3rd International Workshop on Wireless Networking and Control for Unmanned Autonomous Vehicles

UAVNet: A Mobile Wireless Mesh Network Using Unmanned Aerial Vehicles

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Overview

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Motivation

- Deployment of Wireless Mesh Networks (WMNs) can be time consuming or even impossible in harsh environments.
- Design, implementation, and evaluation of a prototype of autonomous networked UAVs (UAVNet)
- Each quadrocopter-based UAV carries a wireless mesh node, which is directly connected to the UAV’s flight electronics building an IEEE 802.11s WMN.
- Each wireless mesh node acts as access point and provides network access for IEEE 802.11g devices.
Possible Applications

> Communication infrastructure in disaster scenarios
> Emergency situations, e.g., avalanches
> Sensor networks in inaccessible areas
**Hardware Platform**

> **Quadrocopter** *(mikrokopter.de)*
>   — Frame
>   — 4 brushless motors
>   — Battery
>   — Flight electronics
>     - Flight controller controlling motors
>     - Navigation controller with GPS and 3D compass

> **Wireless mesh node**
>   — Professional Mesh OM1P from Open-Mesh
>   — ADAM embedded Linux with IEEE 802.11s
UAVNet Scenario

1. Serial link between wireless mesh nodes and to navigation controller (debug port)
2. Wireless mesh nodes as mesh access points for end systems using IEEE 802.11g
3. Configuration devices to configure and monitor UAVNet using IEEE 802.11g
4. Data traffic between the end systems relayed via IEEE 802.11s
Software Architecture

- **uavcontroller**
  - on mesh node handles any internal / external communication

- **uavclient**
  - on configuration devices and end systems

- **Libraries**
  - **libuavext**
    - TCP/UDP data transfer
    - Error control and data encoding
    - Host name and address configuration/translation, DHCP server for clients
  - **libuavint**
    - Serial connection management
    - Message and command exchange between mesh node and navigation controller
iPhone/iPad Control Software

Positioning type

**Signal distance**
The UAV finds its position depending on the signal strength between the two endpoints.

**Geographical distance**
The UAV finds its position depending on the geographical distance between the two endpoints.
Relay Scenarios with Single/Multiple UAVs

1. 1st UAV explores position of 2nd end system (outgoing from 1st end system) and broadcasts its position when found.
2. Positioning of 1st UAV at centre between end systems
3. Movement of 1st UAV towards 1st end system until predefined RSSI is reached
4. Next UAV moves to 1st UAV and then towards 2nd end system until reaching predefined RSSI to previously positioned UAV
5. Repeat step 4 until all UAVs positioned. UAVs periodically broadcast ping messages with network and UAV information.
Options

> Searching modes

— *Manual*: 1\textsuperscript{st} end system tells GPS position of 2\textsuperscript{nd} end system to UAV.

— *Autonomous*: UAV calculates and visits multiple way points on a spiral until signal from 2\textsuperscript{nd} end system has been detected.

> Positioning modes

— Geographical

— *Signal strength (RSSI)*
Evaluation: TCP in Single-Hop Scenario

[Diagram showing a network setup with drones and client devices, illustrating the comparison of TCP throughput in different scenarios: No UAV, Location Positioning, and Signal Strength Positioning.]
Evaluation: TCP in Multi-Hop Scenario

TCP throughput on the ground
TCP throughput in the air

Ground
Air
UAVNet Demo

Anaheim, December 7, 2012
Conclusions

> UAVNet can be configured, deployed, and monitored by a single user, using an iPad/iPhone control software.
> Implementation of UAVNet without modification of original flight electronics firmware → compatibility and expandability.
> Performance advantages compared to ground-based network
Thank You for Your Attention!

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