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Persistent Systems, LLC

Case Study:

Wave Relay MANET Communication System Connects Swarming Unmanned Aerial Vehicles

The Johns Hopkins University Applied Physics Lab (JHU/APL) is developing the next generation of unmanned aerial vehicles (UAVs) for use in military applications. As currently deployed, each military UAV requires a separate soldier to operate it from the ground during the mission. APL is developing swarming UAVs that fly in self-coordinating groups, allowing a single ground controller to monitor the mission of an entire swarm of UAVs. This reduces the number of human operators and increases the intelligence of the autonomous vehicles.

Fig 1: APL Engineer Launching UAV

While in the past UAVs communicated via a sophisticated ground control station, the development of the swarming capability placed unique new requirements on the wireless communication system: it required a completely peer-to-peer mobile ad hoc networking system that would enable the UAVs to communicate directly, with or without connectivity to a ground control station. Only a true peer-to-peer MANET would allow the UAVs to coordinate their missions and exchange data directly with one another. In addition to the peer-to-peer communication requirements, there was also a need for wireless communication both between the planes and from the planes to the ground controller. By utilizing the planes as communication relay points, the communication range could be significantly extended.

Fig 2: Autonomous UAV Landing

APL therefore selected the Wave Relay MANET system to provide wireless communication for the swarm of UAVs, the ground control station, and the chem/bio sensors that are remotely deployed on the ground. Small single radio embedded Wave Relay routers were integrated into the UAV wings, and custom antennas were integrated into the winglets. The UAV has extremely stringent requirements with respect to size, weight, and power consumption. The Wave Relay system was smaller and lighter and consumed less power than the previous non-multi-hop radios that it replaced.

The Wave Relay system provided APL with the ability to operate in the 900 MHz, 2.4 GHz, or 5 GHz frequency bands. Initial tests were performed in both the 900 MHz and 2.4 GHz bands. The UAV was fitted with a 1 dB omni directional dipole antenna, and the ground station used a small 3 dB rubber duck antenna. The UAV was placed into a holding pattern at a distance of approximately one mile from the ground controller. Extremely low gain antennas were used to simulate a worst-case plane-to-plane communication link. (In future deployments the ground controller could be equipped with a significantly higher gain directional antenna, which would increase range and performance.) TCP throughput tests were conducted to determine the performance of the radios at a one-mile range. The 900 MHz radios were able to achieve real TCP throughput of between 2 and 3.5 Mbps on average, with a maximum recorded throughput of 5.6 Mbps at one mile. The 2.4 GHz radios performed even better, delivering between 5 and 8 Mbps of average throughput, with a maximum recorded value of 13.8 Mbps at one mile. The high throughput provided by Wave Relay exceeds the communication requirements of the swarming application and even provides sufficient bandwidth to stream video from multiple UAVs to the ground control station. Traditionally, the UAV video feeds are handled by a separate radio system; however with Wave Relay it should be possible to transmit both video and communications on a single radio platform.

In addition to testing the throughput and range between the plane and the ground controller, the APL team demonstrated the ability to use multiple planes in a formation

designed to form a communication relay chain. A Wave Relay router was attached to a Chemical/Biological sensor located on the ground. Multiple UAVs coordinated to provide a communication relay, enabling the ground controller to retrieve data from the sensor by relaying it across multiple wireless hops. This multi-hop data forwarding exercise demonstrated Wave Relay's ability to operate as a peer-to-peer MANET communication system providing reliable multi-hop routing even under high levels of mobility.

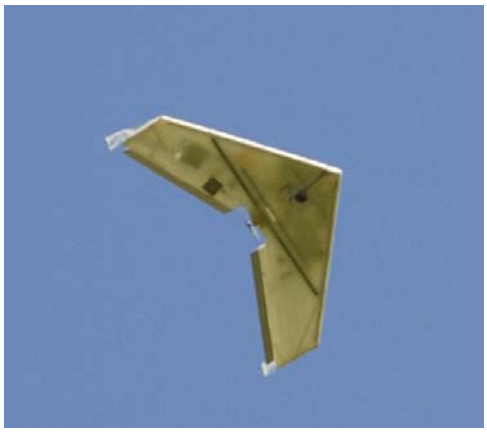

Fig 3: Wave Relay Equipped UAV

The Wave Relay system provided the right combination of size, weight, power consumption, and high throughput communication performance, making it an ideal solution for swarming UAV platforms.

About Applied Physics Laboratory

The Applied Physics Laboratory (APL) is a not for profit laboratory and division of the Johns Hopkins University. APL conducts research and development primarily for national security as well as non-defense projects of national and global significance. APL is located midway between Baltimore and Washington, D.C., in Laurel, MD.

About Persistent Systems

Persistent Systems, LLC is a privately owned wireless mobile mesh network hardware manufacturer. Based in Baltimore, Maryland, Persistent Systems develops high-end mesh networking equipment for telecom providers, industrial and manufacturing companies, and DoD integrators. The key differentiators of Wave Relay when compared with other mesh solutions are its massive network scalability, its ability to operate under high levels of mobility, and its true peer-to-peer design. http://www.PersistentSystems.com