Abstract

The research of this Ph.D. is fulfilled in the context of the optimized monitoring of Internet of Things (IoT) networks. The IoT enables the interconnection of billions of sensors, actuators, even humans to the Internet, creating a wide range of services, some of which are mission-critical. However, IoT networks are faulty in nature; Things are resource-constrained in terms of energy and computational capabilities. Moreover, they are connected via lossy links. For IoT systems performing a critical mission, it is crucial to ensure connectivity, availability, and network reliability, which requires *proactive* network monitoring. The idea is to oversee the network state and functioning of the nodes and links; to ensure the early detection of faults and decrease in node *unreachability times*. It is imperative to minimize the resulting monitoring energy consumption to allow the IoT network to perform its primary function. Furthermore, to realize the integration of the monitoring mechanism with IoT services, the proposed models should work in tandem with the IoT standardized protocols, especially the IPv6 for Low-power Wireless Personal Area Networks (6LoWPAN) and the Routing Protocol for Low-power and lossy networks (RPL). In this challenging context, the first step of analysis is to ensure the (*optimal*) placement of monitoring nodes (*monitors*) to cover the given domain. Leveraging the graph built by RPL (the DODAG), the monitoring coverage can be modeled as the classic Minimum Vertex Cover (MVC) on the DODAG. MVC is NP-hard on general graphs and polynomial-time solvable on trees. To reduce the computational complexity, we introduce an algorithm to convert the DODAG into *nice-tree* decomposition. We demonstrate that the monitor placement, in this case, is only Fixed-Parameter Tractable, and can also be polynomial-time solvable. The monitoring role should be distributed and balanced to prolong network longevity. To that end, assuming periodical functioning, we propose to assign Vertex Cover(VC) sets to time periods in a three-phase centralized monitoring approach. In the first phase, multiple minimal VC are computed. The assignment of the VC across the planning horizon is handled in the second phase; by modeling the scheduling as a multi-objective Generalized Assignment Problem (GAP). To minimize the state transitions in a duty-cycled monitoring approach, the optimal sequence between the sets of monitors across time periods is computed in phase three; by modeling it as a Traveling Salesman Path Problem (TSP-Path). In a third contribution, we provide the exact solution to the defined monitoring placement and scheduling problem via formulating a Binary Integer Program. The model serves as a benchmark for the performance evaluation of contemporary models. Moreover, the monitoring mechanism must adapt to real-time network instabilities. Therefore, in our final contribution, we propose a dynamic distributed monitoring scheduling mechanism, which is implemented in the Contiki OS for constrained networks, and experimented using the COOJA simulator; the *de facto* simulator for IoT applications. Results demonstrate the models' effectiveness in realizing full monitoring coverage with minimum energy consumption and communication overhead, and a balanced distributed monitoring role.