

**A Framework for Data Dissemination and Coverage
Enhancements for UAV Assisted Wireless Ad hoc Network**

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ABSTRACT

Unmanned aerial vehicle (UAV) popularly known as a drone is a versatile aerial robot that has found practical applicability in military, commercial and civilian use. The UAV in collaboration with wireless network can provide coverage and service solutions that can uplift the inherent problems with the wireless ad hoc network. The aerial and ground network together can perform complex tasks and mission objectives. The UAV can be used to assist ground ad hoc network leading to significant gains in network performance and energy consumption. The UAV can be used as a relay to transmit data from one part of the topology to another, a mobile base station for wireless sensor network and service provider for isolated nodes. The collaborative network presents challenges of its own. The enhancements require careful and strategic planning for UAV placement and trajectory design. The wireless network requires schemes for collaborative formation of the aerial and ground wireless ad hoc network. The topological formation, designing effective coverage solution and incorporating dynamic path changes constitute the main effort in using UAV assisted wireless ad hoc network.

This thesis presents a framework for UAV assisted wireless ad hoc networks. The framework uses UAVs to form collaborative ground to air wireless ad hoc network. The collaboration yields substantial benefits in terms of network performance for the ground ad hoc network. The framework describes the scheme that can be used to effectively use UAVs to assist in packet forwarding by the ground ad hoc network. The UAV offers line of sight wireless coverage with low latency paths for the ground nodes. The ability of aerial mobility combined with versatile mobility and deployment models ensure the high magnitude service availability to the ground wireless ad hoc network. In order to facilitate the data dissemination process, the framework strategically redesigns the

network topology to work in collaboration of the aerial network. Path formulation strategies are necessary to provide fair and on demand service to the ground nodes. Towards this end, first an optimized clustering method that works in collaboration with the aerial node is devised. Then a coverage solution is present to maximize the node coverage in wireless ad hoc network.

The wireless ad hoc network is marred by congestions and latency issues, the main reasons being their multi-hop nature and use of same wireless medium by multiple nodes. A wireless network faces delays in packet transmission as the number of nodes communicating in an area rises. The multi-hop routes of an ad hoc network further introduce delays and packet drops. The clustered wireless ad hoc network divides the network topology in small manageable sections. While the clustered wireless ad hoc network focuses on reducing energy consumption, the cluster-heads get burdened with data traffic. The node hierarchy in packet transmission leads to congestion. The UAV assisted wireless ad hoc network can eliminate these multi-hop routes by introducing line-of-sight coverage and reducing the hop count. The UAVs can act as cluster-head and mobile base station to effectively circumvent the short comings of wireless ad hoc network. The proposed method uses end-to-end delays as a factor for topological divisions. The proposed method monitors the network and performs sub-divisions in topology whenever the performance of a cluster falls below an acceptable threshold. The UAVs can be deployed for each cluster for effective data dissemination solutions. The method eliminates the need for multi-hop paths, cluster-head for data forwarding and selection of cluster-head before data transmission can commence. The simulation results show that higher data transmission rate and packet delivery ratio is achievable while keeping the energy consumption on par with existing approaches.

The UAV assisted wireless ad hoc network requires placement and trajectory optimization. The ground nodes are seldom localized to a given area. The variation in topology along with node mobility patterns makes the ground node coverage a complex task. The carefully planned UAV placement technique can serve maximum number of nodes with minimum number of UAVs similarly a single UAV model can serve maximum number of nodes with minimum number of waypoints. The placement and path formulation model should reduce neighbor interference from other UAV transmissions. The proposed coverage enhancement scheme uses a UAV's wireless beam width to map the area and find potential placement coordinates that can minimize the neighbor interference, cover maximum number of nodes with line-of-sight and provide service to isolated nodes in the topology. The proposed method uses similarity coefficients to find similarities in an area of the topology and thereby adjusting the placement coordinates to account for minimal overlap of services. An evolutionary algorithm is used to find a suitable placement solution from a search space of candidate solution. The simulation results shows that the proposed method can provide service to maximum number of nodes in the topology with limited number of UAVs. Similarly the maximum number of nodes served with minimum waypoints in a single UAV model.

A UAVs trajectory is generally mapped to the network nodes it needs to serve. A wireless network will face performance issues when a large number of users try to communicate in vicinity. The higher network utilization by the users creates routing hotspots in the direction of the data flow. The routing hotspot typically reduces average throughput and packet delivery ratio in their vicinity. The wireless ad hoc network is prone to link failure. A crucial node can simply leave the network or run out of battery leaving section of a topology disconnected. The event-handling model can identify these events and use a UAV to assist the wireless ad hoc network. However, fixed trajectory models are

inadequate to process the situation. The UAV assisted wireless ad hoc network require on demand placement solutions to dynamically change their trajectory and serve a section of topology that is experiencing network performance issues. The proposed framework uses time series-based prediction models to find topological areas with performance issues and probabilistic prediction to find events with performance issues in the topology. The identification of performance issues is used to trigger a response that places a UAV to the stressed area thereby providing faster line-of-sight data flow path to the ground ad hoc network.