Chapter 22

A Distributed and Local-World Topology Evolution Model for Wireless Sensor Network

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ABSTRACT

In this paper, a new evolution model based on complex network among the cluster heads in wireless sensor network is proposed. The evolution model considered distributed and local-world mechanism during the evolving process. The theoretical analysis of this model exhibits a power-law degree distribution with mean-field theory, which provides good fault-tolerance. The degree exponent is not a fixed number, which changes with the distribution of the cluster heads and the energy as well as the communication radius. Furthermore, the degree exponent can lead to an upper limit -2 when the distribution of the cluster heads and the energy are both uniform distribution. Analysis and simulation show that the network exhibits well robustness and a power-law degree distribution.

1. INTRODUCTION

Wireless sensor network (WSN) is a highly distributed network, which is usually made up of hundreds even thousands of distributed sensor nodes organized in ad-hoc paradigm to monitor physical phenomenon (G. J. Pottie, 2000). WSN covers a wide range of applications, since it is easily deployed and self-organized, such as environmental monitoring, military target tracking, natural disaster relief and health monitoring (Akyildiz I F, 2002). WSN has become one of the key modern information technologies, which is changing people's lives and the way people interact with the physical world. Meanwhile, the sensor nodes are battery operated. Many applications of

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WSN require thousands of sensor nodes which are deployed in remote areas, and the battery replacement is impractical (Lindsey S, 2002). Therefore, energy efficiency in in-network data processing is very important, and how to prolong the lifetime of the network is an important concern in the study of WSN (Tan, H. Ö, 2003).

The study of complex networks (Barabási A L, 1999; Watts D.J,1998) has become a common focus of many branches of science, which can describe many systems in nature, such as the WWW, social networks and so on (Albert R, 2000). Most complex networks are scale-free networks, which are robust against random removal or failures of nodes. However, the preferential attachment mechanism which is the important feature of scale-free networks does not work on the global network sometimes, but does work on a local world such in the regional economy cooperative organization, protein–protein interaction network or a domain in the computer network. Xiang Li (2003) proposed a novel evolving network model with the new concept of local-world connectivity. The local-world evolving network model represents a transition between power-law and exponential scaling, can maintain the robustness of scale-free networks and can improve the network reliance against intentional attacks.

Topology construction is an important issue for network connectivity, the network lifetimes and the robustness of the network. The development of complex networks provides new ideas for topology construction of WSNs. Scale-free networks have power-law degree distributions and show an excellent robustness against random node damage. Therefore, it is significant to consider complex networks topology when optimizing the topology in WSNs (A. Helmy, 2003; L. X-Y, 2003; X. Zhang, 2009). Recently, scale-free network has been used in the topology evolution of WSNs (Cheng L J, 2009; Hailin Zhu, 2009).

In this paper, we proposed a local-world and distributed topology evolution model for wireless sensor networks. Different from existing schemes, the proposed model considered a distributed mechanism during the evolving process.

The remainder of this paper is organized as follows. In Section 2, the related work is summarized. In Section 3, an algorithm of local-world and distributed topology evolution model is proposed and analyzed. In Section 4, the simulation to present the features of the networks generated by the proposed algorithms is given. Finally, the conclusion of this paper is given.

2. RELATED WORK

Recently, many energy-aware and fault-tolerant topology control algorithms for wireless sensor networks have been presented. Xiang Y L (2003) first considered how the transmission range is related with the number of nodes in a fixed area such that the resulted network can sustain k-fault nodes with high probability, and then present a localized method to control the network topology. Bernd Thallner (2005) presented an improvement of topology control algorithm for very dynamic networks and low power devices, which constructs a fault-tolerant topology for energy efficient and fault-tolerant multi-hop communication in a two-tier network consisting of a large number of wireless nodes and several gateway nodes. Abhishek Kashyap (2006) considered the problem of adding the smallest number of additional (relay) nodes so that the induced communication graph is 2-connected, and extensions to higher dimensions, which extends with the same approximation guarantees to a generalization when the locations of relays are required to avoid certain polygonal regions. Redundancy mechanism is realized to keep good fault tolerance and robustness. However, with the increasing communications, it reduces the performance of system and the lifetime of the wireless sensor networks. The complex network theory shows that complex system can keep as well robustness and fault tolerance as in less communication.

Related Content