Consensus Problem in Molecular Communication with Leader Election and Energy Harvesting Algorithms

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Nanotechnology offers promising solutions to problems in biomedical, industrial, environmental and military fields, such as advanced health monitoring, drug delivery systems, and wireless nanosensor networks for biological and chemical attack prevention. A nanomachine is the basic functional unit of any nano-system. The component in these nanomachines is able to perform a specific task such as communication, computation, data storing, sensing and/or actuation at a nano level. The interaction between these nano machines forms a nanonetwork expanding the capabilities and applications of single nanomachines by enabling them to execute more complex tasks in a distributed manner. Molecular communication is considered a bio-inspired paradigm, in which molecules are transmitted, propagated and received between nanomachines.

We consider a nanonetwork consist of n nanomachines communicate through a shared unguided medium by stipulating and controlling diffusion based molecular communication. Each nanomachine $n(i)$ (where, $i \in \{1,2,..N\}$) has the ability to sense the concentration of molecules from the environment and to emit molecules at a particular rate into the environment, one of these n nanomachines is considered as a special node (leader node) $node_c$ (that has some responsibilities to direct and control processes of the consensus protocol), and other nanomachines in different positions from $node_c$ within its transmission range distance d_{max}. We assume that the transmitter nanomachine encodes information depending on the changes in the concentration of the molecules in the environment. The medium of communication might contain residual molecules from previous diffusion (as it is not necessary all molecules would be received by the other nanomachines), and also contains other types of molecules which can be considered as a noise. We assume that nanomachines are placed within a close range so that if one diffuses then all other nanomachines can receive some molecules. When a nanomachine diffuses a unit u of molecules into the propagation medium, these molecules are assumed to spread freely, and their dynamics can be described by the Brownian motion. We assume that nanomachines are synchronized, and can communicate in predefined time round T_0. We assume that T_0 is a system parameter and its length could depend on the network geometric properties. The consensus protocol is consisting of number of different steps in different time rounds. We assume that $T_0=k\ (d_{max})^2/D$, where k is constant that can be equal 1, d_{max} is transmission range distance of the central node $node_c$, and D is the diffusion coefficient. We study consensus problem in molecular communication, inspired by model in [1], where the authors consider an iterative method for communication among nanomachines which enables information spreading and averaging in their nanonetwork. In this paper, we propose a consensus protocol among nanomachines in diffusion based molecular communication. The proposed protocol, includes two phases that take place throughout different time rounds. The first phase, is to estimate the number of nanomachines via $node_c$, the second phase includes number of steps, where each of the nanomachine diffuse their initial value to $node_c$. Then, $node_c$ computes the average of all initial value, which is considered as an important value to reach consensus. We consider two scenarios to implement the consensus protocol. In the first one, a leader election algorithm is utilized to elect a central node. In the second scenario, we assume that nanomachines have energy constraint, so we define an energy harvesting model as a nanomachine might not be able to communicate due to the lack of energy. In each scenario, we compute the consensus protocol's rounds number, taking into account the required time to elect a central node and the needed time to harvest enough energy.

Additional Key Words and Phrases: Molecular communication, Diffusion, Consensus, Leader election, Energy model

REFERENCES

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