Analysis of Gradient-based Routing Protocols in Sensor Networks

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Sensor networks may be most widely used for habitat and environmental monitoring where the attached tiny sensors sample various physical phenomena. Moreover, many of the physical phenomena follow the diffusion property with distance, i.e., $f(d) \propto \frac{1}{d^\alpha}$, where d is the distance from the point having the maximum effect of an event, $f(d)$ is the magnitude of the event's effect and α is the diffusion parameter that depends on the type of the effect; e.g., $\alpha = 2$ for light, and $\alpha = 1$ for heat. The routing protocols used in the sensor networks for habitat and environmental monitoring applications can exploit this natural information gradient to efficiently forward queries towards the source.

Real life sensors are not perfect and are subject to malfunction due to obstacle or sensor/node failures. Also, the characteristics of the sensor nodes, i.e., limited battery life, energy expensive wireless communication and unstructured nature of the sensor network, make data-centric routing protocols based on the information gradient a challenging problem. Several routing protocols have been proposed to exploit the information gradients in the sensor networks. These protocols use greedy forwarding and can be broadly classified as:

1. *Single path approach*[1, 2, 3], where the query reaches to the source from the sink through a single path.

2. *Multiple path approach*[4], where the query uses multiple paths to reach to the source.

In this poster, we do not aim to design new routing protocols per se. Rather, the objective of the research is focused on the evaluation and the analysis of the general approaches to route a query using the natural information gradient in the sensor networks. In the analysis we are interested in two metrics:

1. *Reachability*, i.e., the success probability, which is the probability that the query initiated from the sink will reach to the source.

2. *Overhead* in terms of average energy dissipation, which is the number of transmissions required to forward the query to the source and to get the reply using the reverse path.

For simplicity of the analysis, we use a simple grid topology. Using probability tools and combinatorics we develope simple analytical models of the reachability and the overhead for both approaches. Further, we simulate the protocols which are designed based on these two approaches in more realistic scenarios. Through simulation, we also investigate the *path quality* in terms of the path-length increasing factor. We only consider sensor networks with static nodes, which is usually the case for environmental monitoring. Last, we assume that the queries are triggered after the event's occurrence.

Comparison of both approaches using analytical and simulation results are presented in the poster. From the results it is found that in our model the multiple path approach is energy efficient when the source is 25 hops away from the querier; otherwise, the single path approach is preferable, though the reachability reduces. Also, the multiple path approach results in shorter paths than the single path approach, and the resulting paths are quite close to the shortest possible paths.

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References

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