Exploring a WSN Design Space using Genetic Algorithms

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ABSTRACT

Configuring wireless sensor networks (WSNs) plays an important role for the performance and quality of service of the running application. The huge number of sensor nodes and the possibility of configuring each of them in several ways cause an extremely large design space. Multi-objective genetic algorithms (GAs) are well suited to explore the trade offs in a WSN design space. A GA has many parameters in itself. So properly configuring a GA for design space exploration, given a specification of the WSN to be configured and a time budget available for analysis can lead us to better configurations for the WSN.

KEYWORDS: Wireless sensor network; Design space exploration; Genetic algorithms

1 Configuring a WSN

Every node in a WSN has several controllable parameters. So it can be configured in several ways. A WSN may also have network level configurable parameters. Every configuration affects the quality of considered Quality of Service (QoS) metrics and selecting the best configuration for a WSN is of high importance. In many cases, improving some metrics through configuring nodes in some way might worsen others. Because of these trade offs there can be several configurations that all are Pareto points in the multi-dimensional objective space and the main problem is to find the set of Pareto points. As there are lots of sensor nodes in a typical WSN, there is an extremely large number of possible configurations for the WSN and consequently an exhaustive search of the configuration space is not feasible.

2 Configuring a Genetic Algorithm

Because of the very large design space of typical WSNs, using a heuristic multi-objective search method such as a genetic algorithm to find near-optimal configurations is reasonable. Analysis time and quality of the obtained Pareto points are our two considered criteria to evaluate the performance of a GA. Our goal is to tune the GA according to the WSN design space exploration specification at hand to find better Pareto points in a given time budget.

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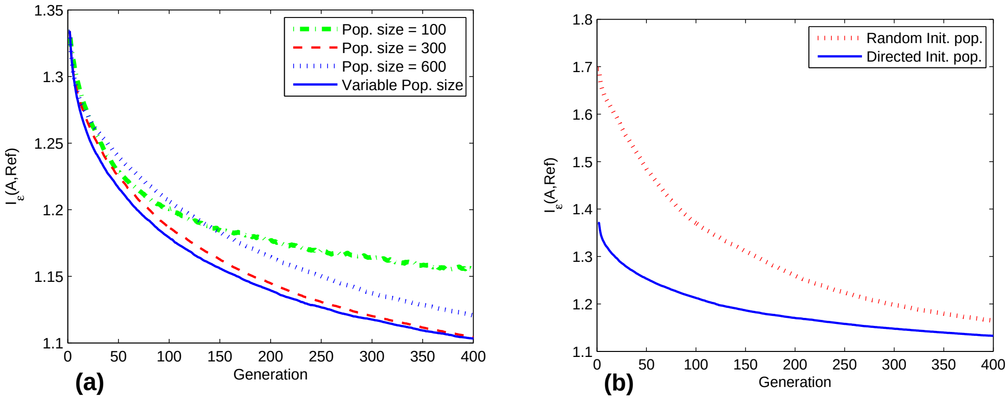

Figure 1: The quality of approximated Pareto points for (a) various population sizes. (b) random and directed initial population selection.

The dimensionality of the design space, the number of sensor nodes, the size of node-level and network-level configuration spaces and the speed of the model evaluation contribute to the WSN DSE specification. The maximum number of generations, the population size, the number of new candidate configurations in each generation and the mutation probability are some configurable parameters of a GA. Also the method of initial population selection and mechanisms of genetic operations can be decided based on the WSN DSE specification. The goal of this research is to develop guidelines for configuring a GA given a WSN DSE specification.

3 Case Study

Figure 1 shows an example of the effect of configuring a GA on the quality of the resulting Pareto points. The curves are obtained from exploring the design space of a gossip-based WSN [vdW08]. Transmission power of the radio and the sampling period of sensor nodes are two node-level parameters in this WSN. We also consider TDMA frame length and the number of active slots per frame as two network-level parameters. Power consumption, latency and reliability are three considered QoS metrics. To evaluate the quality of resulting configurations, we use the *binary* ϵ*-Indicator* [ZKT08] metric which compares two Pareto sets. Fig. 1 shows the $I_\epsilon(A, Ref)$ in which A is the set of Pareto points resulting from the corresponding generation of the GA and Ref is a reference Pareto set that is the result of performing the GA for very many generations. Experiments show that through configuring the GA parameters according to the WSN DSE specifications, we reach better configurations for the WSN in a given time budget for analysis.

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