RESEARCH ARTICLE OPEN ACCESS

Error Control in Wireless Sensor Networks: A Process Control Perspective

Reena R.[1]
1(Lecturer in Electronics, MVGM Govt. Polytechnic College, Vennikulam, Pathanamthitta, Kerala.)

Abstract:

The use of wireless technology in the process industry is becoming increasingly important to obtain fast deployment at low cost. However, poor channel quality often leads to retransmissions, which are governed by Automatic Repeat Request (ARQ) schemes. While ARQ is a simple and useful tool to alleviate packet errors, it has considerable disadvantages: retransmissions lead to an increase in energy expenditure and latency. The use of Forward Error Correction (FEC) however offers several advantages. We consider a Hybrid-ARQ-Adaptive-FEC scheme (HAF) based on BCH codes and Channel State Information. This scheme is evaluated on AWGN and fading channels. It is shown that HAF offers significantly improved performance both in terms of energy efficiency and latency, as compared to ARQ.

***Keywords* — Wireless, Networks, error control scheme (ECS), wireless sensor network (WSN), Process Control, ARQ.**

INTRODUCTION:

Wireless sensor networks (WSNs) are defined by the collaborative transmission of information from multiple sensor nodes observing a physical phenomenon. Due to the severe energy constraints of battery-powered sensor nodes, energy-efficient communication protocols are required to meet application objectives.

Furthermore, the sensor nodes' low power communication constraints exacerbate the effects of the wireless channel, resulting in error-prone links. Correlation between sensors in WSNs can be used for aggregation, collaborative source coding, or correlation-based protocols.

Because these techniques aim to reduce traffic redundancy, the reliability of the filtered packets is critical for energy efficiency. As a result, energy-efficient error control is critical. Furthermore, due to the strict energy consumption requirements, the multi-hop structure of WSNs, and the broadcast nature of the wireless channel, a cross-layer investigation of the effects of error control schemes is required. [1]

Application of WSNS:

Sensors capable of observing various physical phenomena have been successfully designed. The proliferation of Micro-Electro-Mechanical Systems (MEMS) technology has enabled the development of smart sensors. Sensors can now be used to observe not only ambient conditions such as temperature, pressure flow, and so on, but also a variety of other phenomena.

They can sense their surroundings, take measurements, and wirelessly transmit data to a control unit for further processing and decision making. Many applications for WSNs exist, including habitat monitoring, intrusion detection and target tracking and surveillance, oceanography, environmental monitoring, structural health monitoring, infrastructure monitoring, precision agriculture, biomedical health monitoring, hazardous environment exploration, and seismic sensing. Sensors have been thought to be extremely useful in monitoring patients' health. Wearable sensors have gained popularity and applications in elderly care, emergency response, athletic performance research, gait analysis, and activity classification. WSN have been used in shipboard systems as well as road traffic control.

WSN deployment is common for monitoring infrastructure such as bridges, dams, buildings, and pipelines, and can provide early warnings of damage to these structures. Such early warnings aid in minimising property and human life loss. [2-3]

Wireless Sensor Networks:

Figure 1 depicts the general arrangement of sensors in a WSN. The successful implementation of a WSN thus necessitates careful planning and design. WSN deployment necessitates familiarity with communication and signal processing, hardware technologies, embedded system design, and software engineering.

These technologies are vastly different, necessitating a thorough examination of the impact of one factor on the design of others. We present a brief overview of the factors influencing the design and performance of WSNs [4-5].

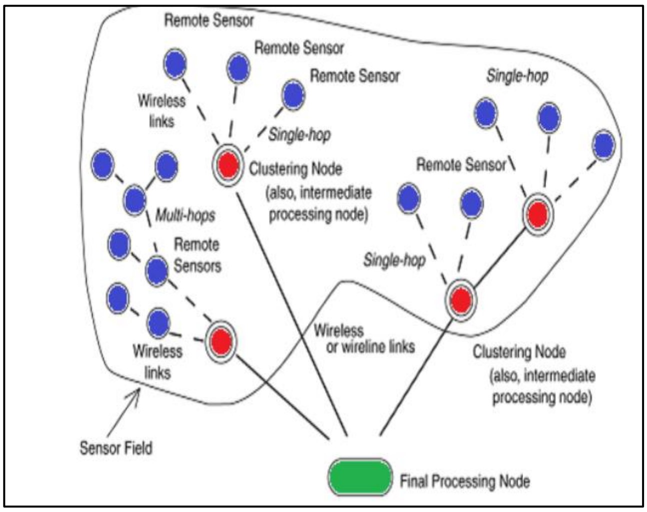

Figure 1: Typical Sensor Network

Sensor nodes are typically deployed in an irregular topology and are densely populated, as illustrated in the diagram (Figure 1). Remote sensors (also known as Motes) detect the phenomenon, pre-process it by converting the sensed quantity into data, and then transmit it. Finally, the observed phenomenon is processed at a central location with sufficient processing capabilities known as a Base Station (BS).

Data transmission from motes to the base station necessitates the establishment of a path. This path is typically multi-hop in nature. Depending on the routing algorithm, the path may employ one of the sensor nodes as the cluster's head and transmit data along the path. However, due to the reasons discussed in the following sections, determining the path from sensor to base station is difficult. [6]

OBJECTIVES:

1. To efficiently disseminate observations gathered by individual sensor nodes to all the sensor nodes in the network.
2. A summary of adaptive ECS for WSN
3. Illustrates the spread of the energy consumption.
4. Define the components of a wireless sensor node

REVIEW OF LITERATURE:

The coding and decoding processes also incur additional costs. These costs, particularly the decoding costs, are mentioned in (Vuran & Akyildiz, 2009) in connection with SA-1100 processor measurements.

Instead, (Björnemo E., 2009) assumes that "the processing energy consumption for coding and decoding is negligible in relation to other processing costs" when using a low-power processor such as the MSP430. The findings of support this (Howard, Schlegel, & Iniewski, 2006).

A FEC or HARQ-based error control design will have the advantage of being able to correct a certain number of errors in a packet. In essence, the benefit is a lower packet error rate (PER) when compared to ARQ, but at a higher cost. [7-9]

Pardeep Kumar et al. investigated WMSNs and the security requirements for these networks. The main concerns for healthcare applications are reliable data transmission, fast event detection, timely data delivery, power management, node computation and middleware, patient security and privacy.

An individual's physiological data is extremely vulnerable. Because the sensors in WMSNs are wireless, the network can be easily eavesdropped on using common devices such as smart phones, iPhones, PDAs, and laptops. [10]

Subhagya et al. propose the use of LT code for image transmission in a wireless multimedia sensor network. The paper compares peak SNR and structural similarity index metrics for RS and LT codes in the context of a binary erasure channel with varying erasure probability.

The MatLab simulation results show that LT codes perform significantly better than RS codes. However, there is a lack of clarity regarding the code rate of those codes as well as energy efficiency comparisons between these codes. [11]

RESEARCH METHODOLOGY:

In this work, we evaluate the adaptive ECS for WSN Model, Hybrid-ARQ- Adaptive-FEC and ECSs present to support different reliability, delay constrained, channel types, distance between nodes and data rate in the WSN communication.

The implementation on general processors may be inefficient due to the limitation of the compiler and other factors. All the comparison is based on the assumption of the same error control performance which is evaluated by the WSN.

RESULT AND DISCUSSION:

Table 1 summarises adaptive ECS for WSN. A more realistic network model is a modified multi-hop WSN model.

However, there has been very little research on the design and energy analysis of ECS on this model. To cover a realistic network situation, researchers must focus on the design and energy analysis of adaptive ECSs on a modified multi-hop WSN model. The cost of extra energy consumption due to adaptive techniques should be considered by researchers and incorporated into energy analysis.

Table 1: A summary of adaptive ECS for WSN

ECS(s) and Adaptive Parameter(s)	Network	Results
Convolutional code and encoder memory order	Modified multi-hop WSN model	Normalised energy consumption and optimal memory order for specific SNR.
ARQ, HARQ and selecting among ARQ or HARQ according to distance	Single-hop network	Energy efficiency comparison
BCH and code rate (version)	Single-hop network	Experimental result of version change
Adaptive hybrid BCH code	Multi-hop network	Expected energy consumption and latency analysis
Adaption framework	Single-hop network	Standalone BER results
BCH code with code rate variation depending on CSI and ACK	Single-hop network	Energy efficiency result versus communication distance for BCH and adaptive error correcting code
Adaptive chase-2 decoding for BCH code	Multi-hop network	Decoding energy consumption for BCH code with standard chase and adaptive chase

Finally, the researcher should conduct additional research on the design and implementation of re-configurable transmitter and receiver at the energy and computationally constrained WSN node. [12]

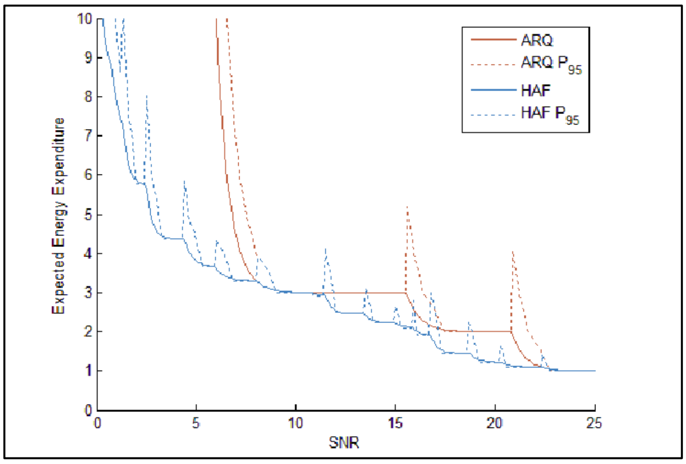

Figure 2: Illustrates the spread of the energy consumption

The 95th percentile in Figure 2 depicts the variability in energy expenditure. The variability in expected energy consumption is clearly greater for ARQ than for Hybrid-ARQ-Adaptive-FEC. Furthermore, through numerical evaluations. [13]

RFID is a non-contact automatic identification technology that employs radio frequency signals to recognise targets and provide access to relevant data. The wireless sensor network has no centre and self-organizes; it is a powerful complement to RFID and can overcome the disadvantages of poor anti-interference and short effective transmission distance. Based on ZigBee and RFID information-fusion technology: the former is used to monitor target environment conditions, while the latter is used to identify target objects.

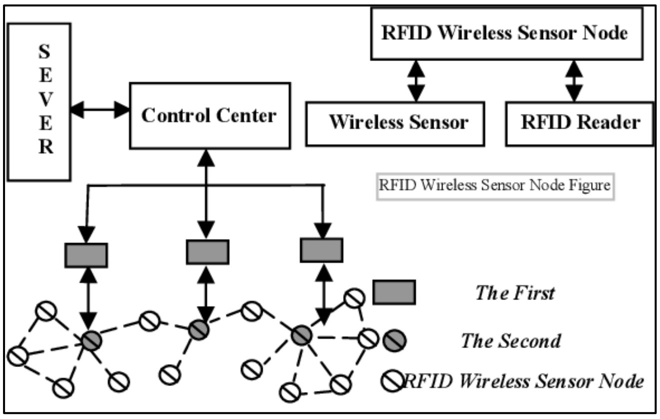

Fig.3 System Network Connect

A sensor node is composed of four basic components, as shown in Fig. 3: a sensing unit, a processing unit, a transceiver unit, and a power unit. It also has application-specific features like a location finding system, a power generator, and a mobilizer. The two main components of sensing units are sensors and analogue to digital converters (ADCs). [14]

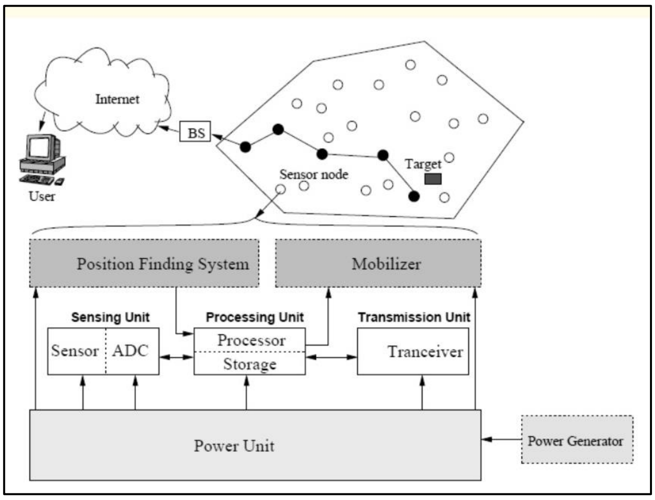

Fig. 4 The components of a wireless sensor node

In WSN communication, different types of ECSs are present to support different reliability, delay constraints, channel types, distance between nodes, and data rate. We provide a brief overview of the various types of ECS used in the WSN. We loosely categorise ECSs used in WSN into five groups, and Fig. 4 shows a broad classification of ECSs for WSN error correction context. [15]

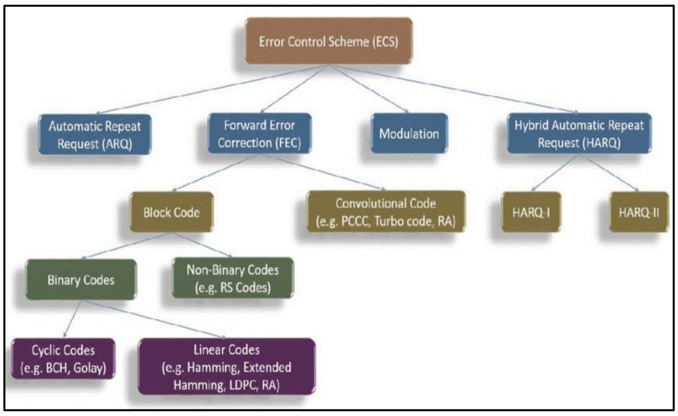

Fig. 5 Classification of Error Correction Scheme (ECS) for Wireless Sensor Network (WSN) in error correction context. [16]

CONCLUSION:

WSN application areas are discussed in this article. The difficulties in designing sensor nodes and constructing wireless communication infrastructure have also been discussed. We presented an overview of various types of ECSs used in the literature for WSN in this paper. To identify the challenges for ECSs, a detailed research study on the WSN channel model, network model, and standards is conducted, as these are critical for designing and implementing efficient ECSs. According to a review of the proposed energy consumption and efficiency models for WSN, existing research has not considered SHAS with high performing ECCs. A more thorough review of ECS design for WSN reveals that there are insufficient research publications on ECS design on a practical network model, namely the modified multi-hop WSN model. Finally, we highlighted future research opportunities for improving WSN ECS design and implementation.

REFERENCE:

1. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “Wireless sensor networks: A Survey,” Computer Networks J., vol. 38, no. 4, pp. 393–422, Mar. 2002
2. Mohammad Matin; Wireless Sensor Networks - Technology and Applications, ISBN 978-953-51-0676-0, InTech, Published: July 18, 2012.
3. Murthy, Manoj; Ad Hoc Wireless Networks: Architectures & Protocols, ISBN 978-81-317-0688-6, Pearson Education, 2007.
4. Akyildiz, Ian F., et al. "Wireless sensor networks: a survey." Computer networks 38.4 (2002): 393-422.
5. Kazem Sohraby, Daniel Minoli, Taieb Znati; Wireless Sensor Networks: Technology, Protocols, and Applications, ISBN 978-0-471-74300-2, John Wiley & Sons, 2007
6. http://www.libelium.com/smart_roads_wsn_smart_infrastructures
7. Vuran, M. C., & Akyildiz, I. F. (2009). Error Control in Wireless Sensor Networks: A Cross Layer Analysis. IEEE/ACM Transactions on Networking
8. Björnemo, E. (2009). Error correcting codes in static channels. In Energy Constrained Wireless Sensor Networks. Uppsala.
9. Howard, S. L., Schlegel, C., & Iniewski, K. (2006). Error Control Coding in Low-Power Wireless Sensor Networks: When is ECC Energy-Efficient. EURASIP Journal on Wireless Communications and Networking, 1-14v
10. Pardeep Kumar, Sang-Gon Lee and Hoon-Jae Lee, E-SAP: Efficient-Strong Authentication Protocol for Healthcare Applications Using Wireless Medical Sensor Networks, Sensors 2012, 12, pp 1625-1647
11. Subhagya, A.M.; Kaythry, P.; Kishore, R. LT Code Based Forward Error Control for Wireless Multimedia Sensor Networks. In Proceedings of the 2017 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), Chennai, India, 22–24 March 2017; pp. 1612–1616
12. Luo, T.; Tan, H.P.; Quek, T.Q. Sensor OpenFlow: Enabling software-defined wireless sensor networks. IEEE Commun. Lett. **2012**, 16, 1896–1899.
13. Proakis, J. G. (2001). Block and Convolutional Channel Codes. In Digital Communications. New York: McGraw-Hill.
14. W. LI, et al, Introductory and actual combat of Zigbee wireless networks, Beijing University of Aeronautics And Astronautics Press, April 2007.
15. Akyildiz I. F. Su W. Sankarasubramaniam Y. Cayirci E. Wirelesssensor. networksA.surveyComputer.Networks38200243 93422
16. Barakah, D.M.; Ammad-uddin, M. A survey of challenges and applications of wireless body area network (WBAN) and role of a virtual doctor server in existing architecture. In Proceedings of the 2012 Third International Conference on Intelligent Systems, Modelling and Simulation (ISMS), Kota Kinabalu, Malaysia, 8–10 February 2012; pp. 214–219.