A Disaster Management Specific Mobility Model for Flying Ad-hoc Network

Amartya Mukherjee, Institute of Engineering and Management, Kolkata, India
Nilanjan Dey, Department of Information Technology, Techno India College of Technology, Kolkata, India
Noreen Kausar, Faculty of Mathematics and Computer Science, Alfaisal University, Riyadh, Saudi Arabia
Amira S. Ashour, Department of Electronics and Electrical Communication Engineering, Faculty of Engineering, Tanta University, Tanta, Egypt
Redha Taiar, Université de Reims Champagne Ardennes, Reims, France
Aboul Ella Hassanien, Faculty of Computers and Information, Cairo University, Cairo, Egypt & Faculty of Computer and Information, Beni Suef University, Beni Suef, Egypt & Scientific Research Group in Egypt (SRGE), Cairo, Egypt

ABSTRACT

The extended Mobile Ad-hoc Network architecture is a paramount research domain due to a wide enhancement of smart phone and open source Unmanned Aerial Vehicle (UAV) technology. The novelty of the current work is to design a disaster aware mobility modeling for a Flying Ad-hoc network infrastructure, where the UAV group is considered as nodes of such ecosystem. This can perform a collaborative task of a message relay, where the mobility modeling under a “Post Disaster” is the main subject of interest, which is proposed with a multi-UAV prototype test bed. The impact of various parameters like UAV node attitude, geometric dilution precision of satellite, Global Positioning System visibility, and real life atmospheric upon the mobility model is analyzed. The results are mapped with the realistic disaster situation. A cluster based mobility model using the map oriented navigation of nodes is emulated with the prototype test bed.

KEYWORDS

Dilution of Precision (DOP), Direction Cosine Matrix (DCM), Disaster Management, Flying Ad-Hoc Networks (FANET), Mobile Ad-hoc Network, Mobility Model, Unmanned Aerial Vehicle

1. INTRODUCTION

The extended Mobile Ad-hoc Network (MANET) and Vehicular Ad-hoc networks (VANET) are the most emerging research domains in contemporary decade. MANET can be visualized as a group of network nodes that can perform a collaborative task. In such case, the network nodes may be homogeneous or heterogeneous type where the different nodes may use the same (for homogeneous) or diverse (of heterogeneous) network protocol or routing methodology. In addition, the network node can have different kind of nature based on the node movement. Based on the physical location of the network, the velocity of the nodes can be the same or different.

Typically, the vehicular Ad-hoc network is a subset of MANET that has been deployed within a group of the ground vehicle. The majority of such network cases consist of a series of vehicles that can generate a connectivity to establish an Internet infrastructure. The movement model in their case is considered to be non-randomized and organized movement fashion. Several routing (Vieira
et al., 2013) methodology and mobility model (Longjiang et al., 2013) has been described beneath this philosophy.

There are several classifications can be considered for the network architecture, such as pure cellular or Wireless local area network (LAN), hybrid, pure Ad-hoc (Bruno et al., 2005; Sarkar et al., 2007; Katsaounis et al., 2014). In pure cellular or wireless LAN architecture, the communication between the vehicle and the gateway has been done using cellular tower. In Ad-hoc category, the data acquired by a sensor have been relayed from one vehicle to another. In the hybrid architecture, both cellular towers as well as the vehicles take the same responsibility to perform the message transfer. The routing protocol such as Ad-hoc on demand distance vector (AODV) (Santhiya et al., 2014), Preferred group broadcasting (PGB) (Lee et al., 2010), Intelligent Dynamic Source Routing (DSR) (Akhter & Singh, 2013), Temporarily Ordered Routing Algorithm (TORA) (Weiss et al., 2005) are the basic back bone of such infrastructure. Amongst that, some couple of traffic specific routing scheme, such as the shortest path based geographical source routing GSR (Cadger et al., 2013). Anchor based street and traffic aware routing (A-STAR), Street topology based routing (STBR) (Paul et al., 2012) and Greedy traffic aware routing (GyTAR) (Ren et al., 2011) are the most frequently introduced schemes.

In the case of mobility modeling perspective VANET (Vehicular ad hoc networks), it can run on several categories of synthetic model (Zhang et al., 2013). The node can move randomly, maintaining a hydrodynamic phenomenon or moves such as the element of First-in-first-out (FIFO) queue. The vehicle mobility can be viewed in macroscopic or microscopic phenomena (Mitsakis et al., 2014). In macroscopic model, the entire motion constrains are to be considered such as streets, road junctions and traffic lights. Therefore, the node’s mobility is predefined with respect to a geographical region and highly depends upon topological maps, obstacles, event points, non random distributions of vehicles driving pattern. Microscopic model is more focused on the behavior of individual vehicles. Although such architectures are widely used in various real life applications, there are some sort of VANET limitations that to be considered in emergency situations, such as earthquake, flood, and cyclone.

The main disadvantage in this context is that a VANET follows an organized movement path to establish the Internet infrastructure amongst \( n \) number of ground vehicle by applying several reactive, proactive and position based routing protocol. The VANET infrastructure cannot be easily deployed where disaster scenario is concerned, as the organized path is hardly available. Due to the current technological enhancement in the last three years, especially the advancement of on board Micro Electro Mechanical System (MEMS) sensor (Degawa et al., 2014) and open source rapid prototyping technology (Lin et al., 2014), the Ad-hoc network concept is migrating beyond the limitation of MANET and VANET to even more smarter realization of Flying Ad-hoc Network (FANET). This newly introduced system is dedicatedly focused on communication and mission critical information exchange in crisis situations. The main platform for the deployment of the FANET ecosystem is typically Small fixed wing (Baek et al., 2013) or a Multirotor (Ramli et al., 2013) aerial vehicle along with any stationary high altitude aerial platform (typical weather balloon).

An Unmanned Aerial Vehicle is a vehicle that can be navigated without a human pilot on board that has several classifications such as the fixed wing and Multirotor system. A fixed wing UAV has been used, while large geographical areas need to survey. Such kind of systems is:

1. More forgiving in the air in the context of piloting and operational error.
2. Has a natural gliding phenomenon even at very high altitude.
3. Offers satisfactory amount of payload capability within vast distance with low power consumption.
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