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

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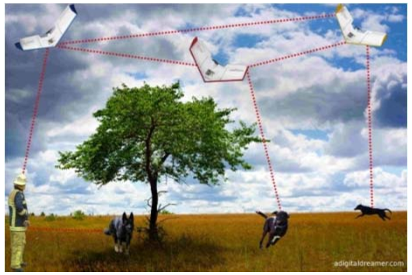
SWARMIX



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)*

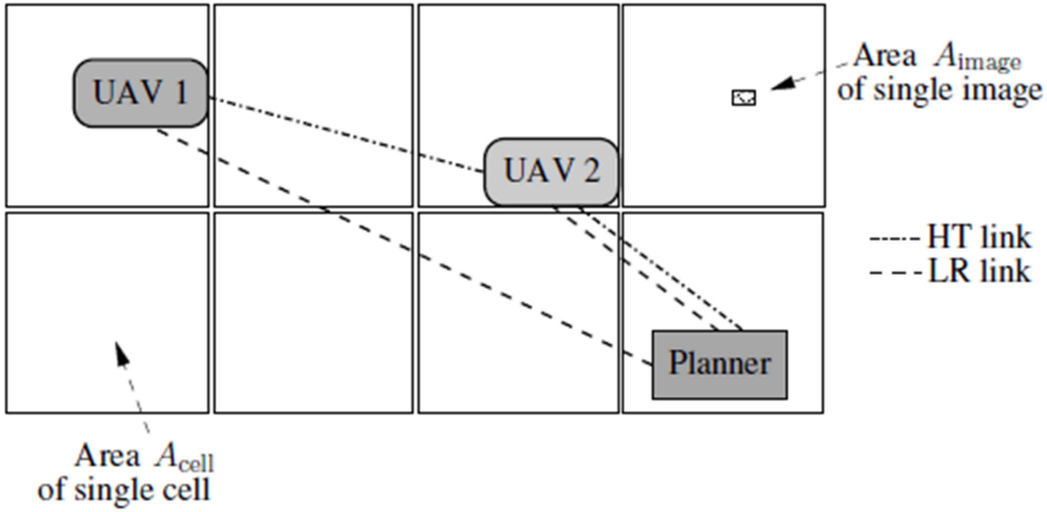
Coordination and networking

- 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 …

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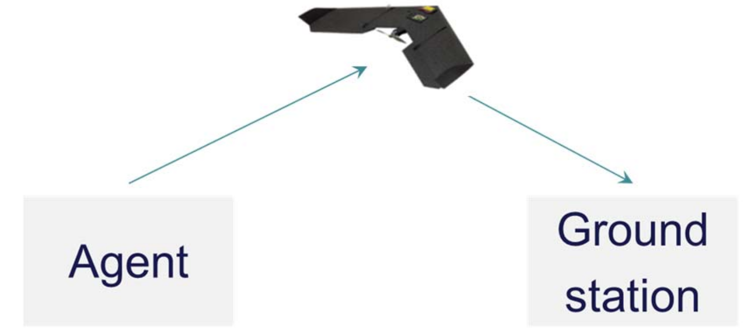
[1] E. Yanmaz, R. Kuschnig, and C. Bettstetter. Achieving air-ground communications in 802.11 networks with three-dimensional aerial mobility. INFOCOM 2013.

UAV Networking – Principles [2]

Relaying



Ferrying

Transmission scheduling

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

[2] D. Henkel and T. Brown. Delay-tolerant Communication Using Mobile Robotic Helper Nodes. In WiOPT 2008: 6th Int. Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks and Workshops, pages 657-666, 2008

UAV Testbed

Swinglet [3]

- Fixed wing UAVs, 80cm wingspan, 500g, 10m/s

Ardudcopter

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

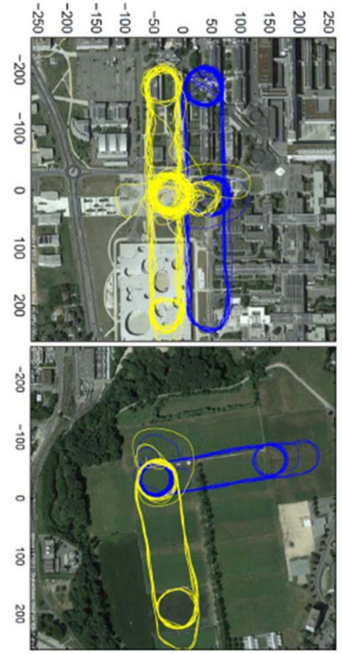
Wireless networking package

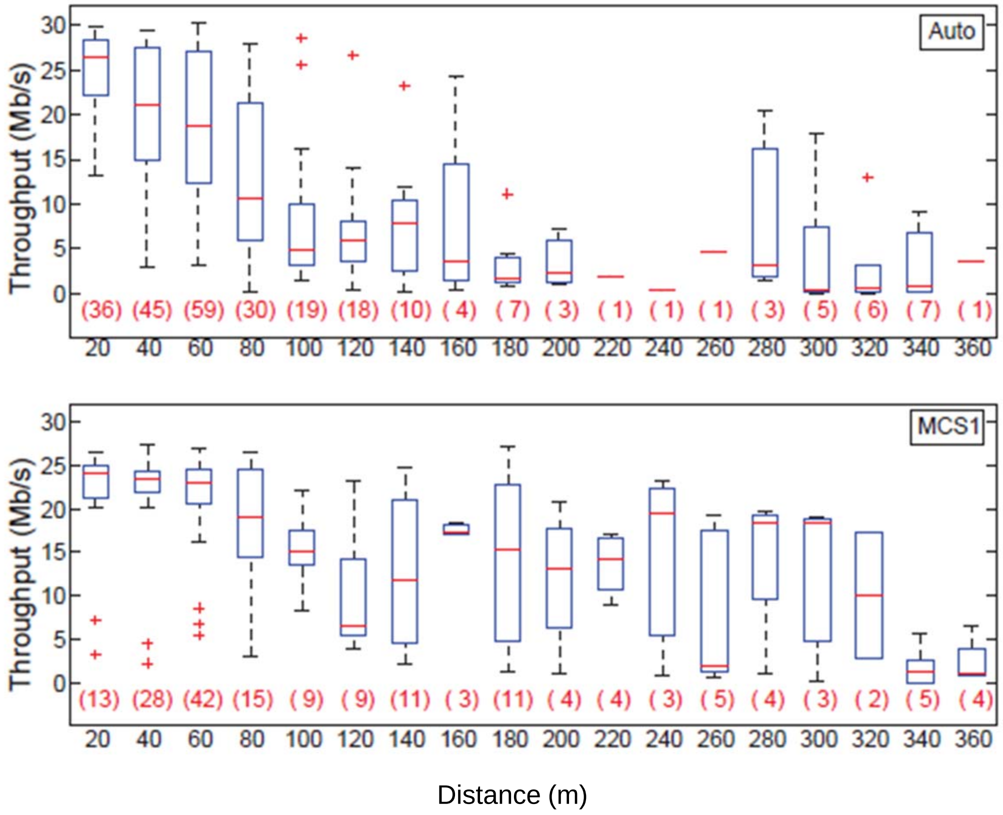
- Gumstix COM (Overo Tide), Tobi expansion board
- WiFi USB dongle capable of 802.11n (two planar antennas)

[3] S. Leven, J. Zufferey, and D. Floreano. A Simple and Robust Fixed-wing Platform for Outdoor Flying Robot Experiments, In Int. Symposium on Flying Insects and Robots, pages 69-70, 2007.

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]

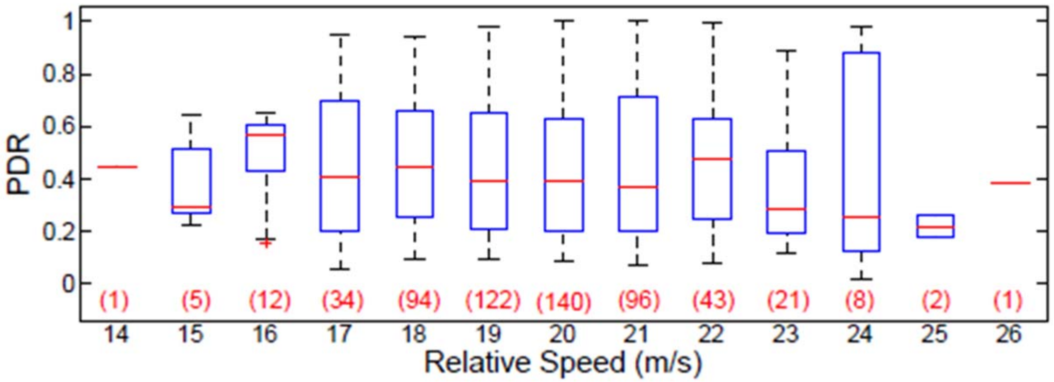




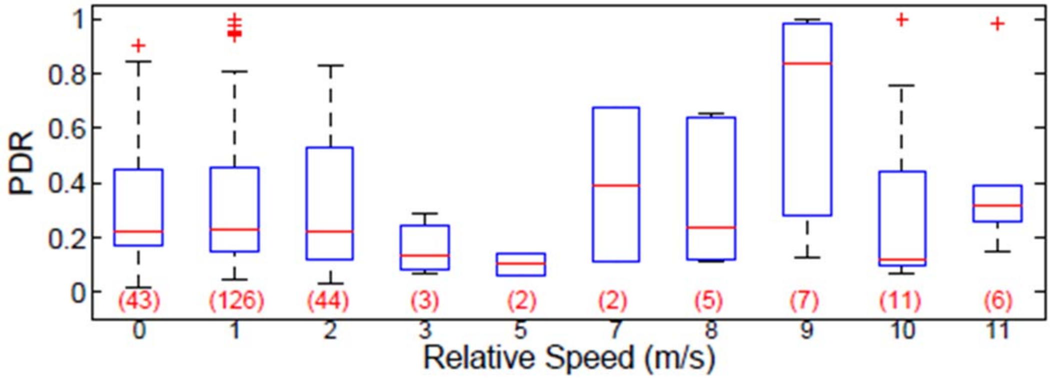
[4] M. Asadpour, D. Giustiniano, K.A. Hummel, and S. Heimlicher. Characterizing 802.11n Aerial Communication. Accepted for publication and presentation at Airborne 2013.

Aerial Link Investigations 2/2

Packet Delivery Ratio [5]



(a) Scenario A.



(b) Scenario B.

[5] M. Asadpour, D. Giustiniano, and K.A: Hummel. From Ground to Aerial Communication: Dissecting WLAN 802.11n for the Drones. Accepted for presentation at WinTech 2013, Sept. 30, 2013

Implications for Image Data Transfer [5]

Data to transmit per cell

# of UAVs

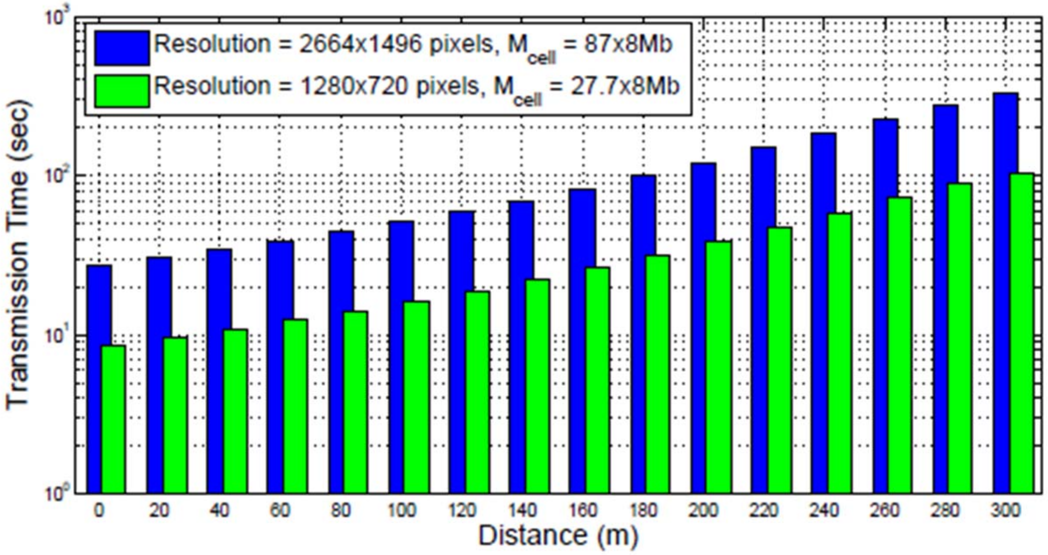
Transmission time

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

Throughput

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”

http://ee.unt.edu/public/namuduri/CFPNextGenAirborneCommunications.pdf

PERFORMANCE 2013 Student Poster Session (Vienna)