FUZZY BASED OPTIMAL SLEEP CONTROL STRATEGY IN WIRELESS SENSOR NETWORKS FOR DELAY SENSITIVE AND INSENSITIVE SCENARIO

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Abstract—

Wireless sensor network is a resource constrained network widely used in various applications where human intervention is not possible. Wireless sensor network works with a battery as the energy source and hence it is not possible to replace or recharge frequently. For enhancing the network lifetime, an energy efficient technique is desirable. For optimizing the power consumption in wireless sensor networks, the paper deals with an approach of using artificial intelligence tool. Fuzzy logic is used here for the decision making tool. The aim of this paper is to optimize sleep time for the nodes of sensor network by proposed new fuzzy based sleep scheduling scheme. A fuzzy rule table is constructed To evaluate the sleep time taking prediction of next inter arrival time of frame and wake up time in to account a fuzzy rule table is constructed. The proposed method offer effective sleep scheduling than conventional sleep scheduling methods.

Keywords- Fuzzy logic, Inter arrival time, wireless sensor network, sleep scheduling.

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I. INTRODUCTION

The important applications of wireless sensor network are towards monitoring applications for sensing and data gathering. The application of sensor is made to monitor the environment or system by measuring physical parameters such as temperature, pressure, humidity etc. Some of the applications are for constant monitoring & detection of specific events, military, battlefield surveillance, forest fire & flood detection, habitat exploration of animals, Patient monitoring, home appliances etc. Without the help of an external infrastructure, in the wireless sensor network, the devices communicate with other devices in an adhoc way. Random deployment, infrastructure-less networks, distributed routing, energy constraint, network lifetime, sensor hardware energy efficiency, distributed synchronization, maintenance recovery, Real-time communication, QoS and Security are some of the design issues of the wireless sensor networks. The sensors are batteries operated device and hence, is impractical to replace in certain environment led to the development of low power sensor platform or motes.

Wireless Sensor Network (WSN) is a collaborative network comprises of spatially deployed sensor nodes which transmit the environmental parameters after sensing them. Over the last decade, it has attracted many researchers with different network architectures and strategies due to its infra structure less feature.

In the design of a WSN many parameters are considered like sensing range, transmission range, node density etc and this makes the designing aspect very challenging. To achieve this, it is critical to capture the impacts of network parameters on network performance with respect to application specifications. Since a distributed network has multiple nodes and services, each node is a shared resource and has to make many decisions. When there exist multiple paths from source to destination, on the other hand, routing strategy is also major concern. Two parameters namely throughput and average packet delivery ratio affects the routing scheme. But the techniques for its improvement are based on hard decision making.

Fuzzy logic is a many valued logic which deals with approximated reasoning instead of hard reasoning. Here the numeric data is expressed in terms of linguistic variables whose values provide a mean of systematic manipulation of imprecise concepts. Fuzzy logic comprises of four stages namely, as fuzzifier, fuzzy inference machine, rule base and defuzzifier. Zadeh first introduced the concept of fuzzy sets [5] through the efforts of many researchers; it is extended to be a theory of fuzzy logic. The degree of truth: truth values range from "completely true" to "completely false are handled by fuzzy logic and thereby provides a better medium to explain linguistic implicit information than traditional two-valued Boolean logic. To make a controlling decision fuzzy control systems will be use as the concept of fuzzy logic. To find precise solutions, the decision making in fuzzy logic is based on if-then rules and the associated inference engine. The decision making in fuzzy logic is based on following steps:

1. Define the input and output variables.
2. Classify these variables into a number of fuzzy sets. Each fuzzy set has a linguistic label.
3. Assignment for each fuzzy set with its corresponding membership function.
4. Building the rule-based inference engine on the basis of fuzzy variable and their membership functions.
5. Fuzzification of the inputs.
6. Generation of fuzzy outputs on the basis of rule base.
7. Integrate these outputs.
8. Defuzzify the output to obtain a crisp decision.

In this paper we seek to address a more general and harder version of this problem, i.e. to decide a schedule activity of sensor nodes so as to improve the sleep latency and power consumption. This has attracted so many researchers over the last decade. But in the MAC protocols the approach from many researchers was based on hard decision making . To improve the performance we have proposed a new fuzzy logic based soft decision making strategy.

The paper is organized as follows: section II describes the proposed scheme based on fuzzy logic controller. Section III describes the simulation results and analysis, while section IV concludes the paper.

II. PROPOSED SCHEME

A. *System Parameters*

To design the whole system some input and output parameters are required which are as follow:

1) *Inter arrival time*: The frames are generated at the OLT intended for node follows a Poisson distribution. Thus the associated inter-arrival times will follow an exponential distribution. Generation of frames is random distribution of time.

First step is to evaluate Current distribution of inter-arrival times. This is accomplished by means of an arithmetic average computed on *n* samples [5]:

$$average(k) = \frac{\sum_{j=0}^{n-1} iat(k-j, k \geq n-1)}{n} \qquad (2)$$

The second step is the actual estimation of the next inter-arrival time. This is accomplished by means of an exponentially smoothed average (ESA). The general expression for an exponentially smoothed average is:

$$ESA(t) = c.Y(t-1) + (1-c).ESA(t-1), t > 0$$

$else$

$$ESA(0) = 0 \qquad (3)$$

Where *t* is a discrete variable indicating discrete time samples, *c* is a coefficient representing the degree of weighting decrease, with a value between 0 and 1 and *Y(t-1)* is the observation at time *t-1*.

2) *Traffic load*: In this paper we consider delay sensitive as well as delay in sensitive traffic case to calculate sleep time. Threshold of this condition is depends on ESA and wake up time.

3) *Sleep Time*: It is defined as time (in ms) for which node trans-receiver is off.

C. *Methodology*

Fuzzy logic is used to calculate overall sleep time using inter arrival time and wake up time.

1. Calculate inter arrival time of current frame distribution using average formula (2)
2. Prediction of inter arrival time (*iat*) of frames is calculated by ESA formula (3).
3. Set wakeup time duration of node in between 0 to 12 ms.
4. Calculate sleep time for each node using fuzzy logic. Fuzzy is used because it gives best result even when input is random.

D. *Algorithm*

Input: Two input parameter is used for fuzzification i.e. prediction of inter arrival time and wakeup time.

Output: Sleep time and power based on fuzzy decisions.

Decide the *Sleep Time* on the following conditions of fuzzy.

if((iat==Short)&&(*Wakeup Time*==Short)

Sleep Time=Poor

else if((iat==Medium)&&(*Wakeup Time*==Medium))

Sleep Time= Good

else if((iat==Large)&&(*Wakeup Time*==Large))

Sleep Time=Excellent

The intermediate value between absolute true and absolute false is included in fuzzy logic which is basically the extension of crisp logic. It improves the accuracy in taking a decision about a system that has vague information. when mathematical models fail to describe the system it has the efficiencey to solve the system uncertainty.

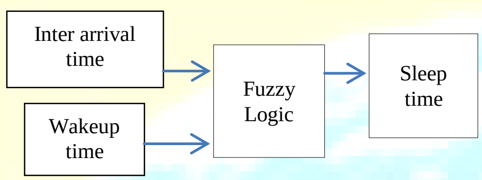

Figure 1. Generation of sleep time using Fuzzy Logic

III. Simulation Results and Analysis

The parameters taken for the simulation study of proposed scheme are given in the table below.

S.NO	PARAMETER	VALUE
1	No. of Frames	100
2	Wake up time	0 – 12ms
3	Active power(P active)	10 W
4	Sleep power (p sleep)	2 W
5	Tolerance	10 ms
6	No. of nodes	37

Table 1. Simulation parameters

The simulation is average of this is analysis and performed 10 times. Sleep time on the basis of inter arrival time for every node is approximated in the conventional technique. However estimation of sleep time for the inter arrival time along with power is used in our proposed technique. The effectiveness of the proposed scheme over conventional scheme is shown in the figures below. The comparison is also shown in Table 2.The previous technique for sleep time calculation without fuzzy (delay Insensitive) represents in Fig.4, which is based on inter arrival time and the proposed technique is represent in Fig. 5,which is based on fuzzy sleep time.

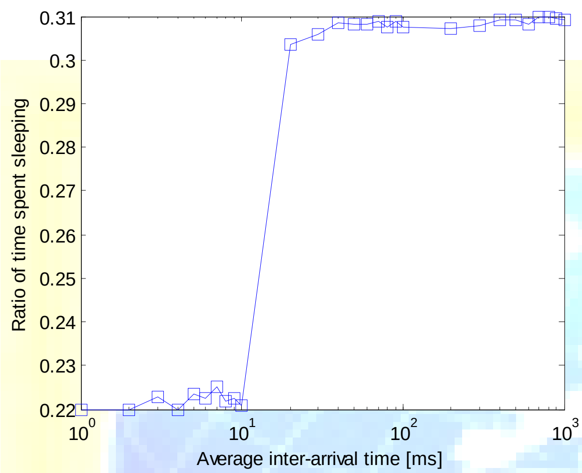

Figure 2. Sleep time calculation without fuzzy (Delay Sensitive)

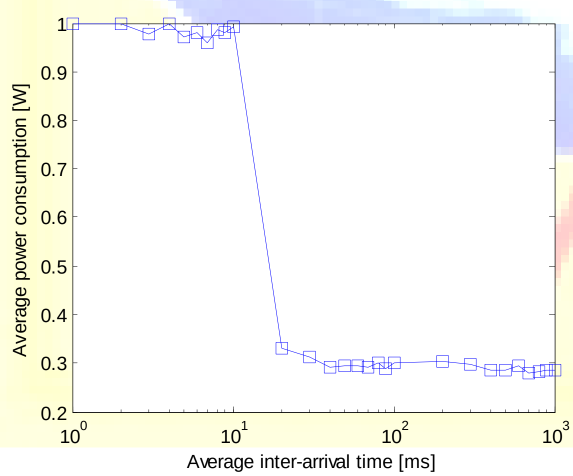

Figure 3. Power calculations without fuzzy (Delay Sensitive)

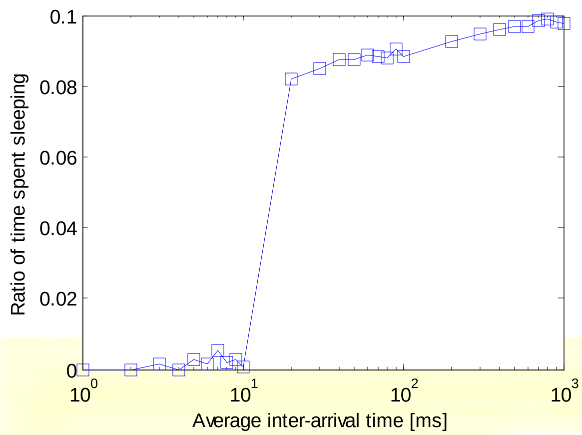

Figure 4. Sleep time calculation without fuzzy (Delay Insensitive)

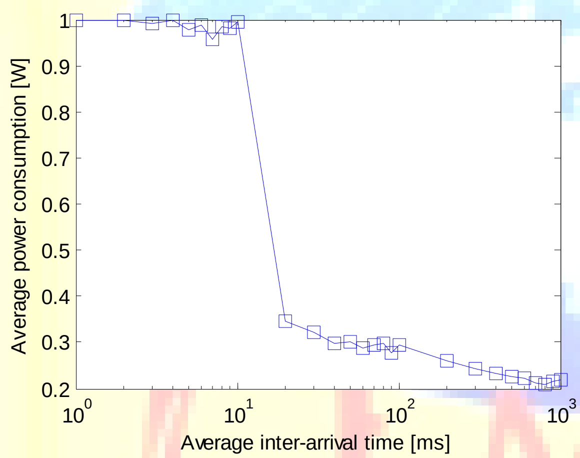

Figure 5. Power calculations without fuzzy (Delay Insensitive)

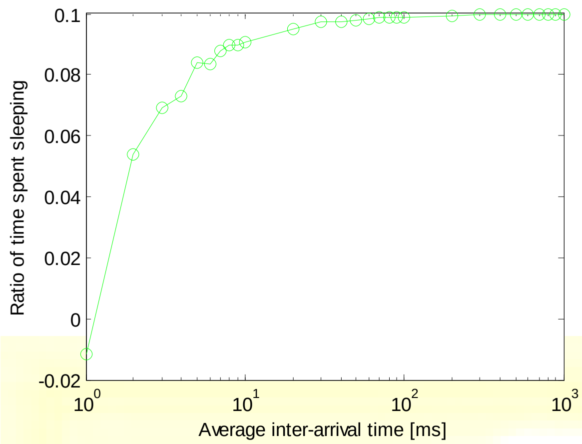

Figure 6. Sleep time calculation with fuzzy (Delay Sensitive)

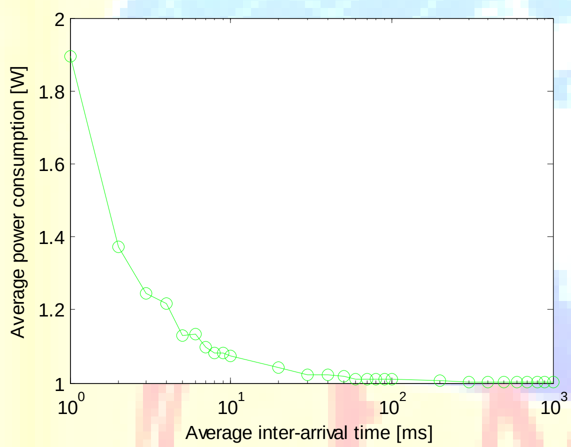

Figure 7. Power calculations with fuzzy (Delay Sensitive)

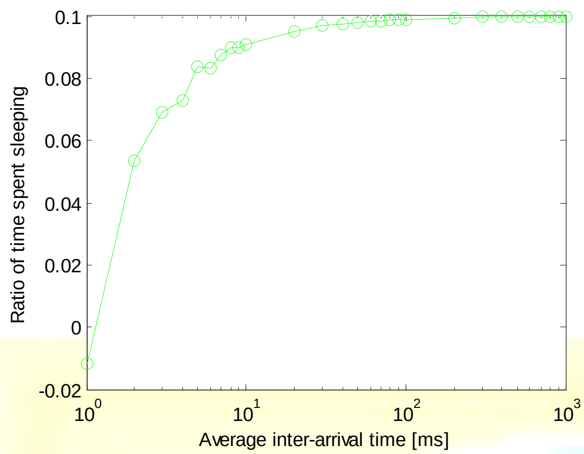

Figure 8. Sleep time calculation with fuzzy (Delay Insensitive)

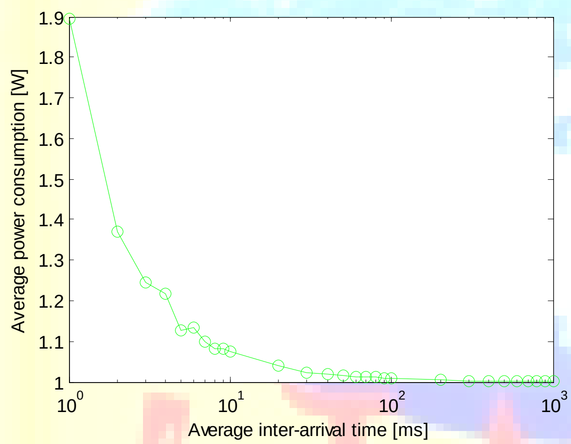

Figure 9. Power calculations with fuzzy (Delay Insensitive)

We observe that sleep time calculation in previous method.

The sleep time increases linearly with respect to average inter arrival time as shows in fig.4 Using exponential distribution even inter arrival time is calculated for frames. On the other hand in our fuzzy based sleep time calculation, the sleep time increases exponentially with respect to average inter arrival time as shown in fig.5. Both the techniques are comparable on different parameter using below table:

S.no	Average inter arrival time in ms	Sleep ratio	Nodes in Sleeping	Sleep ratio	Nodes in Sleeping
		Conventional technique		Proposed technique	
1	1-10	0.00-0.01	10	0.00-0.08	5
2	10-100	0.08-0.09	9	0.09-0.10	11
3	100-1000	0.09	18	0.10	21

Table 2. Comparison of techniques for delay sensitive case

S.No	Average Inter Arrival Time In Ms	Sleep Ratio	Nodes In Sleeping	Sleep Ratio	Nodes In Sleeping
		Conventional technique		Proposed fuzzy based technique	
1	1-10	0.00-0.01	10	0.00-0.08	7
2	10-100	0.08-0.09	9	0.85-0.95	8
3	100-1000	0.09-0.10	18	0.95-0.10	22

Table 3. Comparison of techniques for delay insensitive case

IV. Conclusion

This paper has proposed fuzzy based sleep scheduling for energy saving in WSN. The estimation of sleep time in this work is carried out taking interarrival and residual power in account. Sleep time is calculated using fuzzy tool box and ESA. Proposed method enhances the sleep time from the previous prediction technique of next inter arrival time. The level of sleep time is raised by 10% from the previous one as shown from figures.

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