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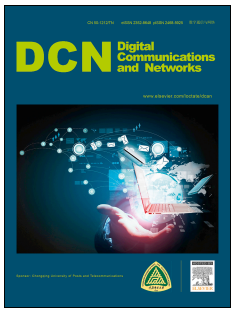

Percolation analysis of large-scale wireless balloon networks

M.D. Nashid Anjum, Honggang Wang, Hua Fang

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Percolation Analysis of Large-Scale Wireless Balloon Networks

MD Nashid Anjum, Honggang Wang, Hua Fang

University of Massachusetts Dartmouth
285 Old Westport Rd, Dartmouth, MA, USA 02747

Abstract

The recent advancement in wireless technology has identified the Wireless Balloon Network (WBN) as a rapid and lucrative solution in order to provide internet facilities in the deprived and challenging areas. A few widely renowned companies such as Google, Space Data Inc., etc., have already made news by initiating their projects based on high altitude WBNs to provide internet facilities in remote areas. Unfortunately, the technical details have been kept confidential so far and mostly unknown to the public research arena. In this paper, we attempt to analyze the percolation properties of the large-scale WBN considering both homogenous and heterogenous wireless nodes. In order to do so, we have modeled WBN as a large-scale random network where the path-loss models of the homogenous and heterogenous WBNs have been reduced into GDM (Gilbert's Disk Model) and RGDM (Random Gilbert's Disk Model) respectively. The bounds on the critical density regime have been derived for both percolation models. Additionally, this paper implemented an experimental test bed for WBN percolation model. Consequently, the findings of this research could be crucial in order to estimate the essential network properties.

Keywords: Percolation, connectivity, WBN, PPP, GDM

1. Introduction

Balloons have been used for gathering weather information since last few decades [1]. However, the concept of the wireless balloon network (WBN) has been introduced very recently. A few widely renowned companies such as Google, Space Data Inc., etc., have recently commenced their projects based on high altitude wireless balloon networks in order to provide internet facilities in the remote areas [1][2][3]. The balloon nodes of a high altitude WBN are deployed over the stratosphere atmospheric layer which is around $6 \sim 31$ miles over the ground level. However, controlling movements of balloon nodes and network topology can be rather challenging in high altitude WBN. In order to tackle this difficulties Facebook innovated a groundbraking solution by replacing the balloon nodes of the WBN by solar drones [4][2].

Besides high altitude WBNs, low altitude WBNs have been envisioned as a rapid solution to provide temporary networking facilities over hazardous and affected areas during the period of natural calamities [5][6][7][8]. In addition, the pilot tests of the WBNs have been done successfully on both the high altitude [2] and low altitude platforms [7][8]. Furthermore, the simple infrastructure, low cost, easy portability, and rapid installation capability of WBNs have proved its immense potential in the application of wireless technology.

Unfortunately, the research progress of the WBN is being kept behind closed-doors so far and merely a few of it have been disclosed in public research platform. Though a few research works have been found in the literature regarding low altitude WBNs ([5][6][7][8][9][10]) there are barely a couple of research works have been found regarding high altitude WBNs ([1][2][3]). Furthermore, these works mostly study the application, infrastructure, and potential of the WBN technology. So far, the analysis of the network properties have been ignored largely.

In this paper we put effort to analyze the percolation property of a WBN. Unlike ordinary ad-hoc networks a WBN is three dimensional in nature thus the percolation modeling becomes more challenging. Moreover, a WBN can be

Email addresses: manjum@umassd.edu (MD Nashid Anjum), hwang1@umassd.edu (Honggang Wang), hfang2@umassd.edu (Hua Fang)