A Fuzzy Energy Management Approach for Multimedia Traffic in WSN

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Abstract: Wireless Sensor Network (WSN) is an innovative ad-hoc network with distributed sensing and processing capacities made up of collection of sensor nodes. The sensors transmit information to the sink. The routing protocols for WSN are based mostly on efficiency of energy and some deal with real-time requirements. In this paper, a fuzzy logic system is incorporated to improve the quality of the service of the network. The number of packets transmitted successfully, energy and number of hops from sink are taken into consideration by the fuzzy logic system to improve the throughput of the network. The proposed protocol is compared with AODV to evaluate its efficiency.
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1. Introduction

A wireless sensor network (WSN) is a self-organized collection of sensor node. In general, WSN is an innovative ad-hoc network with distributed sensing and processing capacities [1]. They comprise of unattended 1000s & 1000s of tiny battery energized devices (sensor nodes). They are micro sensors which are cubic centimetres in size and each such node comprises of processor, memory type, a RF transceiver, an energy source, and huge sensors & actuators. These nodes converse wirelessly and order themselves into networks. And they are capable of sensing data from their location, perform trouble-free computations and transmit the data by mean of wireless directly to command centre or through some cluster head, known gateway.

In several applications, the collection of calculated information required to be sent to the sink within a particular time period, in order to maintain certain event record in a timely mode. Consistent with an event exigency and importance, each data packets coupled with some events are assigned diverse end-to-end deadline requirements. The packets delivered to the sink prior to the deadline are considered useful. The sense of balance amid end-to-end performance and energy consumption needs to be upheld, as the network's lifetime is a vital factor in WSN. Sensors nodes are expected to with stand for a long time period even though it is battery operated. Thereby, energy is a limited concern in a WSN and so its efficient usage is a hard task. The life span of the sensor network depends upon the energy efficiency. A sensor's energy is consumed promptly with these activities: sensing, computing & communicating.

The routing protocols are based mostly on efficiency of energy and some deal with real-time requirements [2]. But the introduction of quality of service (QoS) into routing decision suffers from overhead of tables and states maintenance for each sensor node [3]. Routing is a locale, where efficient deployment of energy to be made. These criteria use stable (crisp) metrics for building energy-conscious routing decisions. As WSN's application area is certain, gateways are chosen to be commanding over the sensor nodes. By this, the energy-constrained sensor node takes in a straight line communication with the remote sink. The strict energy constraints, huge mass of sensor nodes, minor cost and inactive nodes state make WSN (information gathering) differ from ad-hoc net (distributed computing) [4].

Octav Chipara & Zhimin designed a Realtime Power-Aware Routing (RPAR) protocol that achieves application-specified communication delays at low energy cost by animatedly adapting transmission power and routing decisions [5]. An adaptive routing protocol (ARP) proposed that energetically adjusts the transmission rate of data packets during the end-to-end transmission [6]. In this paper, an energy efficient method for packet transmission in WSN based on fuzzy logic is proposed. A fuzzy logic based approach for energy-aware routing in WSNs is flexible and so that it can put up sensor networks comprising various types of sensor nodes having varied energy.

A cluster of nodes is mined by a gateway in cluster-based architecture. The gateway can communicate in a line with every sensor nodes and picks their status. Each sensor nodes in turn send their sensed data to this gateway. But this paves more cost for the sensor nodes that is far to the gateway. So the gateway can be reached through multiple-hops and is liable for setting up of routes and maintain the centralized routing table. Gateway calculates the cost of link amid of two sensor nodes by the fuzzy routine. When all the available links costs to the gateway are measured using fuzzy logic, the route can then be determined using a shortest path algorithm. Various optimization tradeoffs such as lower transmission power vs. longer transmission duration, computation vs. communication multi-hop vs. direct communication etc. is taken into consideration. Fuzzy logic suits in these contradictory requirement applications.

2. Related Works

At present the increasing concentration is mainly on WSNs in which constructing an energy-efficient clustering protocol is the main consideration. In order to enhance the lifetime of the network the hierarchical clustering algorithms are of greater importance. Two phases: the setup phase and steady state phase are present in every clustering algorithm. The cluster head selection is the main goal of these algorithms. Dilip Kumar et al., [7] studied the effect of heterogeneity of nodes in terms of their energy in hierarchically clustered wireless sensor networks. An assumption is that the supplementary energy resources equip a percentage of the population of sensor nodes. Another assumption is that the sensor nodes are not mobile but they are randomly distributed along with knowledge about the dimensions of the sensor field and the coordinates of the sink. The benefit of the presence of node heterogeneity is not attained by every sensor nodes that are equipped with the equal amount of energy is an assumption in homogenous clustering protocols. An energy efficient heterogeneous clustered approach for wireless sensor networks on the basis of weighted election probabilities of each node to develop into a cluster head considering to the residual energy in each node is introduced by modifying the above approach. Compared to LEACH the simulation results show the superiority in efficiency of the proposed heterogeneous clustering scheme to extend the network lifetime.

Congestion has a significant effect in the degradation of the network's performance in the WSN's. The network load is very low in inactive conditions but congestion happens when there is an event detected that leads to heavy load in the network. Therefore, the entire performance of the network degrades because of this congestion. So, the immediate requirement in WSN's is to detect and control congestion. Chakravarthi, et al., [8] proposed a well-organized method in order to detect and control congestion effectively. A metric named Congestion Degree (Cd) is calculated to detect the congestion. The ratio between packet inter arrival time and packet inter service time is the calculated Cd metric. After the detection of congestion employing the Implicit Congestion Notification (ICN) signaling, it is notified. To minimize the congestion after the congestion notification signal is received the controlling of the transmission rate is performed. Additionally, using Fuzzy Logic Controller the congestion control is executed. For delivery ratio with various transmission rate and the PDR is compared with CODA for the purpose of measuring the performance of the network.

In an inactive or light load the event-driven sensor networks are operated that turns to be active unexpectedly as a response to a monitored or detected event. Many differing degrees of congestion are caused in the network relying on the sensing application because of the transport of event impulses. The likelihood of congestion is extreme at these periods of event impulses and to the users the information in transit is very essential. This problem is dealt by Wan et al., [9] by proposing an energy efficient congestion control scheme called CODA (COngestion Detection and Avoidance) for sensor networks. Three mechanisms are incorporated in CODA: 1) detection of receiver-based congestion, 2) open-loop hop-by-hop backpressure; and 3) regulation of closed-loop multi-source. A detailed design, accomplishment, and estimation of CODA employing simulation and testing are presented. Two significant performance metrics: energy tax and fidelity penalty are presented in order to estimate the effect CODA on implementation in sensing applications. An experimental sensor network testbed based on Berkeley motes implementing CSMA to illustrate the advantages in performance and problems faced by using CODA in practical engineering are discussed. The results obtained from simulation reveal that the performance of data dissemination applications like directed diffusion through hotspots, and decreasing the energy tax by low fidelity penalty on sensing applications is drastically advanced by CODA. It is illustrated that many congestion scenarios are tackled by CODA to respond efficiently and it is believed that the deployment of these networks accelerates tends CODA to prevail.

In WSN for the optimization of energy consumption several schemes and methods are developed recently. For efficient utilization of energy many efforts are taken in the field of "routing". Fixed (crisp) metrics are implemented in these efforts in order to create energy-aware routing decisions. In WSN, Haider et al., [10] presented a generalized fuzzy logic based scheme developed for energy-aware routing. The proposed generalized scheme is able to accommodate sensor networks that consist various kinds of sensor nodes possessing various energy metrics due to its soft and tunable nature.

Nikravan et al., [11] utilized a Fuzzy Logic System (FLS) as a decision mechanism for the purpose of selecting next hop node. In real-time packet transmission, to select the next-hop node both transmission rate and energy are selected to be the essential parameters. The results obtained by simulation of the proposed approach reveals that when operated in differing real-time environment the proposed approach affords enhancement in real-time transmission and energy efficiency performance (i.e., it is able to obtain low energy consumption and high packet delivery ratio within deadline).

The intrinsically distributed nature of multi-agent Systems (MAS) affords a guaranteed implementation framework and software modeling in applications of WSN. Limited resources from energy and a computational perspective characterize WSNs, further in the duration of the network's operational lifetime as the effect of environment among others get their toll as the integrity of the WSN coverage area are cooperated. The challenge faced is to develop an accurate model concerning the present condition to obtain effective decisions regarding the future courses of action for these limitations. S. Shen et al., [12] investigated one of the famous agent architecture, the BDI architecture in this perception. In terms of energy-awareness and utility using classical reasoning augmented with a fuzzy component in a hybrid fashion supports to discover the basic problem of belief generation within WSN limitations. Therefore by combining fuzzy reasoning with traditional BDI scheme the energy-aware utility-based agents provide a hybrid approach to deliberative reasoning.

3.Methodology

3.1 Fuzzy Logic System

Fuzzy logic (FL) tries to replicate the thought of human logic [13]. Fuzzy Logic offers various unique characteristics so that to stay as a best alternate for control problems. It's robust as it does not prefer any standard inputs. The output control is a flat control function even with those varied inputs. The FL controller can be changed and tweaked to improve / alter the performance of system with some user defined rules. FL deals with the information analysis by using fuzzy sets that can be represented in linguistic terms. The real value ranges over the mapped set (domain), and the membership function is termed fuzzy set. A truth value between 0 and 1 (to all the points in the domain) is being done by membership function. Various fuzzy sets can be used (triangular, beta, PI, Gaussian, sigmoid etc.) depending on the membership function's shape,

In basic, a fuzzy logic system (FLS) comprises three parts:

- Fuzzifier,
- Inference engine, &
- Defuzzifier.

The fuzzification process prepares the crisp inputs to be fuzzified. These fuzzified values are then handled by the inference engine, which has in a rule base and various methods for inferring the rules. Experts rules / from numerical data extraction forms the rules (FLS heart). The antecedent (IF-PART) and consequent (THEN-PART) are parts of a rule. For a certain fuzzy set, a common fuzzification process is characterised by the membership functions is termed fuzziness. The rules relate the input with the output fuzzy variables using linguistic variables that are represented with a fuzzy set & fuzzy implication operators AND, OR etc. Finding a crisp output value from the fuzzy solution space is the defuzzification. The maximum, centroid, centre-of-sums, mean-of-maxima, and centre-of sets are some defuzzify methods.

The objective of the fuzzy routine is to calculate the value of cost so that to maximize the lifetime of a network. The lifetime of WSN is said as the time when the energy level of the first sensor node becomes zero. The fuzzy rule base help extend the life time of the sensor network and balance the routing load among sensor nodes effectively so that a maximum number of nodes have sufficient energy to continue performing their own sensing tasks.

4. Experimental Setup

The proposed method is investigated by simulating in Opnet. The testbed consists of 28 wireless sensor nodes transmitting information to one sink. The sensor nodes are spread over an area of 4 sq. Km with the farthest node being 5 hops from the sink. The maximum available bandwidth is 11 Mbps and with transmission power of each node is 0.005w. Figure 1 show the testbed used in the simulation platform.

The proposed method was tested with AODV routing protocol for evaluation. High resolution video and random packet traffic was the data transmitted from the nodes to the sink. Simulations were carried out for 300 seconds.

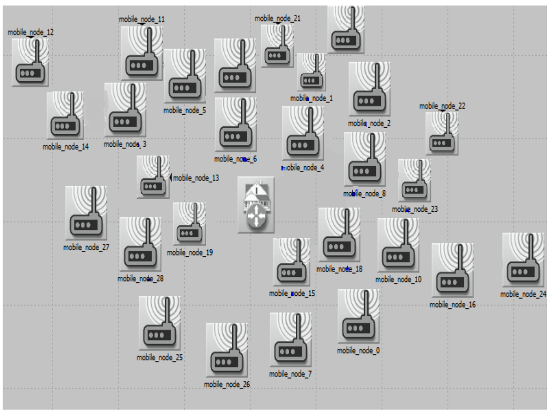

Figure 1: The experimental setup.

5. Results and Discussion

In the proposed method, Number of packets transmitted successfully, Energy and Number of hops from sink were used as the inputs for the FLS. Mean of Maximum was the Defuzzification technique used. Figure 2 shows the input fuzzy variable. Table 1 shows the definition points for the input fuzzy variable.

Figure 3 shows the fuzzy output for selecting the nodes to reach the sink. Table 2 shows the rules generated.

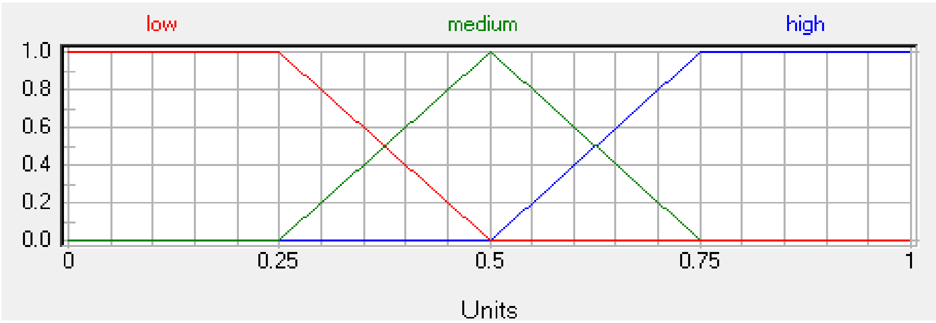

Figure 2: Input Fuzzy Variables

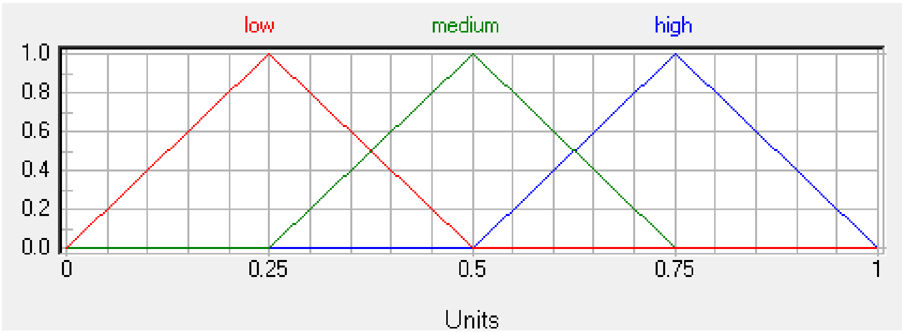

Figure 3: Fuzzy output for selecting the node to reach sink

Table 1: Definition points of input fuzzy variables

Term Name	Shape/Par.	Definition Points (x, y)
low	linear	(0, 1) (0.25, 1)(0.5, 0) (1, 0)
medium	linear	(0, 0) (0.25, 0)(0.5, 1) (0.75, 0)(1, 0)
high	linear	(0, 0) (0.5, 0) (0.75, 1) (1, 1)

Table 2: Rules generated

IF			THEN	
NumberOf Transfer	Energy	HopFrom Sink	DoS	Route Prob
low	low	low	0.01	low
low	low	low	0.98	medium
low	low	low	0.43	high
low	low	medium	0.09	low
low	low	medium	0.19	medium
low	low	medium	0.98	high
low	low	high	0.93	low
low	low	high	0.91	medium
low	low	high	0.52	high
low	medium	low	0.51	low
low	medium	low	0.23	medium
low	medium	low	0.89	high
low	medium	medium	0.26	low
low	medium	medium	0.13	medium
low	medium	medium	0.35	high
low	medium	high	0.50	low
low	medium	high	0.13	medium
low	medium	high	0.77	high
low	high	low	0.39	low
low	high	low	0.05	medium
low	high	low	0.62	high
low	high	medium	0.27	low
low	high	medium	0.67	medium
low	high	medium	0.66	high
low	high	high	0.77	low
low	high	high	0.85	medium
low	high	high	0.91	high
medium	low	low	0.71	low
medium	low	low	0.36	medium
medium	low	low	0.91	high
medium	low	medium	0.32	low
medium	low	medium	0.65	medium
medium	low	medium	0.16	high
medium	low	high	0.17	low
medium	low	high	0.97	medium
medium	low	high	0.15	high
medium	medium	low	0.13	low
medium	medium	low	0.43	medium
medium	medium	low	0.05	high
medium	medium	medium	0.34	low
medium	medium	medium	0.27	medium

IF			THEN	
medium	medium	medium	0.95	high
medium	medium	high	0.43	low
medium	medium	high	0.26	medium
medium	medium	high	0.95	high
medium	high	low	0.72	low
medium	high	low	0.28	medium
medium	high	low	0.19	high
medium	high	medium	0.48	low
medium	high	medium	0.82	medium
medium	high	medium	0.98	high
medium	high	high	0.02	low
medium	high	high	0.68	medium
medium	high	high	0.82	high
high	low	low	0.12	low
high	low	low	0.30	medium
high	low	low	0.32	high
high	low	medium	0.61	low
high	low	medium	0.94	medium
high	low	medium	0.16	high
high	low	high	0.06	low
high	low	high	0.72	medium
high	low	high	0.89	high
high	medium	low	0.66	low
high	medium	low	0.86	medium
high	medium	low	0.17	high
high	medium	medium	0.66	low
high	medium	medium	0.92	medium
high	medium	medium	0.42	high
high	medium	high	0.30	low
high	medium	high	0.42	medium
high	medium	high	0.44	high
high	high	low	0.70	low
high	high	low	0.37	medium
high	high	low	0.59	high
high	high	medium	0.95	low
high	high	medium	0.97	medium
high	high	medium	0.38	high
high	high	high	0.87	low
high	high	high	0.45	medium
high	high	high	0.59	high

The following Figures 4 to 7 shows the simulation result for the number of hops, packets dropped, routing traffic overhead and throughput respectively. The red line in the graph represents the AODV and the blue line represents the proposed method.

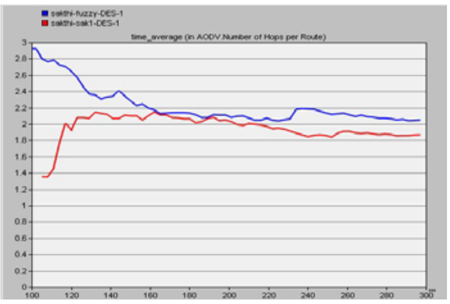

Fig 4: Number of hops

Figure 5 shows the average packet dropped for the entire network.

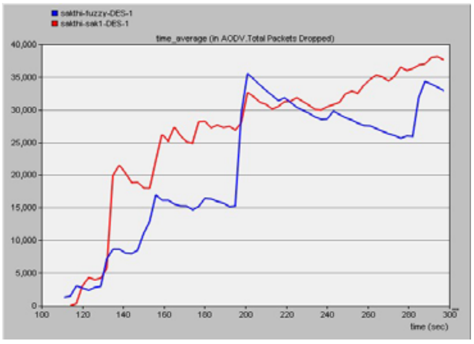

Figure 5: Packets dropped

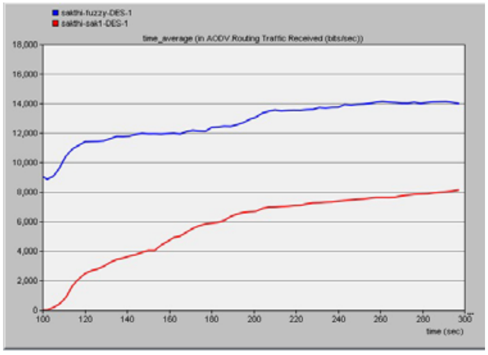

Figure 6: The Routing traffic overhead

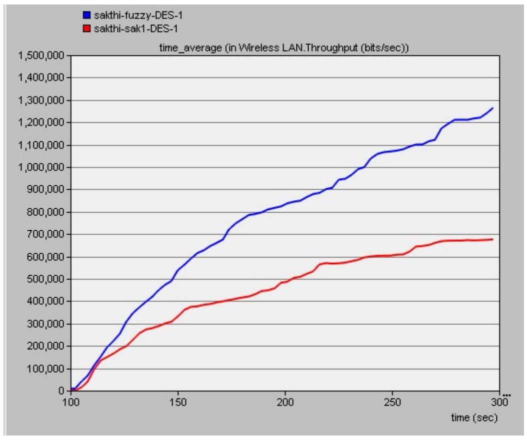

Figure 7: Throughput for both AODV and the proposed fuzzy method

It is evident from the above graphs that the overall performance of the network is improved due to the proposed Fuzzy method when compared to AODV. The number of hops of the proposed method is similar to the AODV. Packets dropped are considerably reduced in the proposed method. The routing traffic overhead is considerably high in the proposed method. This issue has to be addressed to further improve the proposed method. The throughput of the network is significantly higher for the proposed method than the AODV.

6. Conclusion

In this paper, a fuzzy logic system is incorporated to improve the quality of the service of the network. The number of packets transmitted successfully, energy and number of hops from sink are taken into consideration by the fuzzy logic system to improve the throughput of the network. The proposed protocol is compared with AODV to evaluate its efficiency. Simulation are conducted on the opnet platform and parameters such as number of hops, packets dropped, routing traffic overhead and throughput were studied. Simulation results demonstrate the efficiency of the proposed fuzzy method with respect to packet dropped and throughput. Further studies need to be undertaken to reduce the routing traffic overhead.

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