



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

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Stochastic Approach to Quality of Service in Data Gathering for Wireless Sensor Networks  
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In a rare event detection application, asynchronous sleep/wake scheduling is energy efficient because of overhead involved for synchronization in synchronous sleep/wake scheduling. As sensor nodes wake-up independently, asynchronous sleep/wake scheduling increases delay. For such an application, satisfying delay constraint and lifetime requirement with minimum deployment cost is a challenging problem. Specifically, in a rare event-detection application, like fire or disastrous event detection, an event detected close to the central facility needs to reach faster than an event detected far away. In our first contribution, we address the problem of finding a minimum cost WSN for a set of spatially differentiated QoS requirements. First, we use a stochastic approach to calculate the expected e2e delay for a given sensor density. We use this analysis to find the critical expected sensor density that satisfies given e2e delay constraint and lifetime requirement. Later we extended this analysis to find the minimum cost network for a set of spatially differentiated delay constraints and the lifetime requirement. We also verified our mathematical expressions using Monte Carlo simulation and show effectiveness in NS2 simulation.

The clock-skew incurs additional delay during event reporting delay which may violate the delay constraint for a large number of packets in event-driven data-gathering. In the next phase of our work, We find the critical wake-up rate to constrain the increase in end-to-end delay, as a result of clock-skew, within a given delay constraint  $\xi$ , by estimating the expected increase in end-to-end delay using a stochastic approach. We verify our mathematical analysis using Monte-carlo simulation. Further, simulation results in network simulator 2.34 (ns2) confirm the effectiveness of our approach.

In periodic data-gathering, sensors send/receive data packets periodically and switch on the transceiver only during packet transmission to save energy. In order to transfer data-packets a sender-receiver pair establishes clock-

synchronization. Exact clock-synchronization is impossible because of error present in synchronization protocols. In the absence of synchronization, clock-disagreement increases as time passes. To compensate any message loss, the sensor nodes wake up some time earlier, known as guard-time, before the scheduled wake-up time. This strategy consumes more energy especially for long periodic intervals. In this phase of our thesis, in order to increase the lifetime, we propose a multi-beacon guard method to decrease the energy consumption by minimizing the awake time of sender-receiver pair, using periodic switch on/off the receiver during the guard-time. Under the assumption that synchronization error follows the normal-distribution, we provide an optimal solution to determine the number-of-times the receiver needs to wake-up along with wake-up intervals to collectively minimize total energy consumption of the sender-receiver pair during a transmission. We validate our analysis using Monte-Carlo simulation and show the effectiveness in energy conservation using ns2 simulation.

In a hybrid data-gathering, a sensor network dynamically switches between event driven and periodic data gathering scheme. Two key QoS requirements in hybrid data-gathering are lifetime and critical event-reporting delay. In the last phase of our work, we propose a novel hybrid data-gathering protocol that minimizes the critical event reporting delay and maximizes the lifetime in a delay-constrained WSN. In our protocol, the sensor nodes generate periodic events and if a critical event is detected, the event information is forwarded to the base station within a strict delay constraint. We show the effectiveness of our protocol in ns2 simulation and compare our approach with recent hybrid data-gathering protocols.