CHAPTER 3

MOTIVATION

Reliability of Data Acquisition is a key concern in a Wireless Sensor Network since the whole purpose of deploying a WSN is to be able to acquire information, at a remote location, about the environment in which the WSN is deployed. The substantial literature survey indicates that the issue is important and various algorithms, protocols and mechanisms to improve the reliability of Wireless Sensor Networks have proposed.

The issue of reliability assumes even more stringent proportions in the case of a Wireless Sensor & Actuator Network where the acquired information is expected to be the foundation for the decision making process and for actuation of the control elements. However, this is where the current research work appears a little thin as the literature survey indicates that most of the work in the field of reliability appears in context of Wireless Sensor Networks and not as much in WSAN. However, it could be argued that the aspect of reliability of data acquisition is studied in the sensing part of the WSAN rather than in the actuation part. Therefore the Reliability of Data Acquisition problem in WSAN is quite similar to the same issue in WSN except for the additional constraints imposed.

As observed in the literature survey various types of mechanisms are designed to cater to various aspects of reliability in Wireless Sensor Networks including Reliability of Delivery, Reliability of Secure Data, Latency time etc. These include protocols to improve reliability of providing security to the network against hostile attacks by malicious nodes, mechanisms to reduce the Packet Drop rates by the transport protocols, improve the reliability of coverage of the sensed area by novel deployment schemes, methodologies to make the network more tolerant to faults of the sensor nodes in the network and so on. A significant number of algorithms focus on improvement of reliability of delivery mechanism by focusing on providing multiple paths for delivery of information.
Further with the evolution of the Wireless Sensor & Actuator network, most of the work in the field of WSAN is found to be focused on the Actuator-Actuator Communication and coordination, Actuator–Sensor communication, stability of the control action etc. However, the network latency constraints imposed upon the sensing part of the network, in view of the impending control action by the Actuator part of the network, is not particularly addressed as a focus point in an algorithm towards achieving reliability of data acquisition.

Some algorithms have taken on the issue of network latency and have taken steps to achieve the same but the steps taken are not particularly aggressive and the simulated results are not likely to prove beneficial in real context. This is because most of the simulation results shown are using IEEE 802.11 as the PHY & MAC layer with channel transfer rate of 2 Mbps and it has been observed that network latency is in the range of a few milliseconds in this context. However, IEEE 802.11 is not suitable for use in WSN in any real-life implementation, this is primarily because WSN applications generally do not require such high data rates and can’t afford the associated high energy budget required by IEEE 802.11 [42]. Therefore any real-life implementation is unlikely to use IEEE 802.11 protocol [15]; rather the usage of IEEE 802.15.4 or some other variant similar to this is more likely e.g. Zigbee™ [34] uses IEEE 802.15.4 PHY & MAC as does Wireless HART™ [38]. IEEE 802.15.4 has a theoretical bandwidth of 250 kbps which is almost 8.3 times lower than the 2 Mbps used during simulation. Therefore the simulated latency periods of a few milliseconds are not likely to be met or observed in real-life situations. Therefore there is a need to design and test mechanisms for Reliable Data Acquisition in WSN which use IEEE 802.15.4 PHY & MAC layers and are optimized for the constraints and functionalities present in this protocol.

Any design of mechanism for improving reliability of Data Acquisition in WSAN must address the following issues:

1. Data Acquisition mechanism must be reliable in terms of ensuring that sufficient information regarding the event sensed in the deployment environment must be made available to the sink for it to be able to reconstruct the event accurately.

2. Data Acquisition mechanism must meet the time-constraints as may be required by the actuation system i.e. the network latency must be low.
3. Data Acquisition mechanism must be fault tolerant i.e. it must be able to maintain reliability of the acquisition process even if some nodes fail during the data forwarding process.

4. Data Acquisition mechanism must consider the computational, storage and energy constraints that apply on the nodes in the Wireless Sensor & Actuator Networks.

These aspects needed to be addressed and explored and laid the foundation for arriving at the objectives for this research

3.1 Objectives of Research

Reliable Data acquisition refers to the ability of the Wireless Sensor & Actuator Network to

a) Ensure delivery of sufficient amount of the gathered information, by the deployed sensor nodes, to the centralized sink / Actuators for it to be able to faithfully and successfully re-construct or estimate the event and take necessary action in time.

b) Ensure delivery of the sensed information by the deployed nodes within the Network Latency Time constraint i.e. time between sensing of information by the nodes and the time of delivery of information at Sink/Actuators must be less than $T_{\text{NLT}}$

c) Ensure delivery of sensed information by the deployed nodes in a coherent manner

d) Ensure sufficient fault tolerance without comprising on the ability of the centralized sink / Actuators to faithfully re-construct the event sensed by it. The fault tolerance is a part of reliability.

e) Reliability also includes the availability of the data acquisition service being provided by the network for as long as possible without comprising on the basic issue as mentioned above.

3.2 Chapter Summary

The motivation behind the research work has been discussed with reference to the work discovered during the extensive literature survey. The importance of using

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IEEE 802.15.4 in WSN & WSAN applications has been highlighted viz a viz the IEEE 802.11 environment. The various issues to be addressed in connection with achieving and maintaining reliability issues to be addressed for achieving and maintain the reliability of data acquisition in a Wireless Sensor Network and a WSAN are listed. Based on this discussion the objectives of the research have been clearly identified and highlighted. The next chapter presents the algorithms proposed and the theory behind their working.