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Intitulée

Enhancing the Sensor Network Lifetime by Topology Control and Sleep/Wake Scheduling

Soutenue le xx/xx/2016, devant le Jury composé de :

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Abstract

Wireless sensor network technology has the capability of quick capturing, processing, and transmitting critical data in real-time. This technology has made possible to monitor hostile, inaccessible and remote areas. It fulfills a very important need for any real-time monitoring, especially in hazardous scenarios. However, one of the critical challenges in wireless sensor network is the energy conservation. Indeed, WSN consists of a large number of sensor nodes randomly deployed, and, in many cases, it is impossible to replace sensors when a node failure occurs. Thus, applications tend to deploy more nodes than necessary to cope with possible node failures and to increase the network lifetime, which leads to create some sensing and communication redundancy. However, sensors in the same region, may collect and forward the same information, which will waste more energy. Topology control is considered one of the most important techniques used in wireless ad hoc and sensor networks to reduce energy consumption and radio interference. It aims at exploiting the network density to conserve energy and extend the network lifetime by keeping a small set of nodes in active state and turn off the redundant ones. This can be accomplished by adopting a sleep scheduling approach, without sacrificing the network functionalities.

Several topology control algorithms, using the scheduling technique, have been proposed in the literature. The key idea of these protocols is to manage the topology by identifying redundant nodes and schedule nodes for active or sleep modes in order to reduce energy consumption. They determine how many and which nodes should be allowed to sleep, with the purpose to ensure connectivity. However, when running these algorithms, the number of the active nodes is not always the minimum and sometimes the formed topology is not connected. It is difficult to ensure connectivity without sacrificing the optimality. When optimality is achieved, the topology formed by the active nodes may be disconnected. Furthermore, a large communication overhead will be produced during the search of the redundant nodes which leads to large energy consumption. Moreover, few existing works take into consideration the energy wasted during transitions in their scheduling strategy.

In this work, we first, propose a taxonomy of sleep scheduling based-topology control protocols. We classify the topology control protocols based duty cycling into four categories: Flat protocols, Grid-based protocols, Cluster-based protocols and Group-based

protocols. Second, we propose a new grid-based algorithm, called GTC: a Geographical Topology Control protocol, that benefits from the advantages of the existing grid-based algorithms to identify redundant nodes. GTC uses a new scheduling strategy which reduces the number of transitions between active and sleep states in order to minimize the transition energy and ensure the network longevity. It also minimizes the frequency of active nodes election and allows some stability in the topology that avoids a loss of connectivity.

The second contribution investigates the group-based topology control category, since it uses only neighborhood information to group redundant nodes together. So, we propose a Group-based Energy-Conserving Protocol (GECP) which exploits the sensor redundancy in the same region by dividing the network into groups so that a connected backbone can be maintained by keeping only one active node in each group and turning off the redundant ones. It identifies redundant nodes, organizes them into groups with a low communication overhead. It uses the same scheduling strategy as GTC which aims to minimize the number of transitions between active and sleep states and, hence, extend the network lifetime.

In the third contribution, a new distributed Redundancy aware Topology Control Protocol (RTCP) is proposed which uses only the neighbor set as the communication redundancy metric, to avoid any assumptions about communication regularity. RTCP identifies redundant nodes and organizes them into groups with a low communication overhead. The redundant nodes that satisfy some eligibility rules, can form group according to their redundancy degrees, which leads to have a reduced number of groups without lose the network connectivity. RTCP defines a Threshold of connectivity level which allows applications to parameter the desired connectivity degree in the reduced topology.

The last contribution consists on the improvement of RTCP to allow to each sensor node to determine dynamically the value of the Threshold of connectivity level. The proposed protocol, called ERTCP: Enhanced Redundancy aware Topology Control Protocol uses a new metric to determine the equivalent nodes.

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