Design optimization for security-and safety-critical distributed real-time applications

In this paper, we are interested in the design of real-time applications with security, safety, timing, and energy requirements. The applications are scheduled with cyclic scheduling, and are mapped on distributed heterogeneous architectures. Cryptographic services are deployed to satisfy security requirements on confidentiality of messages, task replication is used to enhance system reliability, and dynamic voltage and frequency scaling is used for energy efficiency of tasks. It is challenging to address these factors simultaneously, e.g., better security protections need more computing resources and consume more energy, while lower voltages and frequencies may impair schedulability and security, and also lead to reliability degradation. We introduce a vulnerability based method to quantify the security performance of communications on distributed systems. We then focus on determining the appropriate security measures for messages, the voltage and frequency levels for tasks, and the schedule tables such that the security and reliability requirements are satisfied, the application is schedulable, and the energy consumption is minimized. We propose a Tabu Search based metaheuristic to solve this problem. Extensive experiments and a real-life application are conducted to evaluate the proposed techniques.