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Quality of service management for intelligent systems

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Abstract

A control application requirements currently used is very low, such as packet loss rate, minimum delay on sensor networks with quality of service (QoS) requirements some packet delivery guarantee. This paper is the sampling period at the end of the actuator and sensor data transfer related to the Miss ratio for each source sensor node, use the controller and the internal ANFIS. The proposed scheme has the advantages of simplicity, scalability, and General. Simulation results of the proposed scheme can provide QoS support in WSANs.

Keywords: *Quality of Service (QoS), adaptive neuro-fuzzy inference system(ANFIS), wireless sensor/actuator network(WSAN)*

1. Introduction

Wireless sensor networks (WSN) in the last 10 years in various applications is growing at a rapid pace. Ngai et al, such as event detection, reporting, and WSANs actuator adjustment [3] to support the proposed framework for real-time communication. Trustworthiness issue in WSANs has been discussed in [2]. However, the QoS management issue has not been addressed in any of these works in terms of deadline miss ratio and/or network utilization. Another area closely related to our work is an application of intelligent logic control to resource management in real-time computing and communication systems. In the literature, the use of control based methods for resource management is also called feedback scheduling [1][5][6]. In practice, the QoS requirements differ from one application to another; however, they can be specified in terms of reliability, timeliness, robustness, trustworthiness, and adaptability, among others. Some QoS metrics may be used to measure the degree of satisfaction of these services.

This study deals with QoS management in WSANs. An adaptive neuro-fuzzy inference system (ANFIS) control based QoS management scheme will be developed to facilitate QoS support in resource-constrained WSANs operating in dynamic and unpredictable environments. This approach is by no means an almighty solution to all of the above challenges; it is to explicitly address the impact of unpredictable variations in traffic load on the QoS of WSANs. An ANFIS controller is designed to dynamically adjust the sampling period of relevant sensor in a way that the deadline miss ratio is kept at a desired level. Taking advantage of the feedback control technology, the ANFIS control can provide QoS guarantees while achieving predictable

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application performance. This solution is generic, scalable, and easy to implement. It can simultaneously address multiple QoS problems such as delay, packet loss, and network utilization. Simulation results with Matlab/Simulink-based simulator TrueTime will be given to demonstrate the effectiveness of the proposed scheme.

2. ANFIS control based QoS management

The basic idea of the ANFIS control is to adapt the sampling period of each source sensor at run time such that the deadline miss ratio associated with the real-time data transmission from the source node to the actuator is maintained at a pre-determined desired level. Practically, both a delay larger than the deadline and a loss of packet can be regarded as deadline misses. When the sampling periods of sensors decrease, the traffic load on the network will increase. As a result, the probability of node collisions increases, leading to potential increases in both delay and packet loss rate. Therefore, increasing sampling periods can normally reduce deadline misses [4].

However, too large sampling periods will adversely cause low utilization of the network bandwidth resource. In some applications such as sampled-data control [5], smaller sampling periods may be preferable because the system performance will degrade with increasing sampling periods.

For these reasons, this study suggests to control the deadline miss ratio at a non-zero level. This can achieve high utilization of network resource while limiting the magnitudes of delay and packet loss rate within an acceptable range. In the ANFIS control scheme, a separate QoS manager will be designed for each source sensor node to adjust its sampling period with respect to the deadline miss ratio associated with the transmission of its measurements to the actuator (see Fig. 1).

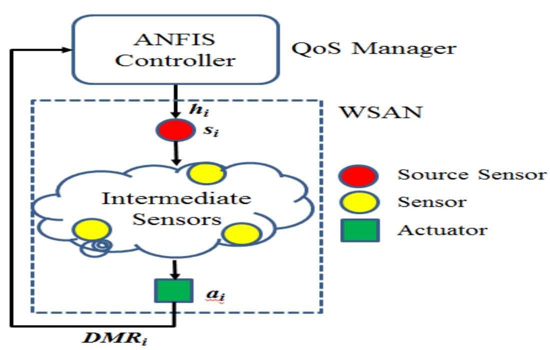

Fig. 1. Topology of a WSAN

The QoS of a WSAN can be affected by many factors. In the case of node movement, node removal or addition, or system update or reconfiguration, it is most likely that the network topology, routing, and node traffic load will change. This can then result in variations in network QoS attributes such as transmission delay, packet loss rate, and utilization. In some situations, the QoS of WSANs may become unsatisfactory when delay and/or packet loss rate are too large. Therefore, QoS management paradigms are needed to enhance the flexibility and adaptability of WSANs with respect to the changing network conditions.

3. Takagi-Sugeno fuzzy model

The role of the ANFIS controller is to determine the sampling period based on current deadline miss ratio and its set point. There are two inputs, the deadline miss ratio control error $e(k)$ and the change in error $de(k) = e(k) - e(k\text{-}1)$. Let DMR be the desired deadline miss ratio, then $e(k) = DMRR – DMR(k)$. The output of the fuzzy logic controller is the change in sampling period $dh(k) = h(k+1) – h(k)$. Consider a first-order Sugeno fuzzy inference system which contains two rules:

Rule 1: If e is A_1 and de is B_1, then $f_1 = p_1x + q_1y + r_1$,

Rule 2: If e is A_2 and de is B_2, then $f_2 = p_2x + q_2y + r_2$.

To facilitate the learning of the Sugeno fuzzy model, it is convenient to put the fuzzy model into framework of adaptive networks that can compute gradient vectors systematically. In conventional neural networks, the back-propagation algorithm is used to learn, or adjust weights on connecting arrows between neurons from input-output training samples. In the ANFIS structure, the parameters of the premises and consequents play the role of weights. Specifically, the shape of membership functions in the "If" part of the rules is determined by a finite number of parameters. These parameters are called premise parameters, whereas the parameters in the "Then" part of the rules are referred to as consequent parameters. The ANFIS learning algorithm consists of adjusting the above set of parameters. For ANFIS, a mixture of back-propagation and least square estimation (LSE) is used. Back-propagation is used to learn the premise parameters, and LSE is used to determine the parameters in the rules' consequents.

4. Simulation

Simulations are conducted in this section to compare the performances of the proposed ANFIS scheme and simple fuzzy logic scheme [7]. Consider a simple yet illustrative WSAN as shown in Figure 1, where s_1, s_2, s_3, and s_4 are source sensor nodes, s_5 is an interfering source node, s_6 is an intermediate node, a_1 and a_2 are actuator nodes. These nodes reside in one collision area, that is, they have to compete for the use of the same wireless channel for data transmission. It is noteworthy that the sampling period of s_5 cannot be adjusted at runtime. The utilized communication protocol is ZigBee with a data rate of 250 kbps. All data packets transmitted over the network are 45 bytes in size, which may correspond to a payload of 32 bytes and an overhead of 13 bytes. The default sampling period for each source node is 10 ms, DMR_R = 10%, and T_{FLC} = 1s. The deadline of a data packet is assumed to be equal to current sampling period of the relevant source node.

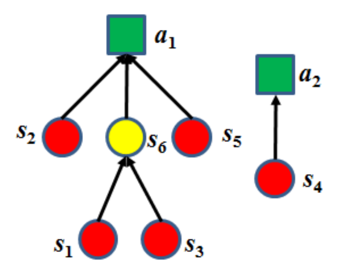

Figure 1. Simulated WSAN system

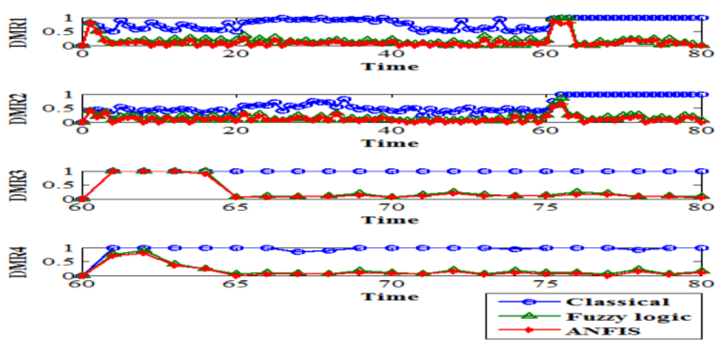

Figure 2. Deadline miss ratios

Figure 2 shows the deadline miss ratios corresponding to the four source nodes. With the classical design scheme, all of the deadline miss ratios are relatively high throughout the simulation. The deadline miss ratios change dramatically as the traffic over the network changes. When the interfering traffic is introduced, i.e. from t = 20s to 40s, both of the deadline miss ratios associated with s_1 and s_2 increase; particularly, the deadline miss ratio for s_1 reaches nearly 100% during this term. When s_3 and s_4 become active (after t = 60s), almost all messages sent by the four source nodes miss their deadlines. Further, it is found that under the same network condition the transmission from s_1 to a_1 may encounter severer deadline miss than that from s_2 to a_1. For instance, the average deadline miss ratios for s_1 and s_2 in time interval [0, 20]s are 66.3% and 38.1%, respectively. The reason behind is that the former experiences more hops than the latter. The average deadline miss ratio throughout the simulation is 80.7%, 57.9%, 100%, and 98.5%, respectively, for each source node.

5. Conclusion

The fuzzy handoff algorithm is not optimized and required constant attention from the human experts. ANFIS is an architecture which is functionally equivalent to a Sugeno type fuzzy rule base. Under certain minor constraints the ANFIS architecture is also equivalent to a radial basis function network. ANFIS is a method for tuning an existing rule base with a learning algorithm based on a collection of training data. In this paper, an ANFIS control based QoS management approach has been proposed for WSANs..

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