COMMUNICATION METRICS FOR SIGNAL PROCESSING DESIGN SPONSORS

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***ABSTRACT** — Conventionally, required amount of computation is the measure of efficiency of the digital signal processing algorithm. The sensor networks that communicate data over long distances for effective processing require extensively more energy and time than local computation. This paper is a part of an endeavour to determine the communication efficiency of the signal processing design. All the findings are focused on probing a distributed sensor network exploiting the digital signal processing design. The anticipations will be evidence for the potential users; which will certainly provide a clear measurement of the communication metrics for the digital signal processing design. It is essential to measure the matrices of the digital signal processing system which is being designed to make sure that the overall performance can be empirically calculated. We have address the attributes of the digital processing system: cost, accuracy, signal coverage, interference, latency, fault tolerance, received signal strength indication, link quality indication, packet error rate and security.*

Keywords — Communication Matrices, Digital Signal Processing s(DSP), Design Sponsors

1. INTRODUCTION

Trends in the technologies to implement the digital signal processing design are exigent to certify the communication measurements of the digital signal processing. Multi-Processor architectures will become more ubiquitous than the distributed wireless sensor networks that process on the long distant communication. To work with the sensor network digital signal processing design we are investigating the communication metrics. Many engineers and operators do not have clear metrics for the distributed wireless sensor networks to make assure that how efficiently will work during certain conditions. The performance of the distributed wireless sensor networks can upturn by using the metrics proposed here.

In the past the appropriate attentions was not specified for defining communication metrics alone. Moreover, such frameworks are developed for specific digital signal processing design not for all. We set up some communication metrics proposed here based on my observation that should be acclaimed for manufacture of distributed wireless sensor network as a design of digital signals processing.

This paper is focused to observe the distributed sensor networks to develop the measurement method like metrics calculation. A distributed wireless sensor network quality attributes are told to find the clear communication metrics. It is expected that this agreed upon set of metrics will be the most prolific in design of the distributed wireless sensor network.

2. RELATED WORK

A metric is a quantitative measure of the system attribute. A system performance is well evaluated when its tasks and function are fully observed. A measurable attributes of a system can easily help to evaluate it communication and overall performance [2]. Observation is a key of monitoring, however observation is only about the data collection. A metric allows finding a pattern and trends in an object's behaviour. To spot these requirements, a research team must investigate designers of the system [1]. The people envision will clearly give us the measurements of the appropriate work out of the wireless sensor network [1]. Uncertainty in the reliability of the wireless link shows the reluctance in the distributed wireless sensor networks [2]. The potential end users comments about the system will give the clear picture of the system communication.

The environmental vulnerabilities and operational limitations can be easily identified by the evaluation program of the sensor networks [2]. The Evaluation program compromised of the set of operational tests that can easily detect the reliability in the links of the sensor network. The metrics are also most important as they recognize the crucial point where the communication delay may occur and whether or not it is adequate for accomplishment for system. I present a handful of communication metrics that can be applied to the distributed wireless sensor network for evaluating communication process in advance.

3. COMMUNICATION METRICS

Distinct communication attributes of the distributed wireless sensor network are focused in this paper. Various factors are keenly discussed that increase the performance of the distributed wireless sensor network. Some metrics are highlighted among these factors or attributes that are best for the communication proficiency evaluation.

A. Cost: The installation cost of the distributed wireless sensor network depends upon the type of the construction, need for radio repeaters, and the number of nodes and the other hard wares. The desired resolution of the system depends upon the number of nodes involved to make a system. On the other hand the number of repeaters involved depends on the factors like construction, size and wireless transmission scheme.

Installation and maintenance cost fell down while switching the system from wired to wireless. This drop of cost is the main advantage of the wireless system over the wired system. The increase in the number of wire of the network increases the complexity in the wired systems of the large building; this made the cost issues more prominent. It has been reported the installation cost of the wired system as $8 and $3 per linear meter of wire in the new or existing construction [4]. The wireless systems installation cost is reported as the 75% of the wired system costs [3].

Taken as a whole, the designers make tradeoffs to reach a required price level for the specific connection of the sensor network. The comparison of the cost of wired and wireless networks would easily show the financial advantages and disadvantages of the distributed wireless sensor network.

B. Accuracy: The sensor output produced by the transducer can be altered by the noise distress ion. Traditionally, accuracy of sensors and other equipment can be disturbed by the internal and external noise, so we measure accuracy for not only the sensors networks but also the all sensor devices. For a typical transmission a sensor reading is converted from analog to digital, the change in accuracy of is measured easily at the receiver end due to the noise interference with the transmitted signal.

Node redundancy works better for accuracy in the wireless sensor networks Noise and non-ideal situations can create the uncertainty to the system which is easily tackled by the high node density, also increase the overall accuracy of the system. A cluster-based topology gives that sway by collecting the sensory data at the same local area. Though there exist some problems of data collection and data correction in this topology when sensors become defective. So redundant measurements taken by the compactly distributed wireless networks help to upsurge the overall accuracy.

C. **Signal Coverage:** Stability of the wireless signal depends upon the factors like design types and exposure of the wireless connection. In ideal case an open field clearly specified the maximum acceptable distance between transmitter and the receiver. But the indoor environments like walls, floors and ceilings give the real approximation of the signal coverage. Construction material in different types interrupts the signals in different levels even destruct it completely. The response of the different frequencies can also be unalike in different constructions. Repeaters and other necessary devices like sensors are used to reduce the attenuation; however the cost of the system increased significantly.

D. Interference: Mostly wireless sensor networks devices operate in the 2.4 GHz bands for that reason there is possibility of the interference of the data of the low- power wireless device with the device operating with higher power. After minimizing the risk of interference, the problem generally exists in the devices operating on the similar frequency.

The interference can be clearly observe by the end user, they express that the received data is somewhat intermingled because of the interference. There must be some pattern of healthy data reported at the end user side to measure the expanse of the interference.

E. Latency: The real time data acquisition is the application- specific matter in the distributed wireless sensor network. The real time performance is confined by the intrinsic features of the distributed wireless sensor networks, for instance dynamic topology, lossy links, limited bandwidth, channel variation. According to the diverse demands of the applications to make available data to a receiver within adequate time, different demands on the end-to-end latency is made. Moreover, latency is most essential measure for some applications like emergency response, quality of service (QOS). The latency should be carefully managed, the best solution is to make trade-offs with the power management.

F. Fault Tolerance: The failure of the arbitrarily installed sensor nodes, networks or sink is mandatory. Failures must be identified for building applications; such faults can affect the performance of the overall system. The poor performance of the sensor networks can be due to the node fault, network faults and sink faults [12]. These faults can be generated by various factors like punitive environment conditions that will worsen the sureness level in the measurement of the performance of the wireless sensor networks [11]. The extreme conditions caused by the various factors are circuit failure, battery leakage and antenna failure. When the number of deployed nodes increased a network failure can be produced due to the communication failure caused by individual nodes. The power supply and the network topology are the main factors for creating the sink failure because this is the point where the data are collected. So any malfunction at sink will cause a huge failure to the system.

G. Received Signal Strength Indication (RSSI): A received radio signals power is measured by the RSSI. Received signal strength indication on the receiver end is calculated at the radio chip. RSSI gives the valuable inference of the network link worth [9, 10]. It only measures the received power strength and does not consider the surrounding noise, so success rate of the packet reception is not always correlated with the RSSI. A high-strength signal in a noisy environment cannot get the high quality link than the low-strength signal without noise.

H. Link Quality Indication (LQI): LQI measures all conceivable frequencies in the physical layer. It considers the signal-to-noise ratio and bulk energy of the signal in the frequency bands. These bands are standard and provide the average correlation values for each entering packet over at least 8 codes periods [3]. LQI is more expressive measure than the RSSI for giving the proper measure of efficiency of communication. LQI is helpful to consider the excellence of the medium between transmitter and receiver [3]. The LQI with RSSI helps the user to assess the communication link while mulling over the environmental effects on the receiver/transmitter pair.

I. Packet Error Rate: The lower packer error rate gives a reliable communication. It gives an expression of the percentage of the lost packets of data over the total number of the packets transmitted. The packet error rate is the ratio of the number of the packets unsuccessfully received to the total number of successful packets received within a specific time period. A reliable communication anticipated that each packet must successfully receive. So there must be a watch for the successfully received packets and not succeeded packets.

J. Security: A critical information infrastructure must have the security threats from the hackers [13]. The hackers can pull the desired data easily by taking the distributed wireless sensor network as a tunnel into the information system. These circumstances usually threaten the military facilities where the wired networks are mainly used. Wireless infrastructures are installed and security managers make the major concerns with that features.

4. METRICS EVALUATION & RESULTS DISCUSSION

A series of test is accompanied to reveal the use of communication metrics for the distributed sensor networks. A single radio transmitter and receiver are used to check the relationship between these metrics.

In the base case two different model of distributed wireless sensor network nodes are selected for metrics

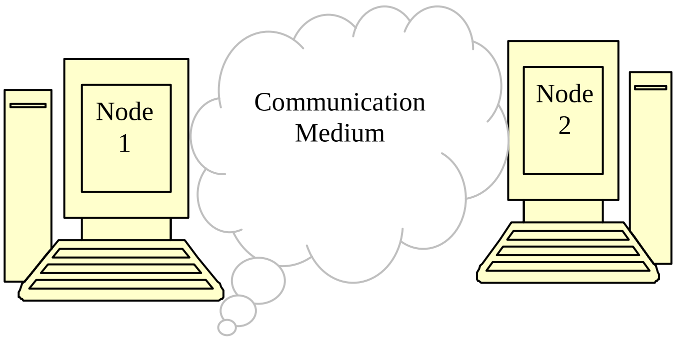


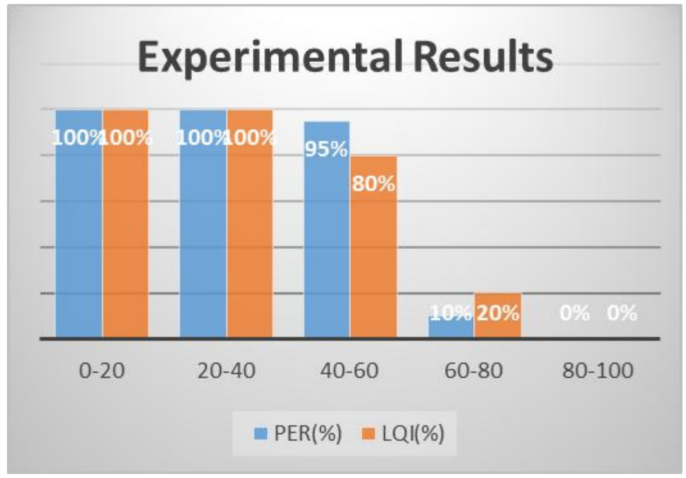
Fig: 1 Experimental Setup

evaluation. Radio signals are processed by these two distributed units contains their own transmitter and receiver too.

The communication metrics are the function of the distance between the transmitter and receiver of the two distributed units. The node 1 sends a message of length 32 bytes at a rate of 15 per seconds. Node ID and a count of the message are attached with the message content. The message length is kept constant to check the metrics. The Transmitter of the both nodes are programmed such as they keep an eye to check as if there is any missed message by the receiver.

In the base case the both nodes were at the kept so near at the distance there no need of the repeater. After that they are placed in different building. Here are observations of the test case when there is no obstacle between the nodes. After that noise reduction devices and signal strength increment devices are used. The all observations are given in the table below. The results shows that as the distances increases the use of the noise reduction and signal strength increment devices like repeaters are used for that purpose.

It is clearly mentioned that when the distance between the nodes are with in the range of 0-2- meter, then the Received Signal Strength Indication is -30 dBm, which gives Received signal strength indication on the receiver end is calculated at the radio chip packer error rate is 100% this ratio shows the number of the packets unsuccessfully received to the total number of successful packets received within a specific time period and Link Quality Indication is also 100%, which shows the signal-to-noise ratio and bulk energy of the signal in the frequency bands. These bands are standard and provide the average correlation values for each entering packet over at least 8 codes periods. It will observe by the experimental results show in below given graph.



5. CONLUSION AND FUTURE WORK

This paper gives the key areas of the concerns that tell us about the communication metrics of the distributed wireless sensor network on the design of the digital signal processing. Such measurement method is developed to give the clear picture of the overall system to the user and also to the designer of the system. This method is evaluated then by experiments. In this paper all the metrics are observed without obstacle in the measurement but in future they must be seen and evaluated at the specified distance so that the system being examined should not be intercepted. The test results are the most beneficial observation for the designers of the distributed wireless sensor networks as a design sponsor of the digital signal processing. The communication metrics are the utilities of the gap between receiver and transmitter which are the part of the two scattered components. The first component transmits a 32 bytes long message which has the data transmit rate of 15 bits per seconds. Component identifier and number of the message are contained with the message packet. The length of the

Table 1: Experimental Results.

Sr. No	Distance(m)	RSSI(dBm)	PER(%)	LQI(%)
1	0-20	-30	100%	100%
2	20-40	-80	100%	100%
3	40-60	-90	95%	80%
4	60-80	-100	10%	20%
5	80-100	-120	0%	0%

essage is saved constantly to verify the metrics. The transmitter of both components are programmed in such a way that they keep an eye to verify as if there is any missed message by the receiver end.

REFERENCES

1. Brambley, M.R, Haves, P, McDonald, S.C, Torecellini, P., Hansen, D., Homberg, D., Roth, K.W." Advanced Sensors and Controls for building Application: Market Assessment and Potential R&D Pathways, " *Pacific Northwest National Laboratory Report PNNL-15149, Richland, WA*. (2005).
2. Swyt, D .A,"An Assessment of the United States Measuring System: Addressing Measurement Barriers to Accelerate Innovation," *NIST Special Publication 1048, National Institute of Standards and Technology, Gaithersburgs, MD* (2007).
3. IEEE 802.15.4-2006 "Wireless MAC and PHY Specification for Low Rate Wireless Personal Area Networks (WPANS)", *IEEE Computer Society, New Yorks, NY*(2006).
4. Lynch, J.P. "An Overview of Wireless Structural Health Monitoring for Civil Structures," Philosophical Transactions Series A: *Mathematical, Physical, and Engineering Sciences*, **365**(1851), 345-372, (2007).
5. Kinter-Meyer, M. and Brambley, M. "Pros & Cons of Wireless," ASHARE Journal, 44(11), 54-61.
6. Roth, K. and Brodrick, J. (2008). *"Energy Harvesting for Wireless Sensors, " ASHARE Journal,* **50**(5), 84-90, (2002).

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7. Zhao, L., Zhang, W.-H.,Xu, C.-N., Xu, Y.-J. and Li, X.-W. "Energy-Aware System Design for Wireless Sensor Network," *Acta Automatica Sinica, Elsevier*, **32**(6), 892-899 (2002).
8. Halperm, M. and Saleem, K. "Battery Power Issues for WSN's", *Proceedings of NICTA Formal Methods Workshop, National ICT Australia,* November 7-9, Sydney, Australia (2005).
9. Kuo, Fei-Ching, Tsong Yueh Chen, and Wing K. Tam. "Testing embedded software by metamorphic testing: *A wireless metering system case study." Local Computer Networks (LCN), 2011 IEEE 36th Conference on*. IEEE, 2011.
10. Ikram, Waqas, et al. "Adaptive Multi-Channel Transmission Power Control for Industrial Wireless Instrumentation.": **1**-1, pp 978-990 (2014).
11. Avizienis, Algirdas, and John PJ Kelly. "Fault tolerance by design diversity: Concepts and experiments." *Computer* **17**. 8 : 67-80, (1984)
12. Huang, Kuang-Hua, and Jacob A. Abraham. "Algorithm-based fault tolerance for matrix operations." *Computers, IEEE Transactions on* 100.6 (1984): 518-528 (1984)
13. William, Stallings, and William Stallings. Cryptography and Network Security, 4/E. *Pearson Education India,* 2006