NODE ACTIVATION POLICIES FOR ENERGY-EFFICIENT COVERAGE IN RECHARGEABLE SENSOR SYSTEMS

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ABSTRACT

Advances in sensor network technology enable sensor nodes with renewable energy sources, e.g. rechargeable batteries, to be deployed in the region of interest. The random nature of discharge and recharge, along with spatio-temporal correlations in event occurrences pose significant challenges in developing energy-efficient algorithms for sensor operations. An important issue in a system of rechargeable sensors is the node activation question − How, when and for how long should a sensor node be activated so as to optimize the quality of coverage in the system ?

We consider two different energy consumption models for a sensor, namely (i) Full Activation model, where a sensor could only be activated when fully recharged, and (ii) Partial Activation model, where the sensor can be activated even when it is partially recharged. In the presence of spatial correlations in the discharge and/or recharge processes, with identical sensor coverages, we show analytically that there exists a simple threshold activation policy that achieves a performance of at least $\frac{3}{4}$ of the optimum over all policies under Full Activation, and is asymptotically optimal with respect to sensor energy bucket size under Partial Activation. We extend threshold policies to a general sensor network where each sensor partially covers the region of interest, and demonstrate through simulations that a local information based threshold policy achieves near-optimal performance.

We then consider the scenario where the events of interest show significant degree of temporal correlations across their occurrences, and pose the rechargeable sensor activation question in a stochastic decision framework. Under complete state observability, we outline the structure of a class of deterministic, memoryless policies that approach optimality as the sensor energy bucket size becomes large. Under partial observability, we outline the structure of the history-dependent optimal policy, and develop a simple, deterministic, memoryless activation policy based upon energy balance which achieves near-optimal performance under certain realistic assumptions. With multiple sensors having identical coverages, threshold based activation policies achieve near-optimal performance. The energy-balancing thresh-

old policies are thus robust to spatio-temporal correlations in the discharge and recharge phenomena.