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Using Spreadsheet Maps for the Placement of Low Altitude Platform (LAP) Wireless Network Nodes After Disasters:

A Practitioner-Friendly Approach to Visual Optimization

Larry J. LeBlanc, Vanderbilt University, USA
Michael R. Bartolacci, The Pennsylvania State University, USA
Thomas A. Grossman, University of San Francisco, USA

ABSTRACT

Low altitude platform (LAP) architectures are an emerging platform for providing temporary wireless network connectivity to areas with a damaged fixed wireless network infrastructure. The authors propose a spreadsheet-based approach for practitioners to locate LAP nodes in the field. This approach does not require radio frequency propagation expertise and incorporates standard models to display the coverage areas for the placement of LAP aerial devices. The proposed tool allows the transmission range for a given aerial device to be visually optimized during deployment. The spreadsheet-based tool the authors are proposing is expressly suited for battery-powered LAP architecture devices with payload weight restrictions, such as those utilizing balloons or kites, that can be quickly deployed by emergency responders. An additional contribution of this work is the development of a hybrid propagation model for LAP device transmissions for deployments above 200 meters which is absent in the literature. This model is a linear combination of two existing models for free space radio propagation.

KEYWORDS

Aerial Device, Helikite, Long-Term Evolution, Low Altitude Platform, Mobile Network Node, Propagation Model, Radio Propagation, Transmission Radius, Unmanned Aerial Vehicle

INTRODUCTION

With the increasing frequency of natural and manmade disasters across the globe, the need for the efficient coordination of first responders and emergency personnel has increased as well. This work seeks to provide the design for a spreadsheet-based tool that can assist field practitioners in the placement of aerial wireless network nodes in areas affected by disasters. Spreadsheet tools have been proposed and deployed for a wide range of disasters and crises including pandemic planning. (Abramovich, et al., 2008) Ginige, et al. (2014) discussed the development and use of a spreadsheet

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application for sharing information following earthquakes in Italy. Such work shows not only the relevance of our proposed tool, but also the potential impact with respect to making emergency response more efficient and save/improve lives of an affected populace.

Recent technological advances in what are known as Low Altitude Platforms (LAPs) have allowed the creation of ad hoc wireless networks to be deployed in the field to assist in the rescue/cleanup after disasters. This work first presents the case for the utility of such platforms in areas affected by disasters where traditional wireless communications are not functioning. It then goes on to describe the basis for a visual optimization approach that is implemented on a spreadsheet to reduce the training required for a user and also to facilitate its use in the field via a portable wireless device. The proposed tool represented a very low-cost approach to improving LAP aerial node placement efficiency due to the fact that it requires only a few hours of spreadsheet development work and it can be run on any wireless device that supports MS Excel. The contribution of the proposed tool is one of practical value to field practitioners who must make judgements on where to deploy LAP network nodes to get "optimal" coverage and service to aid emergency response. Currently, no such tool exists for this emerging wireless communications platform. An additional contribution is the derivation of a hybrid radio propagation model that is to be utilized by tool for displaying LAP transmission radii to field practitioners for deployment heights above the current height limit of standard cellular phone network models.

With the growth in global populations settling along coastlines and geologic faults, and rapid industrialization of all corners of the world, comes the increasing likelihood of larger numbers of people being severely affected directly by natural disasters. Hurricanes, earthquakes, tsunamis, dam failures, oil/chemical spills, etc. create the need for emergency communication among first responders, governmental agencies, non-government aid organizations (NGO's) and the affected populace following each tragic event. One only has to review the ruin left in the path of Hurricane Dorian as it ravaged the Bahamas and created havoc up and down the U.S. east coast. One of the authors was forced to evacuate while visiting coastal North Caroline as Dorian proceeded up the Atlantic coastline of the U.S. As this is written, it is still too early to tally the exact death and destruction caused by Dorian, but another storm that the same author experienced first-hand in the U.S. mid-Atlantic states left a lasting memory. To give a perspective on the tragic impacts of natural disasters, Hurricane (Superstorm) Sandy that came ashore in New Jersey on October 29, 2012 resulted in 53 fatalities in New York State alone. (Greenstein, et al., 2016) In the New York metropolitan area overall (which includes some areas of New Jersey and Connecticut), 97 deaths and billions of dollars of damage was done by the superstorm. (Schmeltz, et al., 2013) Several of these fatalities were the direct result of flood waters that inundated the New York City metro area due to storm surge on coastline, rivers and estuaries, thus preventing residents from evacuating. Other fatalities were the result of wind damage and its associated power outages. In lower Manhattan "nearly 35% of the commercial office space below Chambers Street was temporarily incapacitated by flooding and power outages." (Dunning, 2013). In an urban area such as New York City, many residents would rely on public transportation to evacuate affected areas, but unfortunately subways, buses, and trains were incapacitated in the wake of Sandy in severely affected areas. The lack of a means to evacuate took its toll on the disabled, the poor, and the unprepared. The task of checking on residents left in severely affected areas was then left to first responders and neighbors when the areas became accessible.

Wireless telecommunication is essential for search and rescue, damage assessment, food/supplies delivery, and other vital functions after a disaster. "The primary technological challenge after a disaster is rapid deployment of communication systems for first responders and disaster management workers". (Manoj and Baker, 2007, p. 51) Designing wireless networks to be deployed, in the face of post-disaster conditions which may include a loss of power, inoperable wireless terrestrial base stations, and limited road access, is a challenging endeavor. This design problem is compounded when multiple responding groups are involved in a given area. (Meissner, et al., 2002) The coordination of all these activities among different groups, and within an individual group, of emergency responders