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A self-organized structure for mobility management in wireless networks ☆

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ABSTRACT

The objective of this work is to analyse performance of unstable mobile nodes with self-organization structures in Delay Tolerant Networks (DTN). This process enables the nodes to utilize their power fairly, and ensures that the links are established between nodes and used to improve the connectivity. In this paper two approaches are proposed: 1. Self-Healing (SH) and 2. Unstable Topology Structure (UTS) approaches based on localized computations. The proposed work is proven with simulations by analysing node degree, coverage area and Quality of Service (QoS) parameters. The performance of the work is analysed in a network simulator with mathematical models.

1. Introduction

Topology structure is a technique used mainly in wireless DTN to reduce the initial topology [1–3] of the network in order to save battery power, reduce interference and extend the lifetime of the network. The main goal is to reduce the number of active nodes and active links, preserving the resources for future maintenance in DTN. The necessity of power control [4,5] arises for two reasons. First, it improves the battery life; second, it can impact on the traffic carrying capacity of the network. Unlike wired networks, each node in a wireless multi-path network can change its set of one-hop neighbours, and thereby the overall network topology, by simply changing its transmission and reception power. Without proper topology control algorithms, DTN suffer from poor network utilization and short network lifetime. In DTN, There are many possible routes to a destination, and the nodes use large transmission power to send packets to relatively remote sensor nodes. Many of these problems can be alleviated by topology control techniques; instead of using the possible connectivity [6] of a network to its maximum possible extent, a deliberate choice is made to restrict the topology of the network. Topology control for DTN aims to achieve network-wide or session-specific objectives, such as reduced interference, reduced energy consumption, and increased network capacity, while maintaining network connectivity.

A topology control protocol should deal with all network dynamics and ensure that the network is connected with power efficient links. Many topology control algorithms like COMPOW [7] (Common Power), *k*-Neigh [8] and cone-based topology control (CBTC) [9] are used to maintain the power efficiently, but these approaches do not support self-organization structures during the movement of the nodes. In *k*-Neigh, which assumes continuous transmission until it finds *k*-Neighbours; there is no guarantee of connectivity. In the case of CBTC each node keeps growing the transmitting power until it finds a

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required neighbour or until the node reaches the maximum power. When considering COMPOW, it maintains a common power level, able to reach all nodes in the network. The performance of all these protocols is limited, considering the network dynamics. These approaches motivated us to develop a localized, asynchronous, neighbour-aware structure in wireless DTN that enables nodes to utilize their power fairly and efficiently.

1.1. Necessity of SH structure

Nodes able to form a tree structure are named as SH nodes (used for alternate routing). Once a node is identified as an SH node, it allows unidirectional data flow from leaf nodes (node attached with SH nodes or other than SH nodes/source/destination). This unidirectional flow is used to improve the network lifetime and reduce congestion. The necessity of power control is depicted in Fig. 1. Here nodes Nd1 and Nd3 need to send the packet to Nd2 and Nd4 respectively. Suppose maximum transmission power of each node is 25 mW. But here only 1 mW power is enough to transmit the packet from Nd1 and Nd3.

Thus it can save on battery power. Secondly, in the same figure Nd3 wants to send packet to Nd4 at 1 mW, Nd1 send at 1 mW to Nd2, then both transmissions are received successfully since sender nodes use minimum transmission power to reach destination. If Nd1 broadcast at 25 mW, then interface on Nd4's reception from Nd3 will be high, leading to the loss of packet. Thus disproportional use of one node's power may result in the disfunctionality of other nodes. Thus power control also helps to enhance the traffic carrying capacity.

2. Related work

Alexiset al. [10], gives the survey on graph theory-based topology control methods. Each modelling follows one-hop connectivity and maximum node degree unbounded ($n-1$). Relative neighbourhood graph (RNG), has an edge uv if and only if $||uv|| = 1$ and the intersection of two open disks centred at u; v with radius $||uv||$ contains no node w element of V. The basic idea of the practical topology control algorithm is that every node orders its neighbours (set of nodes in the maximum transmitting range) according to a criterion (e.g., link quality), every node transmits its order at maximum power, based on its own order, and, on the orders of its neighbours, every node determines the set of 'logical' links according to a simple rule. This type of topology control algorithm is given in [11–13], used to abandon long distance neighbours.

Blough et al. [8] proposed a k-Neigh protocol for symmetric topology control in ad hoc networks. K-Neigh is a topology control algorithm based on the number of neighbours and neighbours bounded by a specific value K. Nodes do not know their positions; they simply calculate the distance between themselves and their neighbours. This assumes a continuous communication range and defines it until it reaches k-neighbours. The estimated preferred value of k that guarantees connectivity of the communication graph with high probability 9. Wattenhofer et al. [9,14], proposed a distributed approach for topology control named CBTC. Here node u transmits with the minimum power $P_{u,\alpha}$ required to ensure that in every cone of degree α around u, there is a node that u can reach with $P_{u,\alpha}$. Network connectivity is preserved by taking $\alpha = 2 * \text{pi}/3$.

The need for CBTC arises when using GPS, which does not work in indoor environments. CBTC requires only directional information; it must be possible to estimate the direction from which another node is transmitting. Directional information is found out from directional antennae. CBTC is relay region based, and may have received the most attenuation. Nodes know information about their neighbours based on their relative signal strength and the signal arrival angle. Analysis of a minimum spanning tree (MST)-based topology control algorithm is given [15]. Building of a connected global MST-like topology with only bidirectional links occurs in a localized way. The topology constructed preserves the network connectivity. The

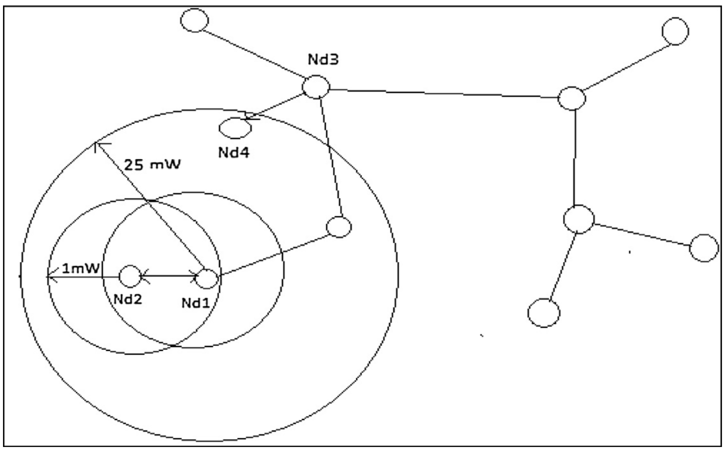

Fig. 1. Necessity of DTN topology control.