They are ready – are they? Examining 802.11n aerial communications of search and rescue UAVs

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Co-work with: Domenico Giustiniano, Mahdi Assadpour, Simon Egli, et al.
SWARMIX

Search and rescue mission

- Minimize completion delay
- Combine cognitive, mobility, sensory skills of search agents
  - Human: smartphones, GPS,…
  - Dog: harness, embedded system, GPS, audio/micro,…
  - UAV: embedded, camera, accelerometer, wind sensor, GPS,…

<<Video>> Thanks to Linda Gerencser (ELTE)

Coordination and networking

- Central planning and control
- Transmission: status, command
- Wireless network: XBee (control), IEEE 802.11n (5GHz, multimedia)

Partners: EPFL, IDSIA, Univ. of Budapest/ELTE, ETH Zurich

www.swarmix.org
Networking Challenges

UAV system view

- Scanning
- Transmitting (networking)

Antenna [1]

- Dynamically changing orientation; lightweight, omnidirectional

Movement

- Changing of position, at possibly high speeds
- PHY: Link quality changes / out of range (disconnections)

To be considered: Battery, motors (?), 3D, airborne, costs …

UAV Networking – Principles [2]

Relaying

Ferrying

Transmission scheduling

- Delay Tolerant Networking (DTN), Adaptive to link quality

UAV Testbed

Swinglet [3]
- Fixed wing UAVs, 80cm wingspan, 500g, 10m/s

Arducopter
- Quadrocopter, operated in ~ 5m/s, few kilograms

Wireless networking package
- Gumstix COM (Overo Tide), Tobi expansion board
- WiFi USB dongle capable of 802.11n (two planar antennas)

Aerial Link Investigations 1/2 …

a Measurement Approach

Throughput of swinglet aerial link: 802.11n auto rate adaptation and fixed MCS1 (max. 30 Mbit/s) [4]

Aerial Link Investigations 2/2

Packet Delivery Ratio [5]

Implications for Image Data Transfer [5]

Transmission time

$T_{\text{transmission}} = \frac{\mathbb{E}[n_{\text{backlog}}]}{S/\mathbb{E}[P]} \cdot \frac{M_{\text{cell}}}{\mathbb{E}[P]} = \frac{\mathbb{E}[n_{\text{backlog}}] \cdot M_{\text{cell}}}{S}$

Fitted throughput function

$\hat{S}(d, n_{\text{backlog}} = 1) = 10^6 \cdot (-6.142 \cdot \log_2(d) + 53.08)$
Conclusions

Wireless transmission under mobility
- A challenge for wireless networking protocols

Leveraging ferrying and relaying
- Transmit when link quality is best
- Avoid interferences with other transmitting agents
- Act in conformance to mission task!
Thank You!

… Some Open Calls

IEEE Communications Magazine – Special Issue on “Enabling Next Generation Airborne Communications”

PERFORMANCE 2013 Student Poster Session (Vienna)