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Machine learning for flying robots in wireless networks

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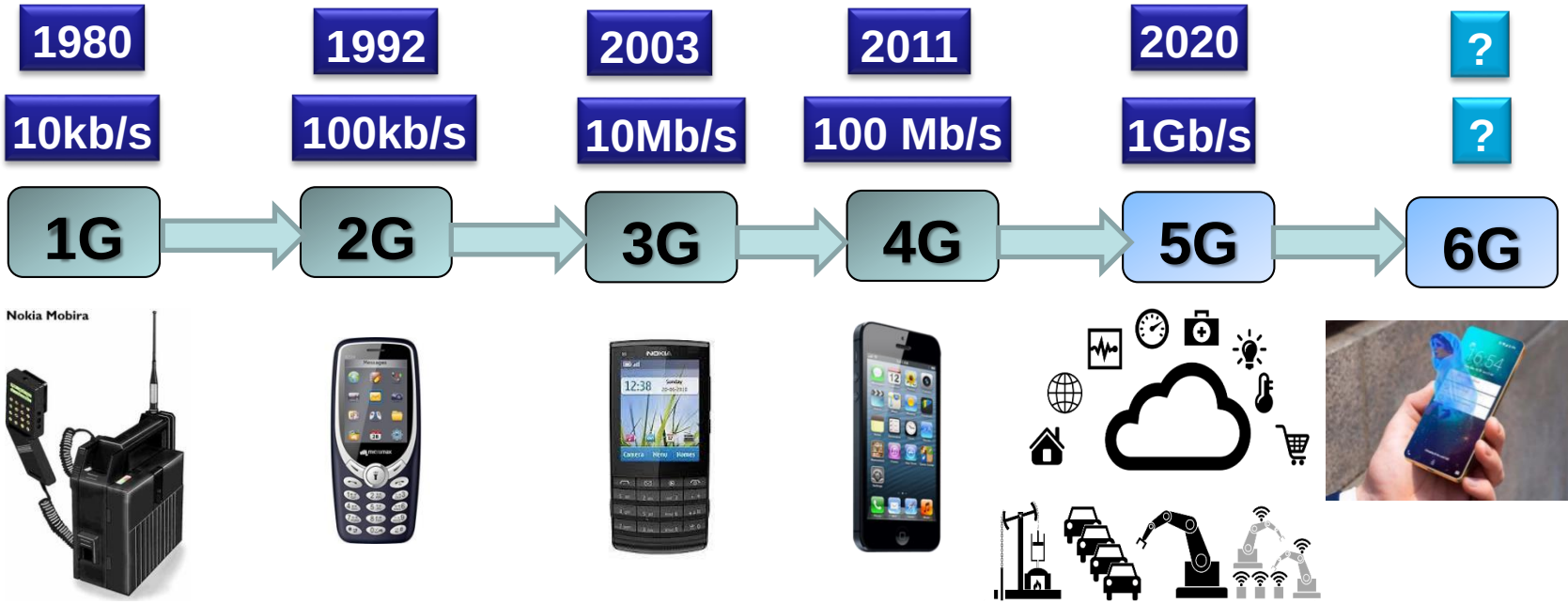
EURECOM, Sophia-Antipolis, France

Nov. 25, 2020 journée scientifique 3IA

Collaboration with Rajeev Gangula,

Wireless networks

- More speed is always good
- The road from 1G to 6G

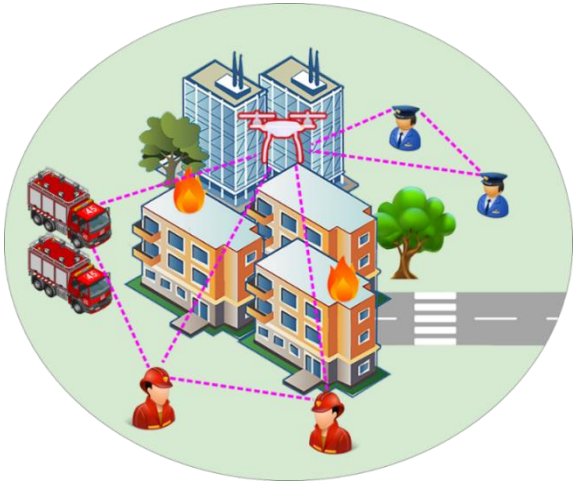


Flying networks: The case for radio-robots

Hot-spots, sport events, flashcrowds

Range extension
Disaster recovery

IoT data harvesting, smart city, etc.



Peer-to-peer connectivity:
Autonomous cars, law-enforcement

Autonomous Flying Radios

- **Case studies:**
  - Drone-as-a-relay
  - Drone-as-a-base station
- **Key challenges:**
  - Maintaining good connectivity and wide coverage
- ***Solutions based on:***
  - *Active learning*
  - *Deep Reinforcement learning*
  - *Optimization techniques*
- ***Real-world experimentations***
  - *flying radio prototype*
  - *Customized drone*
  - *Open source radio platform (OAI)*

Intelligent Data Harvesting

- **Worst-user throughput**

k-th user average throughput over the UAV trajectory

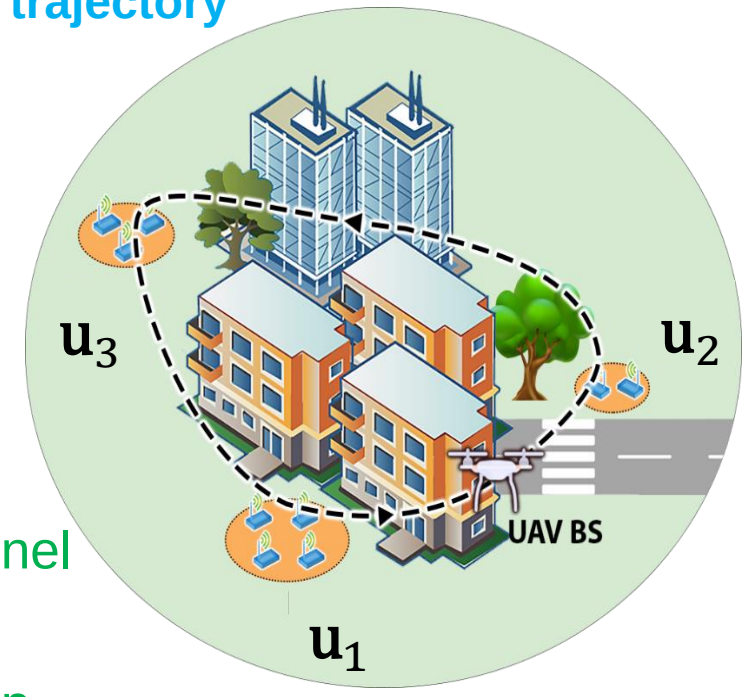
$$\max_{\chi_{UAV}} \quad \min_{k} \ \text{rate}(\mathbf{u}_k, \chi_{UAV})$$

$$\text{s.t.} \quad \text{Flight Time} \leq \text{T}$$

$$\text{UAV starts} = \mathbf{x}_s$$

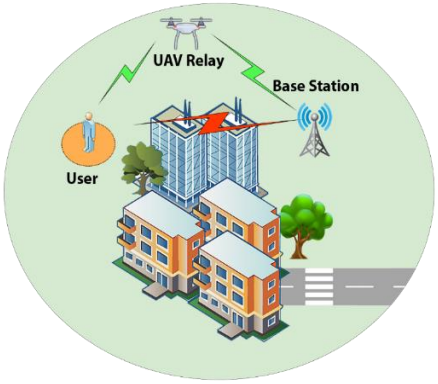
$$\text{UAV ends} = \mathbf{x}_t$$

UAV trajectory

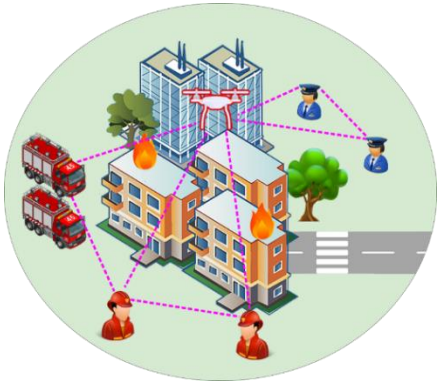


- **Need to:**
  - Estimate $\text{rate}(\mathbf{u}_k, \chi_{UAV})$ → Learn the Channel
  - Know user locations → Localize the Users
  - Have 3D Map information → Learn the Map
  - Generate UAV trajectory → Optimize the Trajectory

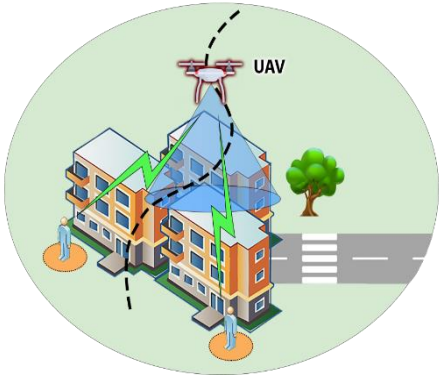
Real World Experimentations (Online Videos)



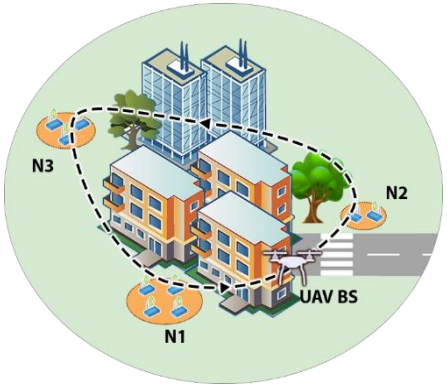
Autonomous
Relay Placement
In LTE networks



Autonomous
UAV Placement
In mesh network



Map Reconstruction
Using
Depth and Radio data



Intelligent
Data Harvesting
for IoT

UAV trajectory design
for
Mobile Localization

UAV Related Publications

- O. Esrafilian, R. Gangula, and D. Gesbert. "3D Map-based Trajectory Design in UAV-aided Wireless Localization Systems." IoT Journal, 2020
- O. Esrafilian, R. Gangula, and D. Gesbert. "Autonomous UAV-aided Mesh Wireless Networks." INFOCOM Workshops 2020
- O. Esrafilian, R. Gangula, and D. Gesbert. "3D-map assisted UAV trajectory design under cellular connectivity constraints." ICC 2020
- O. Esrafilian, R. Gangula, and D. Gesbert. "Learning to Communicate in UAV-aided Wireless Networks: Map-based Approaches." IoT Journal, 2018
- Bayerlein, Harald, Rajeev Gangula, and David Gesbert. "Learning to rest: A Q-learning approach to flying base station trajectory design with landing spots." Asilomar 2018.
- Bayerlein, Harald, Paul De Kerret, and David Gesbert. "Trajectory optimization for autonomous flying base station via reinforcement learning." SPAWC 2018
- O. Esrafilian, R. Gangula, and D. Gesbert. “UAV-relay Placement with Unknown User Locations and Channel Parameters”, Asilomar, 2018
- R. Gangula, O. Esrafilian, D. Gesbert, C. Roux, F. Kaltenberger, and R. Knopp, “Flying Rebots: First Results on an Autonomous UAV-Based LTE Relay using OpenAirInterface”, SPAWC, 2018
- O. Esrafilian and David Gesbert. "Simultaneous User Association and Placement in Multi-UAV Enabled Wireless Networks.", WSA, 2018
- O. Esrafilian and David Gesbert. "3D city map reconstruction from UAV-based radio measurements.", GLOBECOM, 2017
- J. Chen, O. Esrafilian, D. Gesbert, and U. Mitra, “Efficient algorithms for air-to-ground channel reconstruction in UAV-aided communications.”, GLOBECOM Workshops, 2017
- R. Gangula, P. de Kerret, O. Esrafilian, and D. Gesbert, “Trajectory optimization for mobile access point.” Asilomar, 2017

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Thank You!