Abstract

Nanoscale communication networks (henceforth termed as "nanonetworks") consist of at least one synthetic network component of size ranging from 1 to 100 nm, exploit different nanoscale properties, and incorporate the basic elements of communication elements – *transmitter*, *message*, *message carrier*, *medium*, and *receiver*. Limited energy capacity and small magnitude of harvested energy of such nanonetworks make the design of robust networking protocols challenging. Furthermore, potential applications based on nanonetworks are expected to adopt multi-hop communication strategy due to the limited communication range and stringent power budget. Therefore, the study on characterization of the phenomenon of collision, and optimization of energy consumption is of paramount importance for providing foundations on enabling robust multi-hop nanoscale communication networking.

In this Thesis, first we focus on the characterization of collision in bacterial conjugation-based molecular communication nanonetworks, in which bacteria are the carriers of information. We show from existing literature that bacterial *multi-conjugation* process resembles the phenomenon of collision in such bacterial nanonetworks. Furthermore, the effect of such collision on the maximum acheivable throuhput is thoroughly analyzed. Second, we study "catastrophic collision" in the context of electromagnetic nanonetworks, which includes the sequential collision of symbols of a same packet. We analyze the event of catastrophic collision by modeling the energy of a receiver nanodevice as a *Markov process*. Analytical results reveal that the more the receiver is in the "OFF" state, the lesser is the successful probability of reception of symbols.

Third, we investigate the problem of optimizing energy consumption in the context of Green Wireless Body Area Nanonetworks (GBANs), which are capable of communicating in both the electromagnetic and molecular communication modes. We formulate the optimization problem as a cooperative *Nash Bargaining game*. In GBANs, nanodevices bargain with one another in terms of their available energy in order to optimize Quality of Service (QoS) of the system. The results show that the probability of mistuning, which refers to mismatch on the agreement of choice of communication modes between the sender and receiver nanodevices decreases by up to 42%. Finally, we study the problem of optimizing energy consumption for asymmetric data delivery in an envisaged *Coronary Heart Disease* (*CHD*) monitoring system consisting of nanodevice-embedded Drug Eluting Stents (DESs), which are termed as *nanoDESs*. We propose a simple distance-aware power allocation algorithm, named as *catch-the-pendulum* which exploits the periodic change in mean distance between a nanoDES inserted inside affected coronary artery and a nano-macro interface which is placed in the intercostal space of the rib cage of a patient who is suffering from a CHD disease. Extensive simulations confirm better performance of the proposed algorithm in terms of energy consumption, packet delivery, and shutdown phase.

Keywords: Nanoscale communication networks, bacterial conjugation-based nanonetworks, green wireless body area nanonetworks, multi-conjugation, catastrophic collision, Nash bargaining game, nanoDES, asymmetric data delivery.