwater sensor networks. Mobile Computing, IEEE Transactions on, 10(3), 335-348.

[54] Yuan, H., Yugang, N., and Fenghao, G. (2014, May). Congestion control for wireless sensor networks: A survey. In Control and Decision Conference (2014 CCDC), The 26th Chinese (pp. 4853- 4858). IEEE.

[55] Karvonen, H., Pomalaza-Ráez, C., and Hämäläinen, M. (2014). A cross-layer optimization approach for lower layers of the protocol stack in sensor networks. ACM Transactions on Sensor Networks (TOSN), 11(1), 16.

[56] Karaboga, D., Gorkemli, B., Ozturk, C., and Karaboga, N. (2014). A comprehensive survey: artificial bee colony (ABC) algorithm and applications. Artificial Intelligence Review, 42(1), 21-57.

[57] Safa, H., Moussa, M., and Artail, H. (2014). An energy efficient Genetic Algorithm based approach for sensor-to-sink binding in multi-sink wireless sensor networks. Wireless networks, 20(2), 177-196.

[58] Shamshirband, S., Anuar, N. B., Kiah, M. L. M., Rohani, V. A., Petković, D., Misra, S., and Khan, A. N. (2014). Co-FAIS: Cooperative fuzzy artificial immune system for detecting intrusion in wireless sensor networks. Journal of Network and Computer Applications, 42, 102-117.
[59] Ingelrest, F., Barrenetxea, G., Schaefer, G., Vetterli, M., Couach, O., and Parlange, M. (2010). SensorScope: Application-specific sensor network for environmental monitoring. ACM Transactions on Sensor Networks (TOSN), 6(2), 17.

[60] Lee, S., Younis, M., and Lee, M. (2015). Connectivity restoration in a partitioned wireless sensor network with assured fault tolerance. Ad Hoc Networks, 24, 1-19.

[61] Yick, J., Mukherjee, B., and Ghosal, D. (2008). Wireless sensor network survey. Computer networks, 52(12), 2292-2330.

[62] Shelke, M. S. N., and Shinde, M. S. R. (2013). Energy Saving Techniques in Wireless Sensor Networks. International Journal of Scientific & Engineering Research, 4(4), 396.

[63] Rezaei, Z., and Mobininejad, S. (2012). Energy saving in wireless sensor networks. Int J Comput Sci Eng Surv (IJCSES), 3(1), 23-37.

[64] Kumar, M., and Dutta, K. (2015). A Survey of Security Concerns in Various Data Aggregation Techniques in Wireless Sensor Networks. In Intelligent Computing, Communication and Devices (pp. 1-15). Springer India.

[65] Patle, D., and Nemade, S. (2015). A Literature Survey on Different Type of Energy Efficiently Routing Protocol in Wireless Sensor Network. International Journal of Scientific Engineering and Technology, 4(1), 28-31.

[66] Ravi, M., and Subramaniam, P. (2014). Wireless Sensor Network and its Security–A Survey. International Journal of Science and Research (IJSR), 3(12).

[67] Maerien, J., Michiels, S., Hughes, D., Huygens, C., and Joosen, W. (2015). SecLoocI: A comprehensive security middleware architecture for shared wireless sensor networks. Ad Hoc Networks, 25, 141-169.

[68] Mishra, D. P., and Kumar, R. (2015). A Vision of Hybrid Security Framework for Wireless Sensor Network. Indian Journal of Applied Research, 5(1).

[69] Rawat, P., Singh, K. D., Chaouchi, H., and Bonnin, J. M. (2014). Wireless sensor networks: a survey on recent developments and potential synergies. The Journal of Supercomputing, 68(1), 1-48.

[70] Steyn, L. P., and Hancke, G. P. (2011, September). A survey of wireless sensor network testbeds. In AFRICON, 2011 (pp. 1-6). IEEE.

[71] LABRAOUI, N. (2012). LA SÉCURITÉ DANS LES RÉSEAUX SANS FIL AD HOC (Doctoral dissertation). University of Tlemcen, Algeria.

[72] Sun, F., Zhao, Z., Fang, Z., Du, L., Xu, Z., & Chen, D. (2014). A Review of Attacks and Security Protocols for Wireless Sensor Networks. Journal of Networks, 9(5), 1103-1113.
[73] Yu, Y., Li, K., Zhou, W., & Li, P. (2012). Trust mechanisms in wireless sensor networks: Attack analysis and countermeasures. Journal of Network and Computer Applications, 35(3), 867-880.

[74] Semente, R. S., Salazar, A. O., & Oliveira, F. D. (2014, May). CRYSEED: An automatic 8-bit cryptographic algorithm developed with genetic programming. In Instrumentation and Measurement Technology Conference (I2MTC) Proceedings, 2014 IEEE International (pp. 1065-1068). IEEE.

[75] Rico, J., Sancho, J., Díaz, Á., González, J., Sánchez, P., Alvarez, B. L., ... & Ramis, C. F. (2015). Low Power Wireless Sensor Networks: Secure Applications and Remote Distribution of FW Updates with Key Management on WSN. In Trusted Computing for Embedded Systems (pp. 71-111). Springer International Publishing.
H-MAC : A Hybrid MAC Protocol for Wireless Sensor Networks

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ABSTRACT

In this paper, we propose a hybrid medium access control protocol (H-MAC) for wireless sensor networks. It is based on the IEEE 802.11’s power saving mechanism (PSM) and slotted aloha, and utilizes multiple slots dynamically to improve performance. Existing MAC protocols for sensor networks reduce energy consumptions by introducing variation in an active/sleep mechanism. But they may not provide energy efficiency in varying traffic conditions as well as they did not address Quality of Service (QoS) issues. H-MAC, the propose MAC protocol maintains energy efficiency as well as QoS issues like latency, throughput, and channel utilization. Our numerical results show that H-MAC has significant improvements in QoS parameters than the existing MAC protocols for sensor networks while consuming comparable amount of energy.

KEYWORDS

Sensor networks, MAC protocol, energy efficiency.

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REFERENCES

[1] I.F. Akayildiz, W. Su, S. Yogesh, & E. Cayirci, (2008) “A Survey on Sensor Networks”, IEEE Communication, August, pp 102-114

[2] W. Ye, J. Heidemann, & D. Estrin, (2000) “An Energy-Efficient MAC Protocol for wireless Sensor Networks,” in proceeding of INFOCOM 2002, New York, June, pp.1567-1576.

[3] T. V. Dam & K. Langendone, (2003) “An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks,” in proceeding of SenSys’03, Los Angeles, Nov., pp.171-180.

[4] G. Lu, B. Krishnamachari, & C. Ragavendra, (2004) “An Adaptive Energy-Efficient and LowLatency MAC for Data Gathering in Sensor Networks,” in proceeding of WMAN’04, April 2004.

[5] T. Zheng, S. Radhakrishnan, & V. Sarangan, (2005) “PMAC: An Adaptive Energy-Efficient MAC Protocol for Wireless Sensor Networks,” in proceeding of IPDPS’05, April, pp.65-72.

[6] IEEE 802.11 Working Group, (1999) “Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications”.

[7] S.Mehta & K.S. Kwak, (2008) “H-MAC: A Hybrid MAC Protocol for Wireless Sensor Networks,” in proceeding of IEEE Seoul Chapter Paper Contest, December, pp:705/706.

[8] G.Bianchi, “Performance Analysis of IEEE 802.11 distributed coordination function,” IEEE JSAC, Vol.18,no-3, pp.535-547, Mar.2000.

[9] R. Rom and M.Sidi, “Multiple Access Protocols: Performance and Analysis,” Springer-Verlag Publication, 1989.
AOM : An Efficient Approach to Restore Actor-Actor Connectivity in Wireless Sensor and Actor Networks

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ABSTRACT

Wireless sensor and actor networks (WSANs) consist of powerful actors and resource constraint sensors that are linked together in wireless networks. They mostly rely on actors to make proper decisions and perform desired coordination to achieve the goals of the entire network. They are usually deployed in critical applications and actor-actor network connectivity is thus vital to their effective utilization. Since WSAN applications are mostly deployed in harsh environments, actor nodes may fail and so partition their network. We propose a comparatively more efficient distributed approach, nicknamed AOM, to restore actor-actor connectivity upon the failure of any actor. We identify critical actors by combining the result of determining critical actors using the Stojmenovich’s method with the connectivity dominating set (CDS) of the network. This hybrid method of detecting critical actors helps in detecting critical nodes and candidate replacement actors more precisely while minimizing the total number of required messages for network restoration. The failure handling of actors is done in a proactive manner. Our proposed method minimizes both the restoration time of network and the total number of actor movements. When a failed actor is a critical node, actors in its neighborhood are relocated in a coordinated way to reconnect the actor network. The superiority of our approach compared to other works is shown by simulative experiments measuring two important parameters to WSANS, namely, the total number of transmitted messages and the total number of actor movements during actor-actor network reconnection process.

KEYWORDS

Wireless Sensor and Actor Network; Network Restoration; Actor Connectivity; Cut Vertex; Connectivity Dominating Set (CDS)

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REFERENCES

[1] Akyildiz, F. and Kasimoglu, I. H. (2004) Wireless sensor and actor networks: research challenges. Elsevier Ad Hoc Network Journal. 2 351-367.

[2] Akkaya, K., Thimmapuram, A., Senel, F. and Uludag, S. (2008) Distributed recovery of actor failures in wireless sensor and actor networks. Proceedings of the IEEE Wireless Communications and Networking Conference.

[3] Jorgic, M., Stojmenovic, I., Hauspie, M. and Simplot-ryl, D. (2004) Localized algorithms for detection of critical nodes and links for connectivity in ad hoc networks. Proceedings of the 3rd Annual IFIP Mediterranean Ad Hoc Networking Workshop pp. 360-371.

[4] Dai, F. and Wu, J. (2004) An Extended Localized Algorithm for Connected Dominating Set Formation in Ad Hoc Wireless Networks. IEEE Transaction on Parallel and Distributed Systems. 15(10) 908-920.

[5] Abbasi, A. A., Akkaya, K. and Younis, M. (2007) A Distributed Connectivity Restoration Algorithm in Wireless Sensor and Actor Networks. Proceedings of the 32nd IEEE Conference on Local Computer Networks IEEE Computer Society.

[6] Ozaki, K., Watanabe, K., Itaya, S., Hayashibara, N., Enokido, T. and Takizawa, M. (2006) A FaultTolerant Model ofWireless Sensor-Actor Network. Proceedings of the 9th IEEE International Symposium on Object and Component-Oriented Real-Time Distributed Computing IEEE Computer Society.

[7] Wu, J., Yang, S. and Cardei, M. (2008) On Maintaining Sensor-Actor Connectivity in Wireless Sensor and Actor Networks. Proceedings of the 27th Conference on Computer Communications,IEEE INFOCOM pp. 286-290.

[8] Akkaya, K. and Younis, M. (2007) C2AP: Coverage-aware and Connectivity-constrained Actor Positioning in Wireless Sensor and Actor Networks. Proceedings of the IEEE Internationa Performance, Computing, and Communications Conference pp. 281-288.

[9] Das, S., Liu, H., Kamath, A., Nayak, A. and Stojmenović, I. (2007) Ttile., Wireless Sensor and Actor Networks.

[10] Basu, P., Redi, J., Technol, B. and Cambridge, M. (2004) Movement control algorithms for realization of fault-tolerant ad hoc robot networks. IEEE network. 18(4) 36-44.

[11] Li, X., Santoro, N. and Stojmenovic, I. (2007) Ttile., Ubiquitous Intelligence and Computing.
[12] Wang, G., Cao, G., Porta, T. L. and Zhang, W. (2005) Sensor relocation in mobile sensor networks. Proceeding of the 24th Annual IEEE Conference on Computer Communications.

[13] Goyal, D. and J. Caffery, J. (2002) Partitioning Avoidance in Mobile Ad Hoc Networks Using Network Survivability Concepts. Proceedings of the Seventh International Symposium on Computers and Communications IEEE Computer Society.

[14] Seada, K. and Helmy, A. (2004) Efficient geocasting with perfect delivery in wireless networks. Proceedings of the IEEE Wireless Communications and Networking Conference.

[15] Baldwin, P., Kohli, S., Lee, E. A., Liu, X. and Zhao, Y. (2004) Modeling of sensor nets in Ptolemy II. Proceedings of the 3rd international symposium on Information processing in sensor networks ACM.
Empirical Examination of Mobile Ad Hoc Routing Protocols on Wireless Sensor Networks

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ABSTRACT

Wireless sensor networks (WSNs) have great potential of being deployed in many places where traditional wired or wireless networks are not feasible. But they have also many new challenges more than other wireless networks. These challenges include the design of embedded intelligent sensors and wireless networking technology, i.e. routing protocols and network security. WSNs also have some constraints such as sensor nodes failure which render WSN unavailable. The routing protocol in the sensor networks plays a critical role. They influence the performance of the WSNs and have significant impact on the security and the availability of WSNs. Wireless sensor networks (WSNs) have been regarded as an incarnation of Ad Hoc Networks for a specific application. Since a WSN consists of potentially hundreds of low cost, small size and battery powered sensor nodes, it has more potentials than a MANET to be deployed in many emerging areas. However, they also raised many new challenges, and these challenges include the design of embedded sensors and wireless networking technology, i.e. routing protocols and network security. Many ad hoc routing protocols such as AODV, DSR, DSDR, TORA and OLSR, which have been developed particularly for the mobile wireless ad hoc networks (MANETs), performed satisfactorily on MANETs. Research has shown that these ad-hoc routing protocols work well for MANETs with different characteristics and requirements. In this paper, we investigate how well these ad-hoc routing protocols work on wireless sensor networks (WSNs). We focus on their performances in terms of average end-to-end delay, packet delivery ratio and routing overheads.

KEYWORDS

Wireless technology, Sensor nodes, Dynamic routing, Throughput, Wireless Network, End-to-End delay

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REFERENCES

[1] Ian F. Akyildiz, Weilian Su, Yogesh Sankarasubramaniam, and E. Cayirci (2002). A survey on sensor networks, IEEE Communications Magazine, Aug 2002. pp 102-114.

[2] H. Chan and A. Perrig, (2003) Security and privacy in sensor networks, IEEE Computer, Oct 2003. pp 103-105.

[3] Carla Fabiana Chiasserini and Michele Garetto, (2004) Modeling the performance of wireless sensor networks. IEEE INFOCOM, Hong Kong, March 7-11, 2004.

[4] Marco Conti and Silvia Giordano, (2007) Multihop Ad Hoc Networking: The Reality, IEEE Communication Magazine, April 2007. pp 88-95.

[5] Ian Downard, (2004) Simulating sensor network in ns-2. NRL Formal Report 5522.

[6] Deborah Estrin, David Cullar, Kris Pister and Gaurav Sukhatme, (2002) Connecting the Physical World with Pervasive Networks, Pervasive Computing, Jan 2002. pp 59-69.

[7] Qiangfeng Jiang and D. Manivannan, (2004) Routing Protocols for Sensor Networks, Consumer Communications and Networking Conference, First IEEE Volume Issue, Jan 2004. pp 93-98.

[8] Anthony D. Wood and John A. Stankovic (2002) Denial of Service in Sensor Networks, IEEE Computer, Oct 2002. pp54-62.

[9] Yunjiao Xue, Ho Sung Lee, Ming Yang, Priantha Kumarawadu, Hamada H. Ghenniwa and Weiming Shen (2007) Performance Evaluation of NS2 Simulator for Wireless Sensor Networks, IEEE, 2007. pp 1372-1375.

[10] H. Zhou, J. Lu, Z. Zhang, H. Ali, and C. Won (2007) Application and performance of extended TTDD’s in large-scale wireless sensor networks, MSN 2007, LNVC 4864, Dec. 2007. pp 135-142.
A Cross-Layer Approach for Minimizing Interference and Latency of Medium Access in Wireless Sensor Networks

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ABSTRACT

In low power wireless sensor networks, MAC protocols usually employ periodic sleep/wake schedule to reduce idle listening time. Even though this mechanism is simple and efficient, it results in high end-to-end latency and low throughput. On the other hand, the previously proposed CSMA/CA based MAC protocols have tried to reduce inter-node interference at the cost of increased latency and lower network capacity. In this paper we propose IAMAC, a CSMA/CA sleep/wake MAC protocol that minimizes internode interference, while also reduces per-hop delay through cross-layer interactions with the network layer. Furthermore, we show that IAMAC can be integrated into the SP architecture to perform its interlayer interactions. Through simulation, we have extensively evaluated the performance of IAMAC in terms of different performance metrics. Simulation results confirm that IAMAC reduces energy consumption per node and leads to higher network lifetime compared to S-MAC and Adaptive S-MAC, while it also provides lower latency than S-MAC. Throughout our evaluations we have considered IAMAC in conjunction with two error recovery methods, i.e., ARQ and Seda. It is shown that using Seda as the error recovery mechanism of IAMAC results in higher throughput and lifetime compared to ARQ.

KEYWORDS

Wireless Sensor Networks, MAC, IAMAC, Tree-Based Routing, Cross-Layer Optimization, Interference.

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REFERENCES

[1] M. Z. Zamalloa and B. Krishnamachari, "An analysis of unreliability and asymmetry in low-power wireless links," ACM Trans. Sen. Netw., vol. 3, 2007, p. 7.

[2] A. Woo, T. Tong, and D. Culler, "Taming the underlying challenges of reliable multihop routing in sensor networks," Proceedings of the 1st international conference on Embedded networked sensor systems, Los Angeles, California, USA: ACM, 2003, pp. 14-27.

[3] Q. Cao, T. He, L. Fang, T. Abdelzaher, J. Stankovic, and S. Son, "Efficiency centric communication model for wireless sensor networks," Proceedings IEEE INFOCOM 2006. 25TH IEEE International Conference on Computer Communications, IEEE, 2006, pp. 1-12.

[4] A. Cerpa, J. Wong, L. Kuang, M. Potkonjak, and D. Estrin, "Statistical model of lossy links in wireless sensor networks," Proceedings of the 4th international symposium on information processing in sensor networks, IEEE Press, 2005, p. 11.

[5] D. S. Couto, D. Aguayo, J. Bicket, and R. Morris, "A high-throughput path metric for multi-hop wireless routing," Wirel. Netw., vol. 11, 2005, pp. 419-434.

[6] J. Heidemann and D. Estrin, "An energy-efficient MAC protocol for wireless sensor networks," IEEE INFOCOM, New York, USA: 2002, pp. 1567-1576.

[7] T. van Dam and K. Langendoen, "An adaptive energy-efficient MAC protocol for wireless sensor networks," Proceedings of the first international conference on Embedded networked sensor systems - SenSys '03, New York, New York, USA: ACM Press, 2003, p. 171.

[8] W. Ye, J. Heidemann, and D. Estrin, "Medium access control with coordinated adaptive sleeping for wireless sensor networks," IEEE/ACM Trans. Netw., vol. 12, 2004, pp. 493-506.

[9] J. Polastre, J. Hill, and D. Culler, "Versatile low power media access for wireless sensor networks," Proceedings of the 2nd international conference on Embedded networked sensor systems - SenSys '04, New York, New York, USA: ACM Press, 2004, p. 95.

[10] M. Sichitiu, "Cross-layer scheduling for power efficiency in wireless sensor networks," IEEE INFOCOM 2004, IEEE, 2004, pp. 1740-1750.

[11] V. Kawadia and P. R. Kumar, "A cautionary perspective on cross-layer design," Wireless Communications, IEEE, vol. 12, 2005, pp. 3-11.

[12] V. Srivastava and M. Motani, "Cross-layer design: A survey and the road ahead," Communications Magazine, IEEE, vol. 43, 2005, p. 112,119.
[13] J. Polastre, J. Hui, P. Levis, J. Zhao, D. Culler, S. Shenker, and I. Stoica, "A unifying link abstraction for wireless sensor networks," Proceedings of the 3rd international conference on Embedded networked sensor systems - SenSys '05, New York, USA: ACM Press, 2005, p. 76.

[14] N. Ramanathan, M. Yarvis, J. Chhabra, N. Kushalnagar, L. Krishnamurthy, and D. Estrin, "A stream-oriented power management protocol for low duty cycle sensor network applications," Proceedings of the 2nd IEEE workshop on Embedded Networked Sensors, IEEE Computer Society, 2005, pp. 53-61.

[15] J. van Greunen and J. Rabaey, "Lightweight time synchronization for sensor networks," Proceedings of the 2nd ACM international conference on wireless sensor networks and applications - WSNA '03, New York, USA: ACM Press, 2003, p. 11.

[16] J. Elson, L. Girod, and D. Estrin, "Fine-grained network time synchronization using reference broadcasts," ACM SIGOPS Operating Systems Review, vol. 36, 2002, p. 147.

[17] Y. Zhao, M. Ma, C. Miao, and T. Nguyen, "An energy-efficient and low-latency MAC protocol with Adaptive Scheduling for multi-hop wireless sensor networks," Computer Communications, In Press, 2010.

[18] R. K. Ganti, P. Jayachandran, H. Luo, and T.F. Abdelzaher, "Datalink streaming in wireless sensor networks," Proceedings of the 4th international conference on Embedded networked sensor systems - SenSys '06, New York, USA: ACM Press, 2006, p. 209.

[19] T. Melodia, M. C. Vuran, and D. Pompili, "The state of the art in cross-layer design for wireless sensor networks," Proceedings of EuroNGI Workshops on Wireless and Mobility, Springer Lecture Notes on Computer Science, LNCS 388, Como, Italy: 2005.
Performance Analysis of an Improved Graded Precision Localization Algorithm for Wireless Sensor Networks

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ABSTRACT

In this paper an improved version of the graded precision localization algorithm GRADELOC, called IGRADELOC is proposed. The performance of GRADELOC is dependent on the regions formed by the overlapping radio ranges of the nodes of the underlying sensor network. A different region pattern could significantly alter the nature and precision of localization. In IGRADELOC, two improvements are suggested. Firstly, modifications are proposed in the radio range of the fixed-grid nodes, keeping in mind the actual radio range of commonly available nodes, to allow for routing through them. Routing is not addressed by GRADELOC, but is of prime importance to the deployment of any adhoc network, especially sensor networks. A theoretical model expressing the radio range in terms of the cell dimensions of the grid infrastructure is proposed, to help in carrying out a deployment plan which achieves the desirable precision of coarse-grained localization. Secondly, in GRADELOC it is observed that fine-grained localization does not achieve significant performance benefits over coarse-grained localization. In IGRADELOC, this factor is addressed with the introduction of a parameter that could be used to improve and fine-tune the precision of fine-grained localization.

KEYWORDS

Wireless sensor networks, Localization, Centroid, TDOA, Fixed-grid

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REFERENCES

[1] J. W. Kim, H. J. Jang, D. Hwang, and C. Park, A step, stride and heading determination for the pedestrian navigation system, Journal of Global Positioning Systems 3 (2004), no. 1-2, 273–279.

[2] L. Klingbeil and T. Wark, A wireless sensor network for real-time indoor localization and motion monitoring, Proc. of 7th Intl Conf. on Inf. Proc. in Sensor Networks, 2008, pp. 39–50.

[3] D. Ping, Yongjun, X., and L. Xiaowei, A robust location algorithm with biased extended kalman filtering of tdoa data for wireless sensor networks, Proc. of Intl Conf. on Wireless Comm., Networking & Mobile Computing (WCNM’05) (Wuhan, China), vol. 2, 2005, pp. 883–886.

[4] S. Sarangi and S. Kar, A novel algorithm for graded precision localization in wireless sensor networks, Proc. of 1st Intl. Conf. on Networks and Comm. (NETCOM'09) (Chennai, India), pp. 18–22, 2009.
Determination of Optimal Number of Clusters in Wireless Sensor Networks

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ABSTRACT

Prolonged network lifetime, scalability and efficient load balancing are essential for optimal performance of a wireless sensor network. Clustering provides an effective way of extending the lifetime of a sensor network. Clustering is the process that divides sensor networks into smaller localized group (called clusters) of members with a cluster head. Clustering protocols need to elect optimal number of clusters in hierarchically structured wireless sensor networks. Any clustering scheme that elects clusters uniformly (irrespective of the distance from Base Station) incurs excessive energy usage on clusters proximal and distant to Base Station. In single hop networks a gradual increment in the energy depletion rate is observed as the distance from the cluster head increases[17]. This work focuses on the analysis of wasteful energy consumption within a uniform cluster head election model (EPEM) and provides an analytical solution to reduce the overall consumption of energy usage amongst the clusters elected in a wireless sensor network. A circular model of sensor network is considered, where the sensor nodes are deployed around a centrally located Base Station. The sensor network is divided into several concentric rings centred at the Base Station. A model, Unequal Probability Election Model (UEPEM), which elects cluster heads non-uniformly is proposed. The probability of cluster head election depends on the distance from the Base Station. UEPEM reduces the overall energy usage by about 21% over EPEM. The performance of UEPEM improves as the number of rings is increased.

KEYWORDS

Wireless sensor networks, Ad-hoc networks, clustering.

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REFERENCES

1. Chatterjee, M., Das, S., & Turgut, D. (2002). **WCA: A weighted clustering algorithm for mobile ad hoc networks**. Cluster Computing, 5 (2), 193-204.

2. Depeardi, A., Zanella, A., & Verdone, R. (2003). **An energy efficient protocol for wireless sensor networks**. Proceeding of the AINS 2003. Menlo Park.

3. Dietrich, I., & Dressler, F. (February 2009). **On the Lifetime of Wireless Sensor Networks**, ACM Transactions Sensor Networks, 5, pp. 5:1--5:39. International Journal of Computer Networks & Communications (IJCNC) Vol.4, No.4, July 2012 249

4. Ettus, M. (1998). System capacity, latency, and power consumption in multihop-routed SSDMA wireless networks. Radio and Wireless Conference, 1998. RAWCON 98. 1998 IEEE (pp. 55-58). IEEE press.

5. Heinzelman, W., MA Chandrakasan, A., & Balakrishnan, H. (2002). **An application-specific protocol architecture for wireless microsensor networks**, IEEE Transactions on Wireless Communications, 1 (4), 660-670.

6. Hill, J., Szewczyk, R., Woo, A., Hollar, S., Culler, D., & Pister, K. (2000). **System architecture directions for networked sensors**, ACM Sigplan Notices, 35 (11), 93-104.

7. Lee, S., Yoo, J., & Chung, T. (2004). **Distance-based energy efficient clustering for wireless sensor networks**. 29th Annual IEEE International Conference on Local Computer Networks, 2004., (pp. 567-568).

8. Li, C., Ye, M., Chen, G., & Wu, J. (2005). **An energy-efficient unequal clustering mechanism for wireless sensor networks**, IEEE International Conference on Mobile Adhoc and Sensor Systems Conference. IEEE press.

9. Mhatre, V., & Rosenberg, C. (2004). **Design guidelines for wireless sensor networks: communication, clustering and aggregation**, Ad Hoc Networks, 2 (1), 45-63.

10. Mhatre, V., & Rosenberg, C. (2004). **Homogeneous vs heterogeneous clustered sensor networks: a comparative study**, IEEE International Conference on Communications, 2004. 6, pp. 3646- 651. IEEE press.

11. Rajagopalan, R., & Varshney, P. K. (2006). **Data aggregation techniques in sensor networks: A survey**, Communication Surveys and Tutorials, IEEE, 8, pp. 48-63.

12. Shepard, T. (1996). **A channel access scheme for large dense packet radio networks**, ACM SIGCOMM Computer Communication Review. 26, pp. 219-230. ACM.

13. Smaragdakis, G., Matta, I., & Bestavros, A. (August 2004). **SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks**, Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA 2004).
14. Soro, S., & Heinzelman, W. (2005). Prolonging the lifetime of wireless sensor networks via unequal clustering. In Parallel and Distributed Processing Symposium, 2005. Proceedings. 19th IEEE International. IEEE press.

15. Wang, W., Wang, B., Liu, Z., Guo, L., & Xiong, W. (2011). A cluster-based and tree-based power efficient data collection and aggregation protocol for wireless sensor networks. Information Technology Journal, 10, 557-564.

16. Wu, M. Y., Li, C., Chen, G., & Jie. (2005). An energy efficient clustering scheme in wireless sensor networks. In Proceedings of the IEEE International Performance Computing and Communications Conference (pp. 535-540). IEEE Press.

17. Wu, X., Chen, G., & Das, S. (2006). On the energy hole problem of nonuniform node distribution in wireless sensor networks. IEEE International Conference on Mobile Adhoc and Sensor Systems (MASS), 2006 (pp. 180-187). IEEE press.

18. Yi, S., Heo, J., Cho, Y., & Hong, J. (2007). PEACH: Power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks. Computer communications, 30 (14-15), 2842-2852.

19. Younis, O., & Fahmy, S. (2004). HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks. IEEE Transactions on Mobile Computing, 3 (4), 366-379.