Traffic Analysis, Modeling and Their Applications in Energy-Constrained Wireless Sensor Networks – on network optimization and anomaly detection

Summary

Wireless sensor network (WSN) has emerged as a promising technology thanks to the recent advances in electronics, networking, and information processing. A wide range of WSN applications have been proposed such as habitat monitoring, environmental observations and forecasting systems, health monitoring, etc. In these applications, many low power and inexpensive sensor nodes are deployed in a vast space to cooperate as a network.

Although WSN is a promising technology, there is still a great deal of additional research required before it finally becomes a mature technology. This dissertation concentrates on three factors which are holding back the development of WSNs. Firstly, there is a lack of traffic analysis & modeling for WSNs. Secondly, network optimization for WSNs needs more investigation. Thirdly, the development of anomaly detection techniques for WSNs remains a seldomly touched area.

In the field of traffic analysis & modeling for WSNs, this dissertation presents several ways of modeling different aspects relating to WSN traffic, including the modeling of sequence relations among arriving packets, the modeling of a data traffic arrival process for an event-driven WSN, and the modeling of a traffic load distribution for a symmetric dense WSN. These research results enrich the current understanding regarding the traffic dynamics within WSNs, and provide a basis for further work on network optimization and anomaly detection for WSNs.

In the field of network optimization for WSNs, this dissertation presents network optimization models from which network performance bounds can be derived. This dissertation also investigates network performances constrained by the energy resources available in an indentified bottleneck zone. For a symmetric dense WSN, an optimal energy allocation scheme is proposed to minimize the energy waste due to the uneven energy drain among sensor nodes. By modeling the interrelationships among communication traffic, energy consumption and WSN performances, these presented results have efficiently integrated the knowledge on WSN traffic dynamics into the field of network optimization for WSNs.

Finally, in the field of anomaly detection for WSNs, this dissertation uses two examples to demonstrate the feasibility and the ease of detecting sensor network anomalies through the analysis of network traffic. The presented results will serve as an inspiration for the research community to develop more secure and more fault-tolerant WSNs.