Available online at www.elixirpublishers.com (Elixir International Journal)

Network Engineering

Elixir Network Engg. 66 (2014) 20541-20543

ISSN: 2229-712X

A survey on applications of network coding in wireless sensor network for lifetime enhancement

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ARTICLE INFO

Article history:

Received: 18 November 2013;

Received in revised form:

22 December 2013;

Accepted: 2 January 2014;

Keywords

Wireless Sensor Network,
Network Coding,
One Time Control Operations,
Periodic Control Messages,
Energy-Efficient operations.

ABSTRACT

Wireless Sensor Networks have been scattered over many unattainable areas such as glaciers, forest, gas, oil water etc to gather real time sensitive information. These Sensor nodes are capable of gathering a large quantity of data by sensing the area, this consumes a large amount of broadcasting and transmission power and thus reducing the life-spam of batteries running sensor node. Through this paper the researcher investigated relationship between the network coding techniques and the transmission power of WSN. Network coding, in belief, is a Layer 3 invention that enhances the network throughput and performance in wireless networks for multicast or broadcast situations. This Paper basically performs the survey on area the where network coding is applied in WSN to enhance the battery life of the nodes by various researchers. It also analyzes the factors which effects the networks lifetime.

Introduction

Wireless communication technologies and tools have grown very rapidly is past years. This modern technology has greatly improved people's lives. Major disadvantage of wireless networks is that they are dependent on an infrastructure, where nodes at the base stations are connected with wireless entities through a wired network and receive and transmit data between them. The wireless network where no infrastructure exists is the Wireless Sensor Networks (WSNs).

Wireless sensor networks are deployed in many unattainable areas such as glaciers, forest, gas, oil water etc… to gather real time sensitive information. These data are then forwarded to centralized data analysis centres. These networks comprised of numerous small independents energy constrained sensor nodes. To perform various activities such as decision making, gathering information and data for its computing ability, communicates with other sensors the sensor nodes consumes energy i.e. limited resource.

For energy constrained wireless sensor networks, renewing or restoring energy stack (two batteries) of nodes is often not convenient or even not possible, and thus limiting the lifetime of the nodes to only available battery energy. Hence, maximization the lifetime of the WSN is an interesting area for researchers and a variety of methods for this purpose have been proposed until now, for instance, using network coding and random duty cycle at bottle neck zone [1], transmitting power control [2], scheduling with periodical sleep [3], load-balancing with multi-path routing [4–6], etc.

Due to the immediate growth in wireless sensor networks with energy constrained, lifetime enhancing mechanisms has been examined extensively but generally not considering the network coding [7].

Ahlswede et al. first proposed basics of Network coding in 2000[8] to efficiently enhance the energy efficiency and throughput [14] of both wireless and wired communication technologies. Many researchers are investigating various characteristic of network coding such as coding mechanisms [7], use of network coding for opportunistic routing with [9], network optimization for both unicast [10] and multicast networks[9], and performance analysis of network coding [11,12].

The remaining paper is arranged in five different sections. In Section II, presents the basic idea about network coding and its encoding and decoding mechanism. Section III discusses various techniques were network coding were applied by different researchers to enhance the lifetime of WSN. In Section IV and V, different factor are discussed which will be effecting the energy constraints in WSN and challenges faced by the WSN respectively. Then conclusion is drawn stating the scope of network coding in WSN.

Network Coding

Network Coding has the prospective to decrease the number of packets transmitted by encoding several packets together in a communication. It generalizes conventional store-n-forward routing methods by allocating intermediate nodes in the set of connections to encode multiple communicated packets into a single coded packet before transmitting. An intermediate node that is open to broadcast or transmit the packets encoded, then selects a coefficients series $q=(q1,q2,...,q_m)$,known as encoding vector, from Galois Field(28). A combination of m packets G_i (i = 1, 2, 3, 4... m) that the sensor nodes accepts are linearly encoded to a particularly single output packet. These encoded packets at the intermediate node are given by:

$$Z = \sum_{i=1}^{m} qi*Gi , \qquad qi \in GF(28). [1] \qquad (1)$$

These encoded packets are then broadcasted or transmitted along with the coefficient m within the network. At the receiver node the encoding vector q=(q1,q2,...,qm) is used to decode the received coded packet.[1]

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At the receiver end the node decodes the linear series of equations for recovering the actual packets from the received coded packet. The receiver sensor nodes receive the encoding vector q with the encoded data.

The series of linear equations resolved by the node consist of m numbers of equations and n numbers unknown variables for the decoding operations.

$$Yj = \sum_{i=1}^{n} qji*Gi , \quad j=1, 2 \dots m[1] \quad \text{.....(2)}$$

The series of equation received by the nodes are (qi, yi), ... , (qm, ym) where qj denotes the coding vector and yj denotes the information symbol.

For appropriate decoding operations of the actual packets, n number of independent linearly encoded packets should be received at the receiver node.

Application Of Network Coding for lifetime enhancement

M. Nagajothy et al. [8] examined network coding for enhancing the lifetime of the sensor nodes by combining multiple packets together into a single packet and hence decreasing the number of packets to be transmitted in each communication for circular network arrangements. Their investigation was based on the relationship between the traffic rate and energy consumed by varying the density and number of nodes during the transmission.

Y. Hong et al. [9] designed an algorithm for maximizing the network lifetime based on network coding for data gathering. Though, the approach stated in their paper neglected the amount of energy consumed by packets reception, their approach considered that the energy contributed in reduction of the original energy of nodes is actually consumed by transceiver component only.

In [10] P. M Glatz et al. proposed a butterfly structure for low computational power using network coding technique. Their architecture extended the networks lifetime and releases resource restrictions.

In [11] P. M. Glatz et al. developed an autonomous and self-determining layer of network coding that is free from all overheads. It was invented to work with no centralized management and to protect up-to approx. 29% of the packets that were to be transmitted.

Wang et al. [12] designed an algorithm in WSN for the two hop information exchange based upon network coding. They tested and compared their algorithm for both systematic and unsystematic network topologies with and without network coding, and it achieved that the use network coding enhanced performance over simple packet forwarding.

Rout R. R. et al. [1] in 2013 suggested that the area near the base station is very pron towards a bottleneck region because of large amount of traffic flow which restricts the total energy in a wireless sensor networks. They derived that the base station can receive 50% more data with equal energy consumption in the bottleneck region using the random duty cycle and network coding. They also suggested that routing protocol also affects the lifetime of the WSN network. Due to lack of coordination between the nodes there is wastage of some amount of energy because of the collision of data at the receiving node. Thus, the Non Medium Access Control (MAC) protocols affects the network lifetime. They have estimated the lifetime upper bounds first with duty cycle, then with network coding and finally by combining the duty cycle and the network coding together. Their research analysed that using the proposed approach energy consumption in the bottleneck zone is reduced. Thus increasing the lifetime of the network. According to the simulation result network coding based algorithm increases the network lifetime of 2.5% to 9.5% in a WSN with duty cycle.

Y. Peng et al. [13] in 2013 suggested that random linear network coding in multi path with source coding and source forwarding (RNCM-SC and RNCM-SF) mechanisms performs better that the traditional mechanisms for resource redundancy degree, throughput ratio, packet delivery ratio etc in wireless mesh network.

Factors Affecting WSN Lifetime

The major factors which affects the wireless sensor network lifetime are stated as under:

Monitoring Continually

The area under observation should be monitored uninterrupted & continuous therefore that data or information could be identified instantaneously. It can be achieved by making one sensor always in active mode, thus consuming a significant amount of energy.

Requirements for Notification of Events:

Data gathered by the sensor nodes is required to be broadcasted or transmitted to the base station rapidly. In order to receive data- notification messages fast through a wireless sensor network with multiple nodes, most of the sensors node must have their radio transreceivers in the on state either regularly or oftenly so that they can transmit an urgent or important message headed for the base station. This again consumes significant amount of energy.

Messages for Timely Control:

Every node of WSN network requires sending periodic messages for routing information sharing and time synchronization. Sending these messages for timely control also uses significant amount of energy.

Operations for Single Time Control:

There is numerous single-time control operations carried out by the WSN nodes. Most important among them as an example are wireless localization and reprogramming. These activities requires the sensor hops to be active for a very long duration, send and receive large amount of messages for communication, and carry out actuation actions (e.g. generating alarms). These activities also consume sufficient amount of energy.

Incidence of Actions and Measures

Each and every occurring incident requires the sensor nodes close to the happening area to keep on active for some time to identify the incident and also to broadcast and transmit messages to multiple sensor nodes in a network.. Continuing in active state with all the sensors nodes and processor active, WSN again utilizes significant amount of energy.

Challenges for WSN

Some of the major characteristic challenges existing for WSN are classified as attribute and mechanism challenges:

[1] Quality of Service (QoS): Sensors nodes should maintain the quality controls features such as reliability, security, estimate quality of pressure, temperature, noise etc mapped etc.

[2] Type of Service: Sensors nodes should be smart enough to provide meaningful data and actions rather than just transmitting bits between the sensors.

[3] Fault tolerance: Nodes should be robust against node and links failure.

[4] Lifetime: WSN should fulfil its task as long as possible.

[5] Scalability: Architecture & protocols requires maintaining a large number of sensor nodes.

[6] Wide range of densities: Number of nodes differs depending upon the application. WSN should easily adapt change over time due to node movement or node failures.

[7] Programmability: Sensors should flexible enough to enable the re-programming of nodes in the area to react to new situations.
[8] Maintainability: Deployment of the networks should be easily manageable and maintainable.

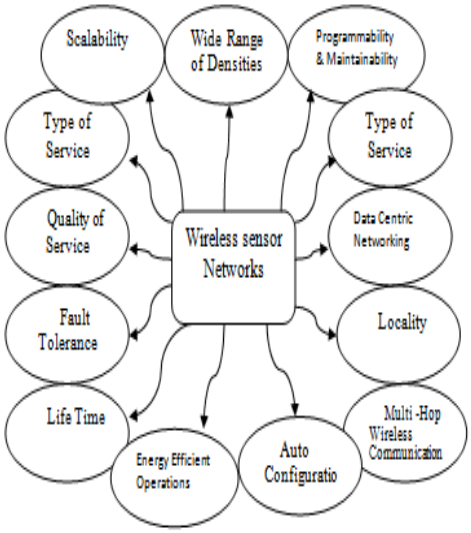

Fig. 1: Challenges for WSN

[9] Multi-hop wireless communication: Efficiently use of intermediate nodes should as relays to save energy & radio transmission.
[10] Energy-efficient operation: Sensing, Computation and transmission of information should be energy efficient.
[11] Auto-configuration: Inclusion of new sensors should automatically configure.
[12] Data-centric networking: Processing should be done on relevant data stored on the central storage and not on the node which is providing it.
[13] Locality: Operations should be done locally with the collaboration with its neighbour's on the nodes itself.

Conclusions

In last few years, these wireless sensor networks (WSNs) have achieved ever-increasing consideration equally from the authentic users as well as research community. These sensors nodes are normally battery-powered instruments or devices; the essential characteristics which face concern are to find mechanism to decrease the energy utilization of the sensors, so as to extend the network lifetime for a reasonable duration. For increasing the amount of energy constrains of a wireless sensor network, thus increasing its lifetime, is the major challenge for sensor networks research.

A new mechanism in the field of communication & networking is Network coding for 21st century. It could improve the network throughput and decreases the energy utilization, and is mostly based on the single transmission rate.

Network coding can provide a better solution to enhance the lifetime of WSN. Still a lot of scope exists in area to overcome the factor effecting the WSN lifetime where network coding can be applied.

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