

Multi-objective optimization for Security and QoS adaptation in Wireless Sensor Networks

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Abstract—In this paper we address the impact of the security cost in terms of energy consumption, processing time, and traffic load on quality of services (QoS) in Wireless Sensor Networks (WSNs). Offering security services (authentication, confidentiality, and integrity) and QoS (throughput, delay, and reliability) guarantee in WSNs is still challenging issue. The security and QoS are opposite parameters, and then security services must be dynamically and optimally adapted to QoS and network constraints (e.g. energy efficiency). Therefore, designing such solution that optimizes multiple conflicting objectives is computationally intractable. We propose a new solution based on multi-objective optimization using genetic algorithm (NSGA-II) for security, QoS, and energy efficiency in WSNs. Resource constraints as well as QoS requirements are respected through use of optimal security level based on evolutionary strategy. The obtained simulation results illustrate that the energy efficiency and the security level optimization is reached with different set of optimal security settings adapted to the QoS and the energy requirements.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are attracting more research attention from both academic and industrial researchers. WSNs are considered as part of new emerging Internet of Things (IoT) paradigm with different application fields varied from healthcare, industrial, home automation, military, environment/object monitoring and tracking [1] [2]. Many of these applications require certain level of QoS and security services like the mutual authentication, the data integrity and the end-to-end data confidentiality. However, security and QoS are relevant to many factors such as the energy status of nodes, the delay, the bandwidth, the data packet delivery ratio.

The support of different security levels, and different QoS requirements must be considered in the design of a new solution for WSNs. Since sensor devices have different constrained in terms of energy (limited battery), memory, processing capability, and data rate an efficient and optimal use of these scarce resources is mandatory. The QoS and security have been always considered as separate entities and research in these areas have largely proceeded independently, but, security impacts overall QoS and WSNs performances. For instance, the goodput decreases when the packet size increases by adding the information related to the security service like the Message Authentication Code (MAC). That's why, it is

important to consider both security and QoS together when designing protocols for WSNs.

In this paper we propose a new solution based on multi-objective optimization using generic algorithm to achieve the best QoS and security level for each class of service. We focus on both available resources related to nodes, and to the network at a given time. The optimization model can be parameterized according to the security level and QoS requirements. In order to achieve that we should maximize the security services level, the throughput, and the packet delivery ratio (PDR) on the one hand, and minimize the delay, the jitter, and the energy consumption on the other hand. We are dealing with several opposite objectives to reach at the same time; to maximize some and minimize others. Therefore, we introduce a multi-objective optimization problem [5] where each objective will be evaluated by mathematical function. Since, these objectives are opposite and interdependent in nature, evolutionary algorithms, particularly Genetic Algorithms (GAs), are best candidat, and suitable methods to solving this kind of problem [5].

The main contribution of this work is to propose a new mechanism based on GA to find the optimal and near-optimal solutions for nonexistence between security and QoS in WSNs. The contributions are summarized as follow:

- 1) Analyze and evaluate the security services level, and the QoS class service metrics in WSNs.
- 2) Propose an efficient and dynamic optimization model that determines a combination of optimal security services setting, satisfying QoS requirement of each class of service while providing efficient energy using elitist non-dominated sorting genetic algorithm (NSGA-II).
- 3) Resolution of the multi-objective problem.
- 4) Performance evaluation of the proposed approach.

The remainder of this paper is organized as follows. In Section II, we present the existing solutions that address security and QoS in WSNs. In Section III, we describe the proposed optimization solution. Section IV presents the resolution of the multi-objective optimization problem. In Section V, we present the obtained simulation results and their analysis. Finally, we conclude the paper by conclusion and future works.