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INTELLIGENT ENERGY COMPETENCY ROUTING SCHEME FOR WIRELESS SENSOR NETWORKS

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Abstract

Wireless sensor networks deal a dominant combination of scattered sensing, computing and communication which lend themselves to uncountable applications and, at the same time, offer many experiments due to their particularities, primarily the inflexible energy constraints to which sensing nodes are typically subjected. The distinguishing characters of sensor networks have a direct impact on the hardware design of the nodes at least four levels: energy source, processor, communication hardware, and sensors. Various hardware platforms have already been designed to test the many ideas produced by the research community and to implement applications to virtually all fields of science and technology. Saving energy is a very critical issue in wireless sensor networks since sensor nodes are classically energies by batteries with a limited capacity. Since the radio is the main cause of energy consumption in a sensor node, transmission/reception of data should be limited as much as possible. So in this research, we have used fuzzy logic techniques for routing in the wireless sensor network. The results obtained show that the method based on fuzzy logic reduces the consumption of energy.

Keywords: Wireless sensor networks, Fuzzy Logic, Energy and distance aware

1. Introduction

Wireless sensor networks (WSNs) are new generation of networks and therefore they encounter a number of challenges. These networks are employed in a range of applications such as collecting environmental information or reporting an event. The main difference between sensor networks with other networks lies in the fact that the former are data-centric and their energy and processing sources are extremely limited. Many authors [1][2][3][4][5][6][8] & [10] have presented papers in the area of WSNs. WSN consists of a large number of sensor nodes which are fragmented to collect information about environment. The main features of these networks are that it have not fixed structure, it is infrastructure less. So nodes present in this network

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coordinate to each other. For this cooperation and communication each sensor having specific range in orders to send the information to the destination and also need to locate neighbouring nodes and communicate them. Our aim is to use fuzzy logic system (FLS) for reducing the consumption of energy in WSNs.

2. Proposed Method

In this proposed method our main function has been to carry out routing in WSN network to enhance the life-time of the network and to broadcast information packages in the shortest possible time. Enhance network life is possible when the nodes have sufficient energy to carry on the process of routing in the network; and sending information in the shortest possible time can only be achieved by covering the shortest distance to the destination.

Sending information from one node to another node with shortest distance and sufficient energy are chosen by decision maker. This decision maker design by fuzzy implication. These sufficient energy and shortest distance are linguistic variables assuming multiple values. So the concept of fuzzy set theory [9] has been used. The state of the node determined by the ratio of energy and distance.

For instance: Let us consider a WSN in which there is a sensor range of D meter for transmission information packages and E joule nodes. Each value of input variables at the source node and output variables at the destination node are linguistic variables. These variables are defined in Table 1 and Table 3 and its associated membership function in Table 2 and Table 4.

Table 1 Linguistic variable of energy

Linguistic Values	Notation	Range
Very Low	E_{VL}	$[E_{VLa}, E_{VLb}]$
Low	E_L	$[E_{La}, E_{Lb}]$
Medium	E_M	$[E_{Ma}, E_{Mb}]$
High	E_H	$[E_{Ha}, E_{Hb}]$
Very High	E_{VH}	$[E_{VHa}, E_{VHb}]$

Table 2: Membership function for energy

	Very Low	Low	Medium	High	Very High
Energy(J)	E_{VLa}-E_{VLb}	E_{La}- E_{Lb}	E_{Ma}- E_{Mb}	E_{Ha}- E_{Hb}	E_{VHa}- E_{VHb}

Table 3: Linguistic variable of distance

Linguistic Values	Notation	Range
Very Short	D_{VS}	$[D_{VSa}, D_{VSb}]$
Short	D_S	$[D_{Sa}, D_{Sb}]$
Middle	D_M	$[D_{Ma}, D_{Mb}]$
Long	D_L	$[D_{La}, D_{Lb}]$
Very Long	D_{VL}	$[D_{VLa}, D_{VLb}]$

Table 4: Membership function for distance

	Very Short	Short	Middle	Long	Very Long
Distance(M)	D_{VSa}- D_{VSb}	D_{Sa}- D_{Sb}	D_{Ma}- D_{Mb}	D_{La}- D_{Lb}	D_{VLa}- D_{VLb}

Let 'S' is the set of states as $S=\{S_{ij}$; i=energy, j=distance}, where i=1,2,3,4,5 stands for Very Low , Low, Medium, High, Very High and j=1,2,3,4,5 stands for Very Short, Short, Middle, Long, Very Long. S_{ij} is defined as the ratio of E_i and D_j by using formula Sij=Energy i/Distance j. For comparing priority of different state within WSN value is calculated by using formula V_{ij}=average of E_i/average of D_j. Each V_{ij} is a linguistic variable having different values which determine the value of different routes of WSN [7].

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Using D (Distance) =300 meter, E (Energy)=30 joule, D_{VSa}=0, D_{VSb}=100, D_{Sa}=50, D_{Sb}=150, D_{Ma}=100, D_{Mb}=200, D_{La}=150, D_{Lb}=250, D_{VLa}=200, D_{VLb}=300 and E_{VLa}=0, E_{VLb}=10, E_{La}=5, E_{Lb}=15, E_{Ma}=10, E_{Mb}=20, E_{Ha}=15, E_{Hb}=25, E_{VHa}=20, E_{VHb}=30

Table 5: State of each route

Sl. No.	Formula	State
1	E_{VL} / D_{VS}	0.1
2	E_{VL} / D_{S}	0.068965517
3	E_{VL} / D_{M}	0.1
4	E_{VL} / D_{L}	0.1
5	E_{VL} / D_{VL}	0.1
6	E_{L} / D_{VS}	0.1
7	E_{L} / D_{S}	0.068965517
8	E_{L} / D_{M}	0.1
9	E_{L} / D_{L}	0.1
10	E_{L} / D_{VL}	0.1
11	E_{M} / D_{VS}	0.1
12	E_{M} / D_{S}	0.068965517
13	E_{M} / D_{M}	0.1
14	E_{M} / D_{L}	0.1
15	E_{M} / D_{VL}	0.1
16	E_{H} / D_{VS}	0.1
17	E_{H} / D_{S}	0.068965517
18	E_{H} / D_{M}	0.1
19	E_{H} / D_{L}	0.1
20	E_{H} / D_{VL}	0.1
21	E_{VH} / D_{VS}	0.1
22	E_{VH} / D_{S}	0.068965517
23	E_{VH} / D_{M}	0.1
24	E_{VH} / D_{L}	0.1
25	E_{VH} / D_{VL}	0.1

Form the above table the least values of state is 0.068965517 and the greatest value is 0.1. Therefore states can be categorized as

Table 6: The category of states

Sl. No.	Category name	Category elements
1	C_1	$S_{11}, S_{13}, S_{14}, S_{15}, S_{21}, S_{23}, S_{24}, S_{25}, S_{31}, S_{33}, S_{34}, S_{35}, S_{41}, S_{43}, S_{44}, S_{45}, S_{51}, S_{53}, S_{54}, S_{55}$
2	C_2	$S_{12}, S_{22}, S_{32}, S_{42}, S_{52},$

From Table 5. slno. 1 indicates very low energy and the very short distance to destination, slno.5 indicates very low energy and the very long distance to the destination & slno. 21 indicate very high energy and the very short distance to the destination. Thus in WSN slno. 21 is the best choice for the energy competency routing scheme. And slno. 5 is the worst choice for the purpose. For comparing priority of 25 states within WSN value is calculated by using formula

$$V_{prioritiy}=(\text{mean of energy})/(\text{means of the distance})$$

Thus we find

Table 7: The value of different states

Sl. No.	Value name	Values priority
1	V_{11}	0.1
2	V_{12}	0.064516129

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3	V_{13}	0.033333333
4	V_{14}	0.025
5	V_{15}	0.02
6	V_{21}	0.2
7	V_{22}	0.129032258
8	V_{23}	0.066666667
9	V_{24}	0.05
10	V_{25}	0.04
11	V_{31}	0.3
12	V_{32}	0.193548387
13	V_{33}	0.1
14	V_{34}	0.075
15	V_{35}	0.06
16	V_{41}	0.4
17	V_{42}	0.258064516
18	V_{43}	0.133333333
19	V_{44}	0.1
20	V_{45}	0.08
21	V_{51}	0.5
22	V_{52}	0.322580645
23	V_{53}	0.166666667
24	V_{54}	0.125
25	V_{55}	0.1

Values in descending order

$V_{51} > V_{41} > V_{52} > V_{31} > V_{42} > V_{21} > V_{32} > V_{53} > V_{43} > V_{22} > V_{54} > (V_{11}$ or V_{33} or V_{44} or $V_{55}) > V_{45} > V_{34} > V_{23} > V_{12} > V_{35} > V_{24} > V_{25} > V_{13} > V_{14} > V_{15}$

Table 8: Linguistic variables for values

Sl. No.	Linguistic variable	Value
1	Very Bad	V_{VB}
2	Very Bad to Bad	V_{VB-B}
3	Bad	V_{B}
4	Very Poor	V_{VP}
5	Very Poor to Poor	V_{VP-P}
6	Poor	V_{P}
7	Less Satisfactory	V_{LS}
8	Satisfactory	V_{S}
9	High Satisfactory	V_{HS}
10	Medium Low	V_{ML}
11	Medium	V_{M}
12	Medium High	V_{MH}
13	Less Good	V_{LG}
14	Less Good to Good	V_{LG-G}
15	Good	V_{G}
16	Good to Very Good	V_{G-VG}
17	Very Good	V_{VG}
18	Less Excellent	V_{LE}
19	Less Excellent to Excellent	V_{LE-E}
20	Excellent	V_{E}
21	Very Excellent	V_{VE}
22	Too Very Excellent	V_{TVE}

Fuzzy implication of different route

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1. IF (E is E_{VL} AND D is D_{VL}) THEN V is V_{VB}
2. IF (E is E_{VL} AND D is D_{L}) THEN V is V_{VB-B}
3. IF (E is E_{VL} AND D is D_{M}) THEN V is V_{B}
4. IF (E is E_{L} AND D is D_{VL}) THEN V is V_{VP}
5. IF (E is E_{L} AND D is D_{L}) THEN V is V_{VP-P}

6. IF (E is E_{M} AND D is D_{VL}) THEN V is V_{P}
7. IF (E is E_{VL} AND D is D_{S}) THEN V is V_{LS}
8. IF (E is E_{L} AND D is D_{M}) THEN V is V_{S}
9. IF (E is E_{M} AND Distance is D_{L}) THEN V is V_{HS}
10. IF (E is E_{H} AND D is D_{VL}) THEN V is V_{ML}
11. IF ((E is E_{VL} OR E is E_{M} OR E is E_{H} OR E is E_{VH}) AND (D is D_{VS} OR D is D_{M} OR D is D_{L} OR D is D_{VL})) THEN V is V_{M}
12. IF (E is E_{VH} AND D is D_{L}) THEN V is V_{MH}
13. IF (E is E_{L} AND D is D_{S}) THEN V is V_{LG}
14. IF (E is E_{H} AND D is D_{M}) THEN V is V_{LG-G}
15. IF (E is E_{VH} AND D is D_{M}) THEN V is V_{G}
16. IF (E is E_{M} AND D is D_{S}) THEN V is V_{G-VG}
17. IF (E is E_{L} AND D is D_{VS}) THEN V is V_{VG}
18. IF (E is E_{H} AND D is D_{S}) THEN V is V_{LE}
19. IF (E is E_{M} AND D is D_{VS}) THEN V is V_{LE-E}
20. IF (E is E_{VH} AND D is D_{S}) THEN V is V_{E}
21. IF (E is E_{H} AND D is D_{VS}) THEN V is V_{VE}
22. IF (E is E_{VH} AND D is D_{VS}) THEN V is V_{TVE}

Table 9: Fuzzy matrix for different route

Energy/Distance	D_{VS}	D_{S}	D_{M}	D_{L}	D_{VL}
E_{VL}	V_{M}	V_{LS}	V_{B}	V_{VB-B}	**V_{VB}**
E_{L}	V_{VG}	V_{LG}	V_{S}	V_{VP-P}	V_{VP}
E_{M}	V_{LE-E}	V_{G-VG}	V_{M}	V_{HS}	V_{P}
E_{H}	V_{VE}	V_{LE}	V_{LG-G}	V_{M}	V_{ML}
E_{VH}	**V_{TVE}**	V_{E}	V_{G}	V_{MH}	V_{M}

Thus, each route has a specific value in the WSN. In routing between networks, we go from one state to another and going to a more suitable value must enjoy a greater value. These rules are implemented by using FLS. The states of the two senders and receiver nodes are taken as the input of the FLS and the value is considered as the output. Implication 1 states that if the source node (sender) is in route 5 (that is, it has the very lowest energy and is very long away from the destination), it will receive the lowest value that is V15 means value is very bad (VVB at 0.02). And implication 22 states that if the source node (sender) is in route 21 (that is, a node with the very highest energy and very shortest distance to the destination), it will receive the highest value that is V51 means value is too very excellent (VTVE at 0.5). Figures 1 show the value of each 22 different route.

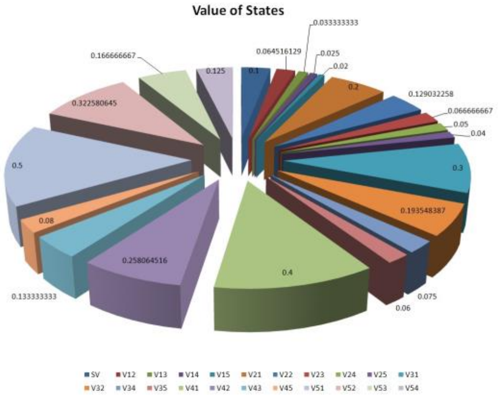

Figure 1: Value of different route

3. Conclusion

WSNs are a widely applicable, major emerging technology. They bring a whole host of novel research challenges pertaining to energy proficiency, robustness, scalability, self-configuration, etc. These challenges must be tackled at multiple levels through different protocols and mechanisms. The real world requires real-time routing protocol in wireless sensor networks to achieve real-time communication besides the energy competency. In this paper, we proposed a fuzzy logic-based energy competency routing scheme for WSN. Both distance and energy are chosen parameters for the FLS, to determine the possible value for each route.

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A Brief Author Biography

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3rd A. P. Burnwal obtained his MSc and Ph.D. degrees in mathematics. He is life member in different society like "Indian Science of Congress Association" Kolkata, "Bharata Ganita Prarisad" Lucknow, "International Society for Ecological Communications" S. K. University, "Society for Sciences", "Society of Environment Sciences", "The Indian Society for Technical Education". He has 35 international/national journals/conferences to his credit. And currently he is Professor in MCA Department of GGSESTC, Kandra, Chas, Bokaro, Jharkhand, INDIA.