Abstract

A Wireless Sensor Network (WSN) is typically deployed in an area of interest for acquiring information in real-time. For acquiring such information, sensor nodes sense their surroundings and communicate that sensed data to the sink(s) for further processing by the end users. However, sensor nodes are resource-constrained, and have limited battery power. So, these nodes collaborate among themselves to achieve their primary objective, i.e., acquiring information, in an energy-efficient manner. Moreover, the nodes follow an Active-Sleep schedule, instead of continuous sensing to save their battery power.

Sensor observations are spatio-temporally correlated. This correlation induces redundancy in the communicated data. For sensor nodes, communicating redundant data is a wastage of their limited battery power. Several existing works exploit spatial correlation by selecting the minimum number of monitoring nodes as the representatives of the whole network. However, sensor observations are also temporally correlated. We use temporal correlation for regulating the Active-Sleep schedule of the nodes to reduce redundancy of communicated data. For calculating temporal correlation among their observations, a sensor node estimates the entropy of its observations, as well as mutual information between the consecutive observations with the help of a Dynamic Bayesian Network. Further, the nodes apply a Reinforcement Learning–based approach to approximate the optimum sleep duration from the calculated temporal correlation.

We conjugate the effects of spatial and temporal correlation together by a cross-layer approach. The proposed cross-layer approach, which bases itself on non-deterministic Reinforcement Learning, conserves battery power of the nodes and reduces the end-to-end delay of the communicated packets. For efficient collaboration, nodes extract information from the Medium Access Control (MAC) layer, and use that information, along with correlation, for proper scheduling of their Active-Sleep states and reducing the end-to-end delay.

In case of event-driven WSNs, sensor nodes communicate both high-priority event-data and also low-priority periodic data. Periodic data are more correlated and have less strict delay constraint than the event-driven data. As the data delivery model for such event-driven WSNs is hybrid in nature, differentiated Quality of Service (QoS) with respect to end-to-end delay is an important factor to attain high performance. We use correlation – both spatial and temporal – for efficient management of the energy-delay trade-off, and for providing differentiated QoS to the communicated data. Context information, such as the transmission rate,

and packet type, are used for differentiating the QoS requirements of the communicated data. Further, context-awareness is used as a means of sharing required information for energy-efficient collaboration.

Generally, resource-constrained sensor nodes are densely deployed for prolonging the network lifetime. In a sparse WSN, average distortion of sensor observations, due to the sparsity of network, is greater than in the dense ones. Moreover, observations of all the nodes, which detect an event, do not have the same significance in the estimation of event parameters. Considering these facts, the proposed sensor collaboration scheme assists, in a distributed manner, the sensor nodes of a sparse WSN, to participate in the event monitoring process. The proposed scheme is based on the principle of Monte Carlo methods. Further, the event monitoring nodes restructure the network topology with the help of the Facility Location Theory, for efficient management energy sources.

Keywords: Spatio-temporal Correlation, Context-awareness, Differentiated QoS, Sparse Network, Dynamic Bayesian Network, Entropy, Mutual Information