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Ethics of Reducing Power Consumption in Wireless Sensor Networks using Soft Computing Techniques

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Abstract

Power eminence controls the suitability of electrical power to user devices. A wireless sensor network is an arrangement collected of several computing and sensing devices distributed within an environment to be monitored. In this network saving power is a very serious issue, since sensor nodes are typically powered by batteries with an inadequate capacity. Since distribution is the main cause of power consumption in a sensor node, broadcast or response of data should be limited as much as possible. To this aim in this research paper, we propose an en ethics of reducing power consumption in wireless sensor networks using soft computing method.

Keywords

Soft Computing, Fuzzy logic, Wireless Sensor Network, Graph Theory

1. Introduction

A wireless sensor network (WSN) consists of a large number of energy constrained, low-cost and low-power sensor nodes. Each sensor node is a device, equipped with multiple on-board sensing elements, wireless transmitter receiver modules, computational and power supply elements and it is characterized by limited computational and communication capabilities. The WSNs are becoming increasingly popular for monitoring spatial phenomena. Indeed, they are deployed to an area of interest to collect data from the environment, process sensed data and take action accordingly. Typical applications of the WSNs include environmental control such as fire fighting or marine ground erosion, but also sensors installation on bridges or buildings to monitor earthquake vibration patterns and various surveillance tasks such as intruder surveillance on premises. In this paper, we proposed a routing based fuzzy logic scheme for real time packet transmission is WSN.

2. Soft Computing Techniques

Soft Computing (SC) is a consortium of methodologies (involving fuzzy sets, neural networks, genetic algorithms, and rough sets) that works synergistically and provides, in one form or another, flexible in-formation processing capability for handling real-life ambiguous situations. Its main aim is to exploit the tolerance for imprecision, uncertainty, approximate reasoning, and partial truth in order achieves tracta-bility, robustness, and low-cost solutions.

Zadeh [1] introduced Fuzzy Logic (FL) which became mathematical discipline to express human reasoning in rigorous mathematical notation. It is a multi-valued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, small/big, short/long etc. Notions like rather long or very long, small very small can be formulated mathematically and processed. Many authors [2],[3],[4],[5] used fuzzy logic or fuzzy approach in wireless sensor network. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster.

There are following operations in using Fuzzy logics are as:-
(1) Determining the input and the output of the system.

(2) Converting input numerical variables into fuzzy variables.
(3) Selecting the shape and boundaries of input membership functions.
(4) Selecting the shape and boundaries of output membership functions.
(5) Determining suitable rules (rule base) and applying them on the input.
(6) Converting fuzzy answers to numerical values as the output.

3. Routing Problem in Wireless Sensor Network

Transmission of information from node Ni to Nj carried out under best circumstances. The word best circumstance is not precisely defined. It is the node (at appropriate distance chosen by decision maker from destination) having enough power. These enough power and appropriate distance are linguistic var-iable assuming multiple values. The state of the node Ni is determined by the ratio of power and distance.
Let P= set of different powers
={VL,LVL,L,ML,M,MH,H,HVH,VH}
Let D=set of different types of distances
={VS,SVS,S,MDS,MD,MDL,L,LVL,VL}
Each value of input variables at the source node and output variables at the sink node are linguistic variables.

Table 1: Linguistic Variable and Range of Power

Linguistic Variable of Power		
Linguistic Values	**Notation**	**Range**
Very Low	VL	$[VL_a,VL_b]$
Low to Very Low	LVL	$[LVL_a,LVL_b]$
Low	L	$[L_a,L_b]$
Medium Low	ML	$[ML_a,ML_b]$
Medium	M	$[M_a,M_b]$
Medium High	MH	$[MH_a,MH_b]$
High	H	$[H_a,H_b]$
High to Very High	HVH	$[HVH_a,HVH_b]$
Very High	VH	$[VH_a,VH_b]$

Table 2: Linguistic Variable and Range of Distance

Linguistic Variable of Distance		
Linguistic Values	**Notation**	**Range**
Very Short	VS	$[VS_a,VS_b]$
Short to Very Short	SVS	$[SVS_a,SVS_b]$
Short	S	$[S_a,S_b]$
Middle Short	MDS	$[MDS_a,MDS_b]$
Middle	MD	$[MD_a,MD_b]$
Middle Long	MDL	$[MDL_a,MDL_b]$
Long	L	$[L_a,L_b]$
Long to Very Long	LVL	$[LVL_a,LVL_b]$
Very Long	VL	$[VL_a,VL_b]$

The complete bi-partite graph is given by fig 1.

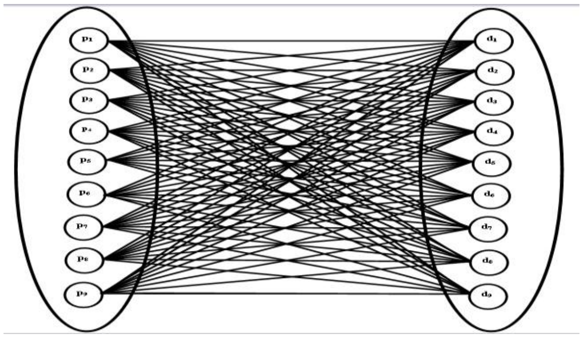

Fig. 1: Bi-partite graph for Power and Distance

G=(V,E) where V={$p_1,p_2,p_3,p_4,p_5,p_6,p_7,p_8,p_9,d_1,d_2,d_3,d_4,d_5,d_6,d_7,d_8,d_9$} and E={$Sp_{11}$, Sp_{12}, Sp_{13}, Sp_{14}, Sp_{15}, Sp_{16}, Sp_{17}, Sp_{18}, Sp_{19}, Sp_{21}, Sp_{22}, Sp_{23}, Sp_{24}, Sp_{25}, Sp_{26}, Sp_{27}, Sp_{28}, Sp_{29}, Sp_{31}, Sp_{32}, Sp_{33}, Sp_{34}, Sp_{35}, Sp_{36}, Sp_{37}, Sp_{38}, Sp_{39}, Sp_{41}, Sp_{42}, Sp_{43}, Sp_{44}, Sp_{45}, Sp_{46}, Sp_{47}, Sp_{48}, Sp_{49}, Sp_{51},Sp_{52},Sp_{53},Sp_{54},Sp_{55}, Sp_{56}, Sp_{57}, Sp_{58}, Sp_{59},Sp_{61}, Sp_{62}, Sp_{63}, Sp_{64}, Sp_{65}, Sp_{66}, Sp_{67}, Sp_{68}, Sp_{69}, Sp_{71}, Sp_{72}, Sp_{73}, Sp_{74}, Sp_{75}, Sp_{76}, Sp_{77}, Sp_{78}, Sp_{79}, Sp_{81}, Sp_{82}, Sp_{83}, Sp_{84}, Sp_{85}, Sp_{86}, Sp_{87}, Sp_{88}, Sp_{89}, Sp_{91}, Sp_{92}, Sp_{93}, Sp_{94}, Sp_{95}, Sp_{96}, Sp_{97}, Sp_{98}, Sp_{99}}

Table 3: The Matrix of Containing Distance and Power can be given as.

Distance/ Power	**VL**	**LVL**	**L**	**ML**	**M**	**MH**	**H**	**HVH**	**VH**
VS	V_{91}	V_{91}	V_{91}	V_{91}	V_{91}	V_{91}	V_{91}	V_{91}	V_{91}
SVS	V_{92}	V_{92}	V_{92}	V_{92}	V_{92}	V_{92}	V_{92}	V_{92}	V_{92}
S	V_{93}	V_{93}	V_{93}	V_{93}	V_{93}	V_{93}	V_{93}	V_{93}	V_{93}
MDS	V_{94}	V_{94}	V_{94}	V_{94}	V_{94}	V_{94}	V_{94}	V_{94}	V_{94}
MD	V_{95}	V_{95}	V_{95}	V_{95}	V_{95}	V_{95}	V_{95}	V_{95}	V_{95}
MDL	V_{96}	V_{96}	V_{96}	V_{96}	V_{96}	V_{96}	V_{96}	V_{96}	V_{96}
L	V_{97}	V_{97}	V_{97}	V_{97}	V_{97}	V_{97}	V_{97}	V_{97}	V_{97}
LVL	V_{98}	V_{98}	V_{98}	V_{98}	V_{98}	V_{98}	V_{98}	V_{98}	V_{98}
VL	V_{99}	V_{99}	V_{99}	V_{99}	V_{99}	V_{99}	V_{99}	V_{99}	V_{99}

Let 'S' is the set of states as $S=\{S_{ij}$; i=power, j=distance$\}$, where i=1,2,3,4,5,6,7,8,9 stands for VL, LVL, L, ML, M, MH, H, HVH, VH and j=1,2,3,4,5,6,7,8,9 stands for VS, SVS, S, MDS, MD, MDL, L, LVL, VL. S_{ij} is defined as the ratio of each value of power and each value of distance. For finding reward r_{ij}, priorities of the states are compared by using formula Sp_{ij}=average value of each P/average value of each D. Each S_{ij} is a linguistic variable having different values, defined by S_{ij}=power i/distance j which determines the reward of state of each node. The set R of different rewards is given by

$R=\{r_{11},r_{12},r_{13},r_{14},r_{15},r_{16},r_{17},r_{18},r_{19},r_{21},r_{22},r_{23},r_{24},r_{25},r_{26},r_{27},r_{28},r_{29},r_{31},r_{32,33},r_{34}.r_{35},r_{36},r_{37},r_{38},r_{39},r_{41},r_{42},r_{43},r_{44},r_{45},r_{46},r_{47},r_{48},r_{49},r_{51},r_{52},r_{53},r_{54},r_{55},r_{56},r_{57},r_{58},r_{59},r_{61},r_{62},r_{63},r_{64},r_{65},r_{66},r_{67},r_{68},r_{69},r_{71},r_{72},r_{73},r_{74},r_{75},r_{76},r_{77},r_{78},r_{79},r_{81},r_{82},r_{83},r_{84},r_{85},r_{86},r_{87},r_{88},r_{89},r_{91},r_{92},r_{93},r_{94},r_{95},r_{96},r_{97},r_{98},r_{99}\}$ where $r_{11}\rightarrow$ VL&VS, $r_{12}\rightarrow$ VL&SVS, $r_{13}\rightarrow$ VL&S, ………………$r_{99}\rightarrow$ VH & VL

A reward r_{ij}(i=1, 2,….9, j=1, 2,…..9) may assume any value of very bad, bad, mild bad, very poor, poor, mild poor, medium, mild good, good, very good, less excellent, excellent, very excellent and so on.

For instance: Let us consider a wireless network in which there is a sensor range of 1000 meter for transmission information packages and power of 200 watt nodes. Some interval of parameters of power and of distances are given as

Power: (0,50), (50,100), (100,200), (200,350), (350,500), (500,600), (600,750), (750,850), (850,1000)
&
Distance: (0,10), (10,30), (30,60), (60,75), (75,100), (100,120), (120,150), (150,170), (170,200)

Here we have following 81 states as shown below

s11=5, s12=2.5, s13=1.666667, s14=3.333333
……… s96=7.5, s97=5, s98=7.5, s99=5

Form the above table the least values of state is 1.666667 and the greatest value is 15. Therefore states can be categorized as

c1={s41,s51,s71,s91},
c2={s31,s44,s54,s61,s74,s81,s94},
c3={s42,s46,s48,s52,s56,s58,s72, s76,s78,s92,s96,s98}, c4={s34,s64,s84}, c5={s45,s55,s75,s95}, c6={s11,s21,s32,s36,s38, s43,s47,s49,s53,s57,s59,s62,s66,s68,s73,s77,s79,s82, s86,s88,s93,s97,s99}, c7={s35,s65,s85}, c8={s14,s24,s33,s37,s39,s63,s67,s69,s83,s87,s89}, c9={s12,s16,s18,s22, s26,s28}, c10={s15,s25}, c11={s13,s17,s19,s23,s27,s29}

We have the descending order of values of states is shown as

c11>c10>c9>c8>c7>c6>c5>c4>c3>c2>c1
Here we find s11 has the very low power and very short distance, s19 has the very low power and the very long distance to the destination & s91 is has the very high power and the very short distance to the destination. Thus in a node s91 is the best choice for the routing. And node s19 is the worst choice for the purpose. To compare among the priorities of the 81 states for the purpose of determining the rewards we use the formula given by

$S_{prioritiy}$=(mean of power)/(means of the distance)
Thus we find

s11= 5, s12=1.25, s13= 0.555556, s14= 0.37037,…….., s95=10.57143, s96=8.409091, s97=6.851852, s98= 5.78125, s99= 5

Therefore priorities of the state can be categorized as
c1={r91}, c2={r81}, c3={r71}, c4={r61}, c5={r51}, c6={r41}, c7={r92}, c8={r82}, c9={r72}, c10={r31}, c11={r62}, c12={r52}, c13={r93}, c14={r83}, c15={r21}, c16={r73}, c17={r42}, c18={r94}, c19={r63}, c20={r84}, c21={r95}, c22={r74}, c23={r53}, c24={r85}, c25={r96}, c26={r64}, c27={r75}, c28={r32}, c29={r86}, c30={r97}, c31={r54}, c32={r65}, c33={r76}, c34={r43}, c35={r87}, c36={r98}, c37={r11,r66,r77,r88,r99}, c38={r55}, c39={r89}, c40={r78}, c41={r44,r67}, c42={r56}, c43={r22}, c44={r79}, c45={r68}, c46={r33}, c47={r57}, c48={r45}, c49={r69}, c50={r58}, c51={r46}, c52={r59}, c53={r34}, c54={r47}, c55={r48}, c56={r35}, c57={r23}, c58={r49}, c59={r36}, c60={r12}, c61={r24,r37}, c62={r38}, c63={r25}, c64={r39}, c65={r26}, c66={r13,r27}, c67={r28}, c68={r29}, c69={r14}, c70={r15}, c71={r16}, c72={r17}, c73={r18}, c74={r19}

Thus the following priorities of states
C1>C2>C3>C4>C5>C6>C7>C8>C9>C10>C11>C12>C13>C14>C15>C16>C17>C18>C19>C20>C21>C22>C23>C24>C25>C26>C27>C28>C29>C30>C31>C32>C33>C34>C35>C36>C37>C38>C39>C40>C41>C42>C43>C44>C45>C46>C47>C48>C49>C5

0>C51>C52>C53>C54>C55>C56>C57>C58>C59>C60>C61>C62>C63>C64>C65>C66>C67>C68>C69>C70>C71>C72>C73>C74

We find that each node has a specific state in the network. In routing between two nodes, let us go from state to another and going to a more suitable state must enjoy a greater reward. The states of sender and receiver nodes are taken as the input of fuzzy system and reward is as the output.

4. Conclusion

Routing in sensor networks has concerned a lot of devotion in the recent years and introduced unique challenges compared to traditional data routing in wired networks. So power saving is the most important concern in wireless sensor networks applications which should be consider in all aspects of networks. Fuzzy logic as intelligent tools shows great compatibility with WSN's characteristic and can be applied in different energy conservation scheme of them. The real world required real-time energy saving in wireless sensor networks to achieve real-time communication. So with the growing demand for real time services in wireless sensor networks this paper deals with power & distance as parameters in wireless sensor networks and determination of reward by using fuzzy logic.

References

[1] Lotfi A. Zadeh, "Fuzzy Logic, Neural Networks and Soft Computing", Communication of the ACM, 37(3), pp 77-84, 1994

[2] Mahmood R. Minhas et al.," Fuzzy Algorithms for Maximum Lifetime Routing in Wireless Sensor Networks", IEEE "GLOBECOM", 978-1-4244-2324-8/08/$25.00 © 2008 IEEE.

[3] Rekha Chakravarthi and Dr.C.Gomathy ," A Fuzzy Approach to Detect and Control Congestion in Wireless Sensor Networks", Indian Journal of Computer Science and Engineering (IJCSE), 3(3) ,pp. 476-483, 2012

[4] Haditabatabaee Malazi et al., "Fed: Fuzzy Event Detection Model for Wireless Sensor Networks", International Journal of Wireless & Mobile Networks (IJWMN), 6(3), pp 29-45, 2011

[5] HevinRajesh et al., "Fuzzy Based Secure Data Aggregation Technique in Wireless Sensor Networks", Journal of Computer Science 8 (6), pp. 899-907, 2012

[6] U. Natarajan and R. Saravanan (2001), "Artificial neural network (ANN) for adaptive control optimization (A.C.O) of turning process", proceedings of IPRoMM 2000 PCEA, Nagpur, pp 378-384,

[7] Chuan-Kang Ting et al., (2009), "Wireless Heterogenous Transmitter Placement Using Multi-objective Variable-Length Genetic Algorithm," IEEE Trans. on Systems, Man and Cybernetics, 39(4),pp 945-958.

[8] Won Jay Song et al., (2002), "Distributed power control using the simultaneous mutation of genetic algorithms in cellular radio systems," proc. of int'l conf. of IT: Coding and computing, South Korea, pp 361-364.

[9] G. G. Yen (2000), "Wavelet packet feature extraction for vibration monitoring," IEEE Trans. Ind. Electron., 47, pp 650–667.

[10] X. M. Gao et al., (1997), "Power prediction in mobile communication systems using an optimal neural-network structure," IEEE Trans. Neural Networks,8, pp 1446–1455.

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