ABSTRACT

Wireless Sensor Networks are employed in many applications ranging from defense to medicine. The self-organizing nature of these ad hoc networks, non-deterministic performance requirements, heterogeneity and unmanned environments make the design of sensor networks complex and multifaceted in meeting its objectives. Moreover, wireless sensor networks face an inherent tradeoff among their Quality-of-Service (QoS) performance requirements owing to the contradictive definitions of these parameters. In sensor nodes, the power units are found to be limited and non-rechargeable and this leads to practical constraints on functioning of sensor networks. Research works done in reducing the energy consumption in wireless sensor networks compromise on other set of functional requirements such as delay and delivery ratio. Unlike traditional wireless and mobile networks, wireless sensor networks are employed in various applications, that are beyond the scope of communication services and these types of applications have their own set of intrinsic requirements. The impact of these issues is profoundly reflected in our proposed research work.

The formation of wireless sensor networks can basically be categorized in to flat and clustering approaches. Clustering approaches yield betterment in terms of reliability, disaster recovery and extensibility of the sensor applications. Our research work aims at improving the lifetime of the wireless sensor networks by reducing the power consumption and also intends to achieve reduced delay and improved delivery ratio. With these objectives, various clustering approaches are analyzed and this research work proposes four clustering approaches. The scope of this research work is limited to the characteristics and boundaries of a typical continuous monitoring wireless sensor networks.

Our first proposed approach, namely, Adaptive Distributed Clustering Algorithm (ADCA) intends to reduce the power consumption through a Similarity Measure (SM) based energy-aware sleep/duty cycle for sensor networks. This work contributes an effective Similarity Measure calculation for the data collected from neighboring sensor nodes and effectively reveals spatio-temporal correlation of the data. Also, this work introduces a re-clustering technique to improvise the dynamic characteristics of the sensor network.

Our second proposed approach, namely, Distributed Cluster Based Routing (DCBR) algorithm combines the advantages of the clustering approach and the deployment of multiple sinks. The suitable placement of

sinks has been done through global positioning method. This work addresses both inter-cluster and intra-cluster communication issues.

Our third proposed work, namely, Power Efficient Scheduling Technique (PEST) has got its inspiration from the emerging sleep/wakeup schedule scenarios. In many of the scheduling techniques observed from the literature, the synchronization error is assumed to be negligible and many real-time scenarios exhibit a controversial picture on this assumption. Two major components of this synchronization error, namely, clock skew and phase offset show considerable impact on the efficiency and accuracy of the scheduling techniques employed. To minimize the effect of these synchronization errors in a clustered sensor environment, our proposed PEST approach adopts an effective sleep scheduling technique in an intra-cluster environment. Also, this work inherits a capture probability threshold model to handle the tradeoff between the energy consumption and proportion of data collection in a clustered environment. From our research work, certain improvement has been observed in power consumption of the sensor network and without compromising the delay and delivery ratio.

The first three proposed approaches of this research work assume the presence of a range-based localization scenario to obtain the location of sensor nodes. Under practical circumstances, the range-based scenarios require special kind of hardware support (e.g: Global Positioning System)

which makes the solution expensive. From the cost perspective, the performance of our proposed clustered techniques has been evaluated in a range-free localization environment using the proposed Cluster Based Architecture (CBA) technique which requires no special hardware. This range-free clustering approach adopts an event-based and a distance based localization techniques to locate the nodes within a cluster. The results demonstrate the adoptability of the proposed clustering techniques in a range-free environment.

Experimental evaluation of the proposed clustering techniques has been done using NS-2 simulator and the simulation results demonstrate improvement in terms of power consumption, delay and delivery ratio. Also, a cost-effective version of these proposed clustering techniques in a range-free localization environment has also been evaluated. Scalability of the proposed solution is also observed from the experimental results with varied number of sensor nodes.

The proposed clustering techniques of this research work can be applied to real-time sensor application scenarios. Furthermore, this research work can be extended to handle the tradeoff among many other performance requirements of sensor applications such as overhead, fault-tolerance and data accuracy.