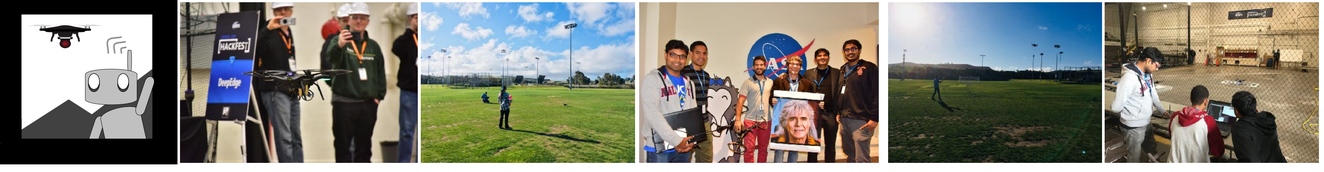

Intelligent and Autonomous Systems Lab

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# Resilient Communication and Computation for Heterogeneous Infrastructure-Assisted UAV Swarms

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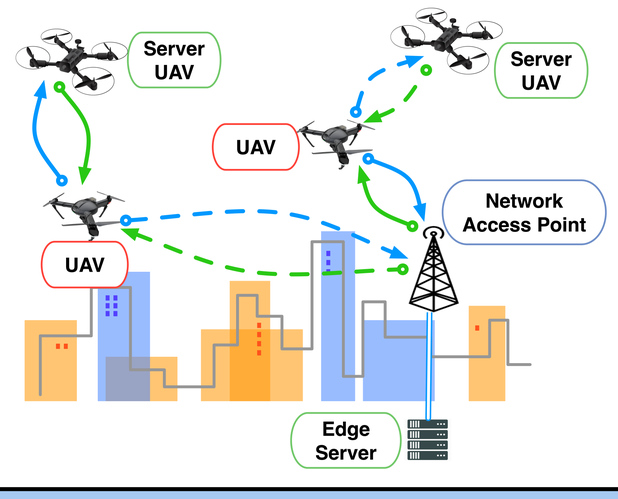
## HYDRA - Resilient Computation for Heterogeneous Autonomous Drone sYstems

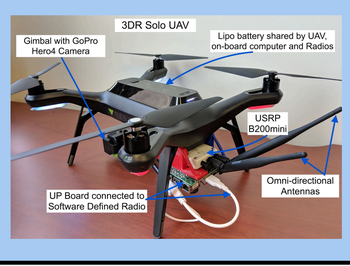
DARPA MTO



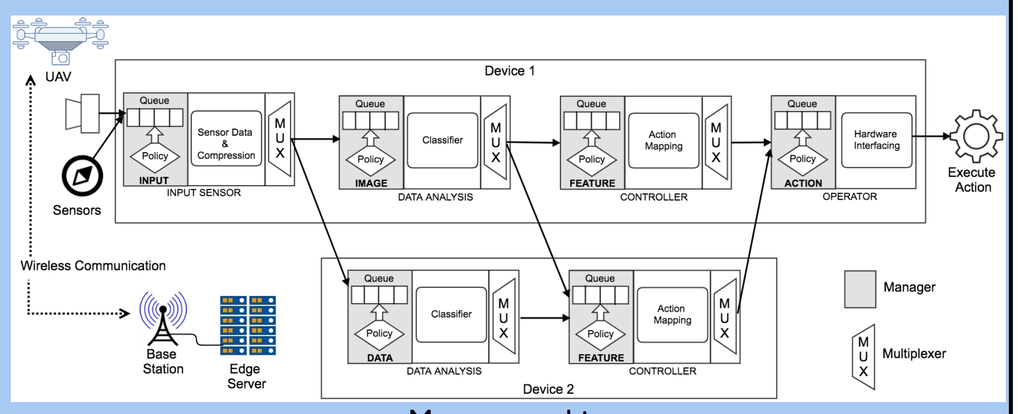

**UAVs have limited energy/computing power due to weight constraints**
- Assistance from strong UAVs or the infrastructure can mitigate this issue (edge/fog computing)
- Volatility of channel quality, and network and server load introduces uncertainty and reduces reliability

**HYDRA**
- Modular architecture for dynamic computing migration
- Multi-user multi-server support for flexible distribution of modules
- Simple/effective probing-based "pipeline" (comms+processing) selection

UAV Explorer




UAV/rover server




Mercury architecture

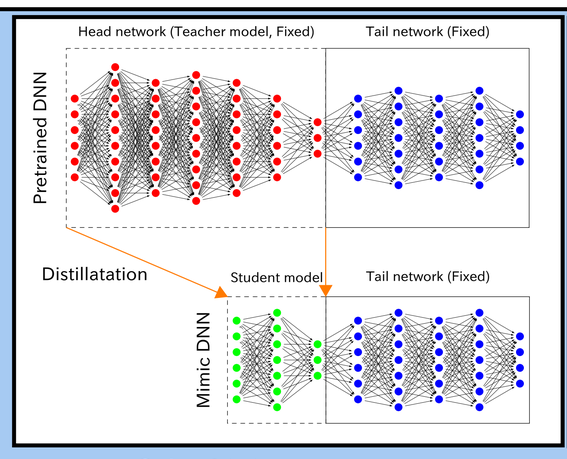
## Split Deep Neural Networks for Efficient Offloading

**Local processing:** slow due to hardware limitations
**Offloading:** need to transport the input over wireless

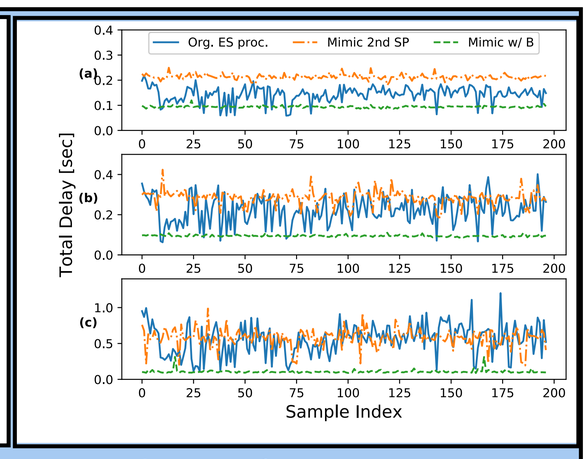
Splitting DNNs can balance computing load, but most complexity resides in the early stages, which also amplify the input.

We modify the architecture of DNNs to:
- Reduce computational complexity at the mobile device by "distilling" the head portion of the DNN
- Reduce the used bandwidth by introducing a "bottleneck" encouraging compact representations given the task

Results on emulated LTE (srsLTE on USRPs) for state-of-the-art image classification

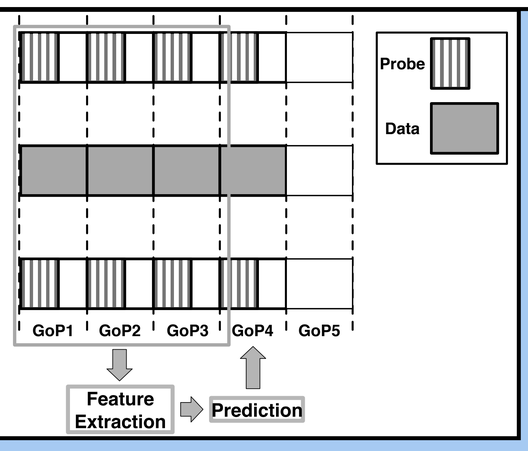



Split DNN architecture




Temporal series of capture-to-output per-frame delay for (a) low, (b) medium, and © high external traffic load

## Data-Driven Dynamic Network/Technology Selection

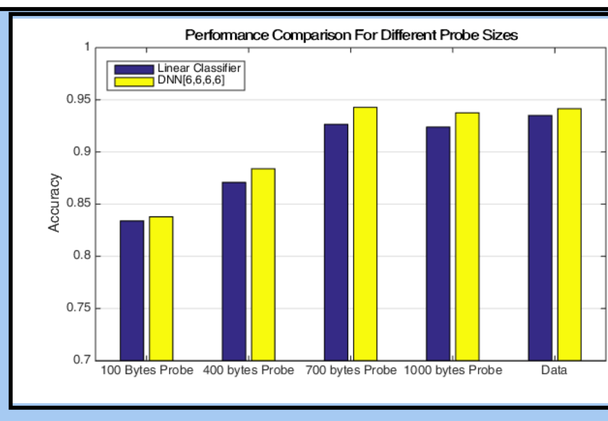



Probing-based prediction/selection

Predictive approach to select channel/technology supporting video feed, telemetry, and sensor feed produced by UAVs

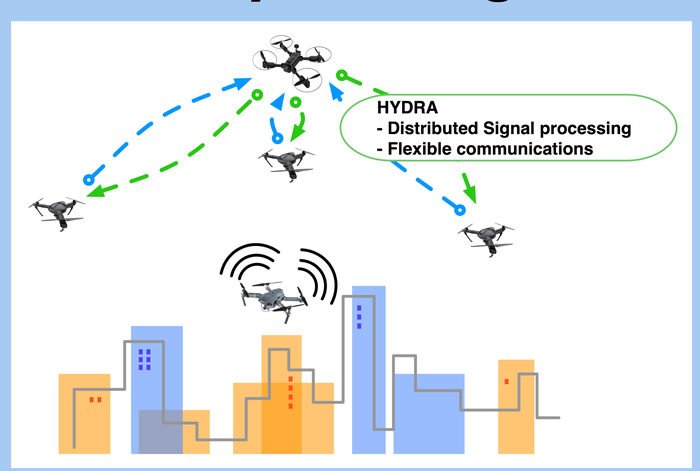
**Issue:** need to collect "data" on unused channels avoiding the disruption of coexisting data streams
- Short probe packet trains transmitted over unused channels
- Output used to predict future performance "if" the actual data were sent
- Output of the actual data stream used for the same scope
- DNN classifier trained from simulation and real-world data

Case study: video transmission over channel with time-varying set of applications running on the background




Classification accuracy achieved by different probe sizes

## On the Fly Learning for Hierarchical Information Filtering/Classification




**HYDRA as a detection and defense system against unauthorized drones**

- Onboard USRPs used to acquire signals emitted from UAVs/controllers
- Spectrum monitoring and modulation detection
- Localization to confirm altitude and assist neutralization
- Packet pattern and deep packet inspection to detect control protocols and characterize the drone
- Neutralization/taking over: selective jamming, control message injection, GPS spoofing/disruption.