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A Study on Energy Harvesting and Sensor Networking for Underwater Environment

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ABSTRACT:

Computer science had effectively deployed the sensor network on earth and on human body but still the underwater is intact area and our 2/3rd part of earth is covered with water. Underwater sensor networks (UWSN) are the emerging and promising communiqué framework which enables a wide range of imperative applications. The characteristics of partially available bandwidth, large propagation delay and high bit error rate (BER) have posed many fundamental challenges. Unmanned and Autonomous Underwater Vehicles (UUVs, AUVs) equipped with underwater sensors, are also envisioned to find application in exploration of natural under sea resources and gathering of scientific data in collaborative monitoring missions. These potential applications will be made viable by enabling communications among underwater devices. Underwater Acoustic Sensor Networks (UW_ASNs) will consist of sensors and vehicles deployed underwater and network via acoustic links to perform collaborative monitoring tasks.

Underwater acoustic sensor networks enable a broad range of applications, including: Ocean Sampling Network, Environmental Monitoring, Undersea Exploration, Disaster Prevention, Seismic Monitoring, Equipment Monitoring, Assisted Navigation, Distributed Tactical Surveillance and Mine Reconnaissance. The present paper contributes towards the sensor networks, design challenges, various energy harvesting techniques and benefits of them under the preview of UWSN.

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STRUCTURAL DESIGN OF SENSOR NETWORKS

The hierarchy of UWSN is typically consists of multiple pervasive sensor nodes, floating sink satellite and the user or base station. Many tiny, smart and inexpensive sensor nodes are scattered in the target sensor field to collect data and route the useful information back to the base station or user. These sensor nodes cooperate with each other via wireless communication to form a network and collect, disseminate and analyze data coming from the environment. After sensed the data they will send that data through any energy efficient topology like hop to hop connectivity or cluster based scheme to the floating sink.

Then that floating sink is essentially a coordinator between the deployed sensors and the user and it can be treated like a gateway node. The gateway node is equipped with better processor and sufficient memory space because the node can provide the need for extra information processing before data is transferred to final destination. From this floating sink the data will be transfer to the user with the help of satellite. Sensor node consists of sensing unit, processing unit, communication unit and battery [4, 7.]

UWSN DESIGN AND CHALLENGES

Many applications of WSN have several restrictions but focuses on Underwater Wireless Sensor Network constraints such as limited energy resource, limited computing power and limited bandwidth of the wireless links connecting sensor nodes[5].

ENERGY HARVESTING

A sensor network is a network of collaborating embedded devices (sensor nodes) with capabilities of sensing, computation and communication, is used to sense and collect data for application specific analysis. Untethered sensor nodes used in these deployments facilitate mobility and deployment in hard-to-reach locations. A major limitation of untethered nodes is finite battery capacity-nodes will operate for a finite duration, only as long as the battery lasts. Finite node lifetime implies finite lifetime of the applications or additional cost and complexity to regularly change batteries[10].

Several solution techniques have been proposed to maximize the lifetime of battery-powered sensor nodes. Some of these include energy –aware MAC protocols (SMAC[14] BMAC[13] XMAC15 power aware storage, routing and data dissemination protocols[11, 12, 16] duty-cycling strategies[17, 18] adaptive sensing rate[19] tiered system architectures[20, 21, 22] and redundant placement of nodes[23, 24]. While all the above techniques optimize and adapt energy usages to maximize the lifetime of a sensor node, the lifetime remains bounded and finite. The above techniques help prolong the application lifetime and /or the time interval between battery replacements but do not preclude energy-related inhibitions.

An alternative technique that has been applied to address the problem of finite node lifetime is the use of ***energy harvesting.*** Energy harvesting refers to harnessing energy from the environment or other energy sources (body heat, foot strike, finger strokes) and converting it to electrical energy. The harnessed electrical energy powers the sensor nodes. If the harvested energy source is large and periodically / continuously available, a sensor node can be powered perpetually.

As a result, energy harvesting techniques have the potential to address the tradeoff between performance parameters and lifetime of sensor nodes. The challenge lies in estimating the periodicity and magnitude of the harvestable source and deciding which parameters to tune and simultaneously avoid premature energy depletion before the next recharge cycle.

ENERGY HARVESTING SENSOR NODES

Energy harvesting refers to scavenging energy or converting energy from one form to the other. Applied to sensor nodes, energy from external sources can be harvested to power the nodes and in turn, increase their lifetime and capability. Given the energy-usage profile of a node, energy harvesting techniques could meet partial or all of its energy needs. A widespread and popular technique of energy harvesting is converting solar energy to electrical energy. Solar energy is uncontrollable—the intensity of direct sunlight cannot be controlled—but it is a predictable energy source with daily and seasonal patterns.

A typical energy harvesting system has three components, the Energy source, the Harvesting architecture and the Load.

Energy harvesting architecture

(i) Harvest-Use; Energy is harvested just-in-time for use and

(ii) Harvest–Store-Use. Energy is harvested whenever possible and stored for future use[25].

Harvest-use architecture: In this case, the harvesting system directly powers the sensor node and as a result, for the node to be operational, the power output of the harvesting system has to be continuously above the minimum operating point. If sufficient energy is not available, the node will be disabled. [27, 28, 29]

Harvest-store-use architecture: The architecture consists of a storage component that stores harvested energy and also powers the sensor node. Energy storage is useful when the harvested energy available is more than its current usage. Alternatively, energy can also be hoarded in storage unit enough has been collected for system operation. Energy is stored to be used later when either harvesting opportunity does not exist or energy usage of the sensor node has to be increased to improve capability and performance parameters. [30,31,32,33]

SOURCES FOR HARVESTABLE ENERGY

A vital component of any energy harvesting architecture is the energy source--it dictates the amount and rate of energy available for use. Energy sources have different characteristics along the axes of controllability, predictability and magnitude.[25] A *controllable* energy source can provide harvestable energy whenever required; energy availability need not be predicted before harvesting. With *non-controllable* energy sources, energy must be simply harvested whenever available. In this case, if the energy source is predictable then a prediction model which forecasts its availability can be used to indicate the time of next recharge cycle.

Further, energy sources can be broadly classified into the following two categories:

(i) ***Ambient energy source:*** Source of energy from the surrounding environment, e.g., solar energy, wind energy and RF energy.

(ii) ***Human power:*** Energy harvested from body movements of humans. Passive human power sources are those which are not user controllable. Some examples are blood pressure, body heat and breathe.[26,27,28,29]

BENEFITS OF ENERGY HARVESTING

Energy harvesting provides numerous benefits to the end user and some of the major benefits about EH suitable for WSN are stated and elaborated in the following list. Energy harvesting solutions can: Reduce the dependency on battery power, installation cost, maintenance cost and Provide long-term solutions.

VARIOUS ENERGY HARVESTING TECHNIQUES

In both academic research works and industry applications, there are many research and development works being carried out on harnessing large-scale energy from various renewable energy sources such as solar, wind and water / hydro NREL (2010). The energy types are thermal energy, radiant energy and mechanical energy.

Solar energy

Solar energy is abundant outdoors during the daytime. In direct sunlight at midday, the power density of solar cells are mature technologies with efficiencies of single crystal silicon cells ranging from 12% to 25%. Thin film polycrystalline, and amorphous silicon solar cells are also commercially available and cost less than single crystal silicon, but also have low efficiency.

Temperature variations

Naturally occurring temperature variations can also provide a means by which energy can be scavenged from the environment. Stordeur and Stark have demonstrated a thermoelectric micro-device capable of converting 15 μW/cm^3 situations in which there is a static 10 °C temperature difference within 1cm^3 are very rare. Alternatively, the natural temperature variation over a 24 hour period might be used to generate electricity. It can be shown with fairly simple calculations, assuming an average variation of 7 °C, that an enclosed volume containing an ideal gas could generate electricity. It can be shown with fairly simple calculations, assuming an average variation of 7 °C, which an enclosed volume containing an ideal gas could generate an average of 10 μW/cm^3. This, however, assumes no losses in the conversion of the power to electricity.

Acoustic noise

There is far too little power available from acoustic noise to be of use in the scenario being investigated, except for very rare environments with extremely high noise levels. This source has been included in the table however because if often comes up in discussions.

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Active human power

The type of human powered systems investigated at MIT could be referred to as passive human powered systems in that the power is scavenged during common activities rather than requiring the user to perform a specific activity to generate power. Human powered systems of this second type, which require the user to perform a specific power generating motion, are common and may be referred to separately as active human powered systems.

CONCLUSIONS REGARDING POWER SCAVENGING SOURCES

Both solar power and vibration based energy scavenging look promising as methods to scavenge power from the environment. In many cases, perhaps most cases, they are not overlapping solutions because if solar energy is present, it is likely that vibrations are not, and vice versa.

SUMMERY

The design of sustainable wireless sensor networks (WSNs) is a very challenging issue. On the one hand, energy-constrained sensors are expected to run autonomously for long periods. However, it may be cost-prohibitive to replace exhausted batteries or even impossible in hostile environments.

REFERENCES

1. D. P and I. A, "Overview of Networking Protocols for Underwater Wireless Communications", IEEE Communications Magazine, Jan, 2009; 49(1): PP 97-102.
2. Junfeng X, Keqiu L, Geyong M, Kai L and Wenyu Q, "Energy-Efficient Tree-Based Multipath Power Control for Underwater Sensor Network", IEEE Transactions On Parallel And Distributed Systems, January, 2012; 23(11): 27.
3. Chetan C and Ramneek S, "A Real-Time Matlab based GUI for node placement and a shortest-path alternate route path algorithm in Wireless Sensor Networks", IJSETT, ISSN No. (Online) 19 April, 2013; 2250-3641.
4. Brain O, Jan R, "Ultra-Low Power Wireless Technologies for Sensor Networks", SPRINGER 2007.
5. Sanatan M, "Energy Efficient Routing Algorithm for Wireless Sensor Networks and Performance Evaluation of Quality of Services for IEEE802.15.4 Networks", Jan 2010; Deptt. Of ECE, NIT, Rourkela.
6. Ian F.A, Dario P, Tommaso M, "State of the Art in Protocol Research for Underwater Acoustic Sensor Networks", ACM workshop on Underwater Networks (WUWNet), 25 September, 2006;Los Angeles, CA,.
7. IEEE Standard 802.15.4, "Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)", 2006.
8. I.F. A, W. Su, Y. Sankara S, Cayirci E., "Wireless Sensor Networks: A Survey", ELSEVIER, Accepted: 20 December, 2001, Published: 2002; 38(4): 393-422,
9. Young C.Y., Kumar S.P. and Hamilton B.A., "Sensor Networks: Evolution, Opportunity and Challenges", , Proceedings of IEEE; 2003; 91(8): 1247-1256.

10. Sujesha S and Purushottam K, "Energy Harvesting Sensor Nodes: Survey and Implications", IEEE communications surveys and tutorials, 2011; 13(3).
11. Heinzelman W.,. Chandrakasan A, and Balakrishnan H., "Energy efficient Communication Protocol for Wireless Micro Sensor Networks", in Proc. 33rd Annual Hawaii International Conference on System Sciences., IEEE, Jan, 2000;.8: 8020.
12. Buettner M., Yee G. V., Anderson E. and Han R., "X-MAC: A Short Preamble MAC Protocol for Duty Cycled Wireless Sensor Networks", in Proc. 4th International Conference on Embedded Networked Sensor Systems, ACM, November, 2006; 307-320.
13. Polastre J., Hill J. and Culler D., "Versatile Low Power Media Access for Wireless Sensor Networks", in Proc. 2nd International Conference on Embedded Networked Sensor Systems, ACM, November, 2004; 95-107.
14. Heidemann W. Ye. J. and Estrin D., "An Energy-Efficient MAC Protocol for Wireless Sensor Networks", in INFOCOM 2002, Proc. 21st Annual Joint Conference of the IEEE Computer and Communication Societies, 2002; 3: 1567-1576.
15. Intanagonwiwat C., Govindan R., and Estrin D., "Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Network", in Proc. 6th Annual International Conference on Mobile Computing and Networking, ACM, 2000; 56–67.
16. Desnoyers P., Ganesan D., H. Li, M. Li, and Shenoy P., "PRESTO: A Predictive Storage Architecture for Sensor Networks," in Proc. 10th Conference on Hot Topics in Operating Systems, 2005;USENIX Association: 23.
17. Ganeriwal S., Ganesan D., Shim H., Tsiatsis V., and Srivastava M. B., "Estimating Clock Uncertainty for Efficient Duty-cycling in Sensor Networks," in Proc.3rdACM Conference on Sensor Networking Systems, Nov. 2005; 130–141.
18. Dutta P., Grimmer M., Arora A., Bibyk S., and Culler D., "Design of a Wireless Sensor Network Platform for Detecting Rare, Random, and Ephemeral Events," in In The 4thInternational Conference on Information Processing in Sensor Networks2005; 497–502,.
19. Liu H., Chandra A., and Srivastava J., "eSENSE: Energy Efficient Stochastic Sensing Framework Framework for Wireless Sensor Platforms," in Proc. 5th International Conference on Information Processing in Sensor Networks, April 2006;235–242.
20. Gnawali O., Jang Ki. Y., Paek J., Vieira M., Govindan R., Greenstein B., Joki A., Estrin D., and Kohler E., "The Tenet Architecture for Tiered Sensor Networks," in Proc. 4th International conference on Embedded Networked Sensor Systems, ACM, November, 2006; 153–166.

21. Kulkarni P., "Senseye: A Multi-tier Heterogeneous Camera Sensor Network," Ph.D Disser. , University of Massachusetts, Amherst, 2007: Adviser-Prashant Shenoy and Adviser-Deepak Ganesan.
22. Kulkarni P., Ganesan D. and Shenoy P., "The case for Milti Tier Camera Sensor Networks", in Proc. International Workshop on Network and operating Systems support for digital audio and video, ACM, June 2005; 141-146.
23. Wang X., Xing G., Zhang Y., Pless C. Lu, R., and Gill C., "Integrated Coverage and Connectivity configuration in wireless sensor networks," in Proc. 1stInternational Conference on Embedded Networked Sensor Systems. ACM, November 2003; 28–39.
24. Kumar S., Lai T. H. and Balogh J., "On K-Coverage in a Mostly Sleeping Sensor Networks", Wireless Networks, SPRINGER, 2008; 277-294.
25. Kansal A., Hsu J., Zahedi S., and Srivastava M. B., "Power Management in Energy Harvesting Sensor Networks", Transaction in Embedded Computing Systems, ACM, 2007; 6(4):32.
26. Paradiso J. A. and Feldmeier M., "A Compact, Wireless, Self-Powered Push Button Controller", in Proc. 3rdInternational Conference on Ubiquitous Computing. SPRINGER-VERLAG, 2001; 299–304.
27. Shenck N. and Paradiso J., "Energy Scavenging with Shoe-mounted Piezoelectrics", IEEE Micro, May/Jun 2001; 21(3);30–42.
28. Kymissis J., Kendall C., Paradiso J., and Gershenfeld N., "Parasitic Power Harvesting in Shoes", in 2nd International Symposium on Wearable Computers. IEEE, Oct 1998; 132–139.
29. Starner T., "Human-powered Wearable Computing", IBM Systems Journal.1996; 35(3):618–629.
30. Jiang X., Polastre J., and Culler D., "Perpetual Environmentally Powered Sensor Networks", in 4th International Symposium on Information Processing in Sensor Networks., April 2005; 463–468.
31. Taneja J., Jeong J., and Culler D., "Design, Modeling, and Capacity Planning for Micro-solar Power Sensor Networks", in Proc. 7th International Conference on Information Processing in Sensor Networks, 2008; 407–418.
32. Raghunathan V., Kansal A., Hsu J., Friedman J., and Srivastava M., "Design Considerations for Solar Energy Harvesting Wireless Embedded Systems", Fourth International Symposium on Information Processing in Sensor Networks, April 2005; 457–462.

33. Park C. and Chou P., “Ambi Max: Autonomous Energy Harvesting Platform for Multi-Supply Wireless Sensor Nodes”, 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, Sept. 2006; 1:168–177.
34. Kulah H. and Najafi K., “Energy Scavenging From Low-Frequency Vibrations by Using Frequency Up-Conversion for Wireless Sensor Applications”, IEEE Sensors J., March 2008; 8:261–268.
35. Weimer M., Paing T. and Zane R., “Remote Area Wind Energy Harvesting for Low-power Autonomous Sensors”, 37thIEEE Power Electronics Specialists Conference, June 2006:1–5.
36. Yen K. T. and Sanjib K. P., “Review of Energy Harvesting Technologies for sustainable Wireless Sensor Network”, National University of Singapore,www.intechopen.com.
37. Ovaliadis K., Savage N. and Kanakaris V., “Energy Efficiency in Underwater Sensor Networks: a Research Review” JESTR, 20 June, 2010; 151-156.
38. Gitzendanner R., Pugliaa F., Martina C., Carmena D., Jonesa E., Eavesb S., “High power and high energy lithium-ion batteries for under-water applications”, Journal of Power Sources, October 2004; 136:416-418.
39. Yardney Technical Products Inc. (2007), “Design and Performance of Lithium ion cells for underwater energy storage and power delivery”, online: http://www.yardney.com/Lithion.
40. Vasilescu I., Dunbabin M., Corke P., Kotay K. and Rus D. “Data collection, storage, and retrieval with an underwater sensor network”, in Proc. ACM Sensys 2005, November 2005:San Diego, CA, USA.