Enhancing Mini-NDN Support for Ad Hoc Network

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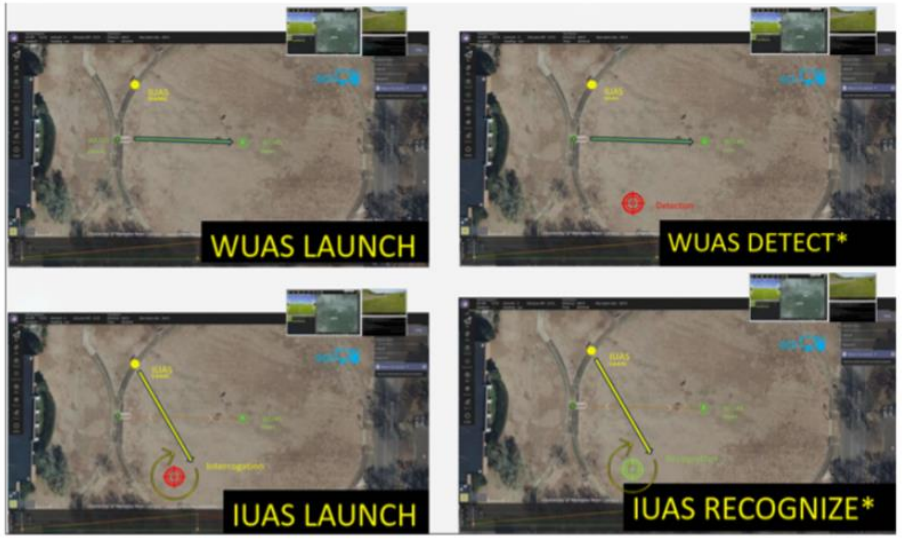
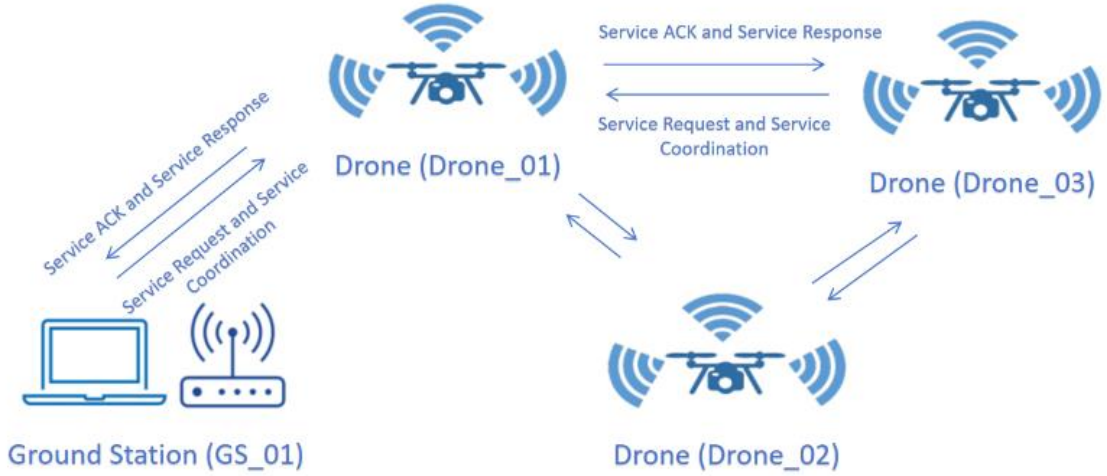
Multi-UAS Multi-Sensor Intelligence, Surveillance, and Reconnaissance (MUAS)





- Multi-UAS Multi-Sensor Intelligence, Surveillance, and Reconnaissance (MUAS) missions

- Ad hoc networks are used in these missions because they offer a decentralized, self-organizing communication infrastructure that does not depend on fixed facilities.

What we need?

- Enable MiniNDN to simulate ad hoc networks and their mobility to facilitate testing of MUAS applications.
  - A new class, MinindnAdhoc, has been added as a subclass of MinindnWifi

- A forwarding strategy for ad hoc network: CCLF[1] is a forwarding strategy for Ad hoc network, but it was implemented in ndn-sim and not available to current NFD.
  - To better support NDN forwarding in Ad-hoc networks, we have ported CCLF from ndnSIM to NFD.

- CCLF requires location info to make better forwarding descision, but GPS info was not available in MININDN and NFD.
  - A new GPSDApp has been added as a subclass of Application. Running it provides the current node's GPS information, which was not supported by Mininet-WiFi.

[1] Leveraging Content Connectivity and Location Awareness for Adaptive Forwarding in NDN-based Mobile Ad Hoc Networks https://named-data.net/publications/leveraging-content-connectivity-and-location-awareness-for-adaptive-forwarding-in-ndn-based-mobile-ad-hoc-networks/

MinindnAdhoc

- This is a class for creating ad-hoc network in MiniNDN-WiFi. It can handle configuration parameters that differ from MiniNDN-WiFi, such as SSID, mode, and channel.

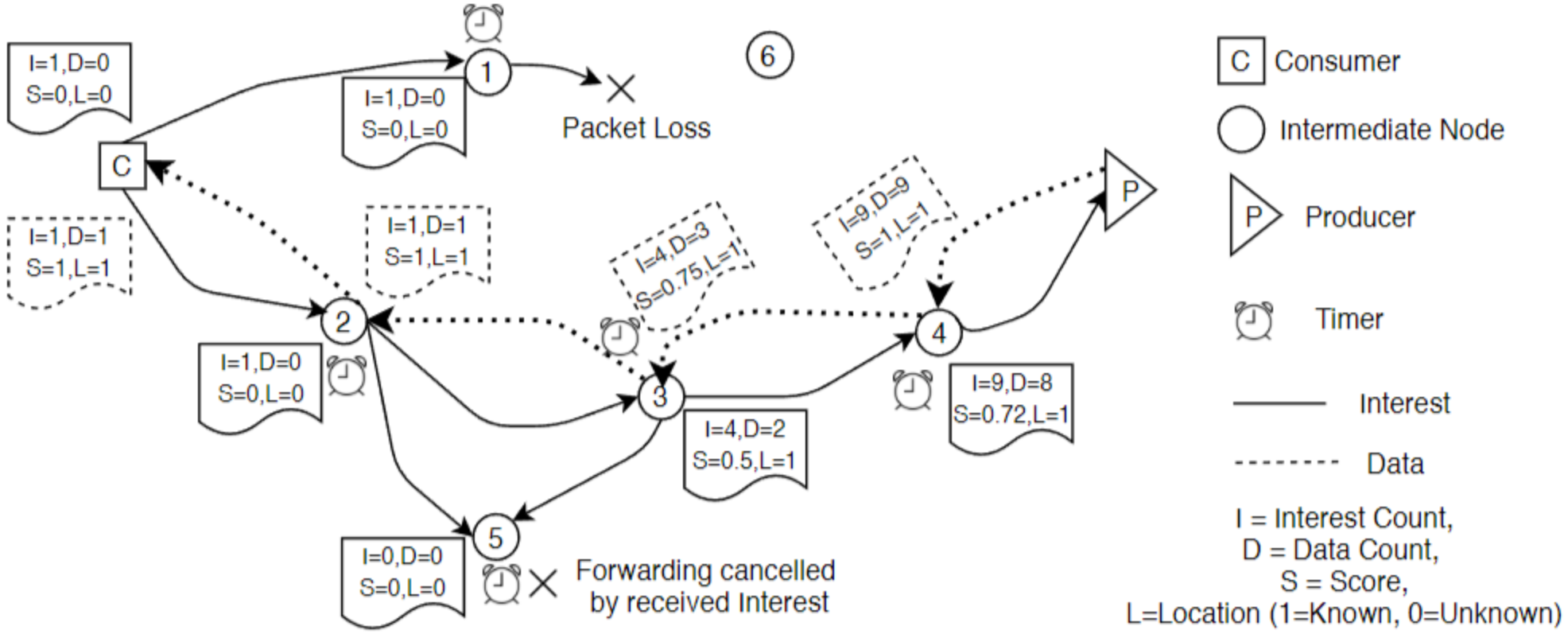
```
[stations]
sta1: position=0,0,0 range=116 min_x=-50 max_x=0 min_y=-50 max_y=0 bitrates=legacy-2.4|1 moving=false
sta2: position=50,0,50 range=116 min_x=0 max_x=50 min_y=0 max_y=50 min_v=5 max_v=5

# loss is optional, default is 0; and it won't work with mobility
# https://github.com/intrig-unicamp/mininet-wifi/issues/53
[adhocNetwork]
adhoc: ssid=adhocNet mode=g channel=5

[mobility]
# Spaces are not allowed in the parameters.
mobilityModel: time=0 model=RandomDirection min_x=-100 max_x=100 min_y=-100 max_y=100 seed=20
```

[1] Multi-UAS Multi-Sensor Intelligence, Surveillance, and Reconnaissance

CCLF[2]: Forwarding Strategy for Ad Hoc Networks



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Porting CCLF from ndnSIM to Mini-NDN

- CCLF was implemented and experimented using ndnSIM [3], which is a simulation tool based on NS-3, designed to model and evaluate NDN architectures and protocols.
  - ndnSIM includes an NFD-like forwarding module but not the full NDN Forwarding Daemon (NFD) [4] implementation. As a result, CCLF has neither been integrated as an optional forwarding strategy in the NFD nor made available for practical use.

- The NDN-related libraries used by CCLF are based on an outdated version from five years ago, which has undergone significant changes since then. The original developer graduated a long time ago, and no one is familiar with the source code.
  - We have updated NDN-CXX to enable NDNLPv2 to attach GPS information to headers.
  - We have updated NFD to support CCLF as a forwarding strategy.
  - We have updated NFD to enable it to get GPS information from the local GPSD.
    - It's just a quick solution, not the best choice

[3] Afanasyev, Alexander, Ilya Moiseenko, and Lixia Zhang. "ndnSIM: NDN simulator for NS-3." (2012).
[4] Afanasyev, Alexander, et al. "NFD developer's guide." Dept. Comput. Sci., Univ. California, Los Angeles, Los Angeles, CA, USA, Tech. Rep. NDN-0021 29 (2014): 31.

GPSD and GpsdApp in MiniNDN

- GPSD is a service daemon that collects data from GPS receivers and provides it to applications in a standardized format.
  - The main program of MiniNDN can obtain the mobility information of nodes, but the nodes themselves cannot access their current location internally. Therefore, a method is needed to transmit mobility information from the main program to the GPSD running inside each node.

- The newly added GpsdApp is an app in MiniNDN (which is responsible for running and managing GSPDs in nodes)
  - it converts the current node's location information into a formatted NMEA GPRMC sentence, including gga_sentence, rmc_sentence, and vtg_sentence, and send it to the node's GPSD using the nc command. This allows the node's GPSD to provide real GPS information to internal applications.

```
cmd = f"echo '{gga_sentence}\n{rmc_sentence}\n{vtg_sentence}\n' | nc -u -w 1 127.0.0.1 7150"
process = node.popen(cmd, shell=True)
```

Ongoing Efforts

- In the original design of CCLF, GPS information was appended to the NDNLPv2 header. However, this approach is neither secure nor efficient, as it limits the dissemination of GPS data within the ad hoc network. GPS information is often one of the most critical factors for making forwarding decisions:
  - we are developing **a protocol that enables secure sharing of location information, mobility data, and other relevant information among trusted ad-hoc nodes**.

- CCLF has several limitations, such as its inability to effectively utilize altitude information, its lack of support for node mobility characteristics, security vulnerabilities, and poor handling of mobile nodes in its Connectivity-Location Tree. We aim to address these issues in CCLFv2.

Thank you!