# Investigating Integrated Access and Backhaul on the Aether 5G Testbed

Jack Brassil

Dept. of Computer Science

Princeton University

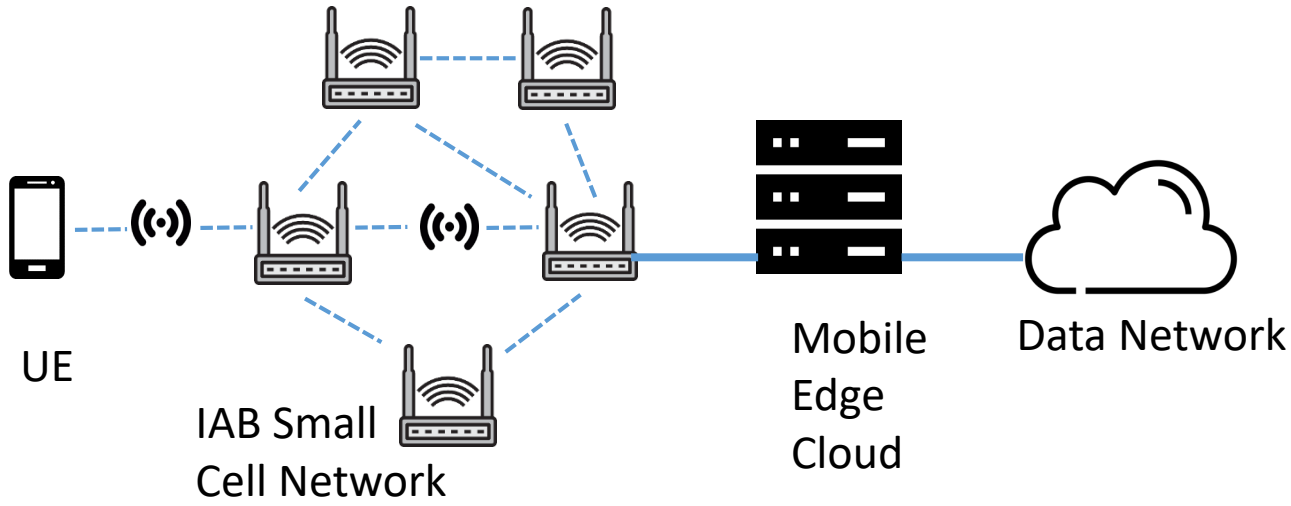
IEEE Future Networks™ WORLD FORUM • 2021

IEEE 5G WORLD FORUM

IEEE

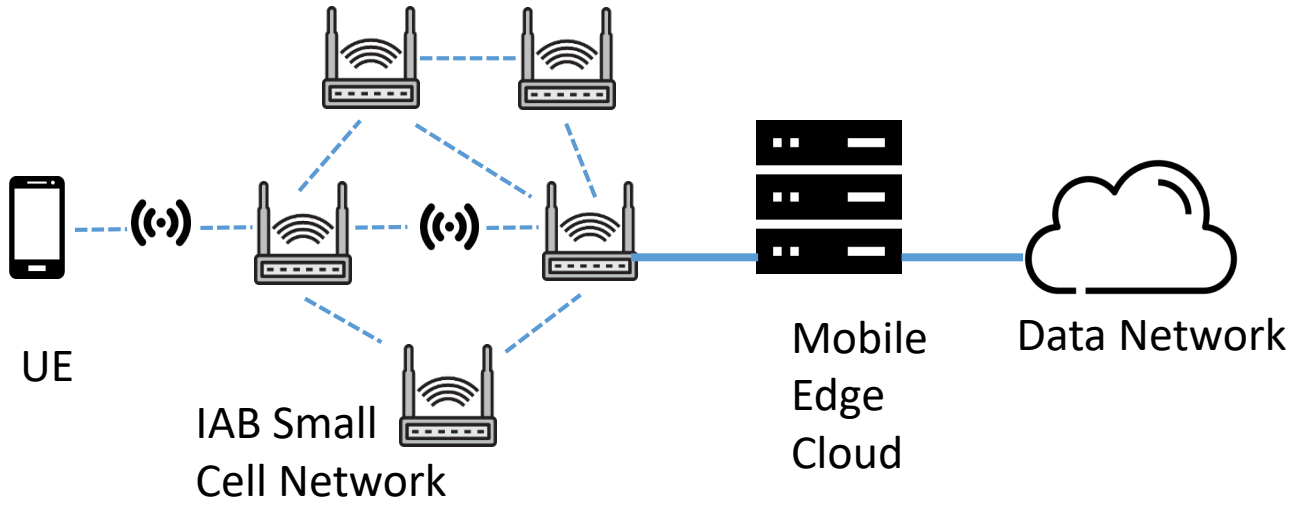
# Integrated Access & Backhaul

- Standardized in 3GPP Release 16
- Wireless replacement of wired backhaul (fiber)
- In-band, relay based multi-hop forwarding architecture
- Resilience through Backhaul Adaption Protocol



# Integrated Access & Backhaul

- Standardized in 3GPP Release 16
- Wireless replacement of wired backhaul (fiber)
- In-band, relay based multi-hop forwarding architecture
- Resilience through Backhaul Adaption Protocol



# Motivation

- Evaluating campus deployment of outdoor small cells
  - Neutral host solution preferred
  - Commercial and research radios
  - Challenges
    - Scaling - many fibers, much trenching, many networking ports required
    - Siting uncertainty
    - Co-engineering different carrier RANs
- Wireless backhaul potentially attractive, cost-saving option (e.g., Wi-Fi)

PRINCETON UNIVERSITY

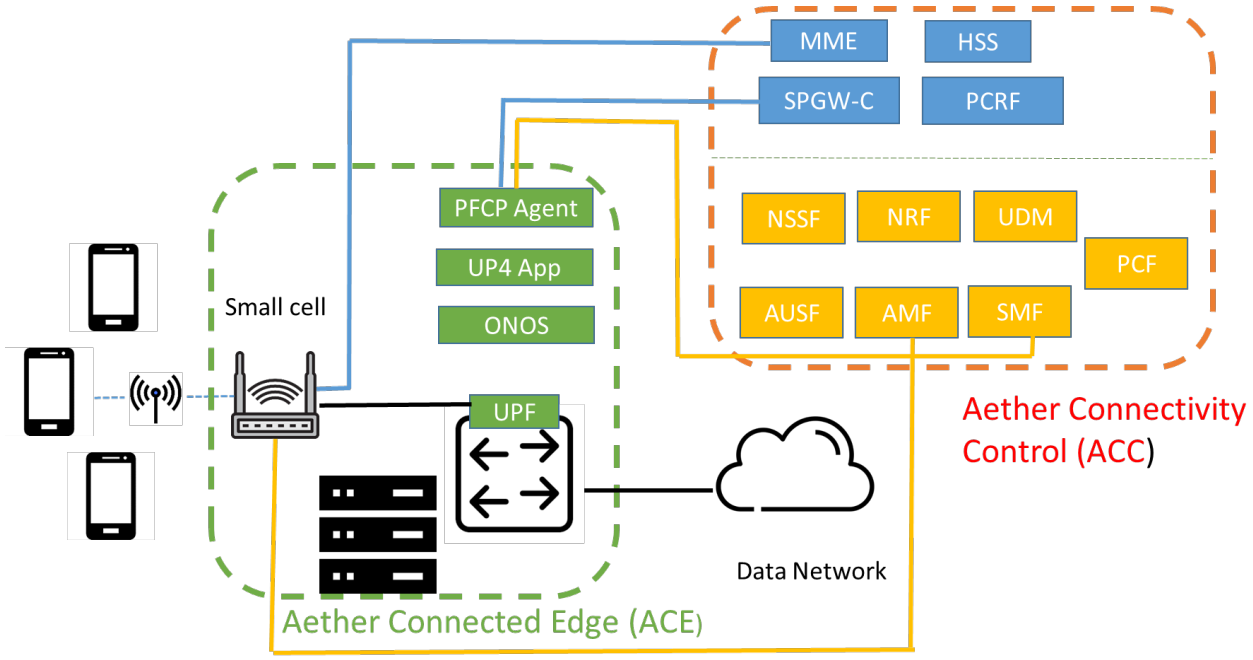
# Project Goal

- Develop a research testbed capable of evaluating a variety of investigations of nG architectures, implementations, & protocols
- Primary testbed objectives include
  - versatility
  - experiment repeatability
  - ease of testbed replication at other sites
- Wireless backhaul the initial use case
  - Standards-compliant IAB is one focus among many
  - Lack of open-source components for 5G → using COTS CBRS RAN with upgrades coming
  - Work-in-progress: OK with basic, limited function emulation for now

PRINCETON UNIVERSITY

# Aether 5G Testbed

- Developed by Open Networking Foundation with support from DARPA Pronto Project
- Disaggregated 5G core – edge deployed locally at 16 university & industry sites
- Shared Google Cloud Platform centralized core
- Novel elements such as programmable switch hardware
- Provides potentially fast path to scale & commercialize your research

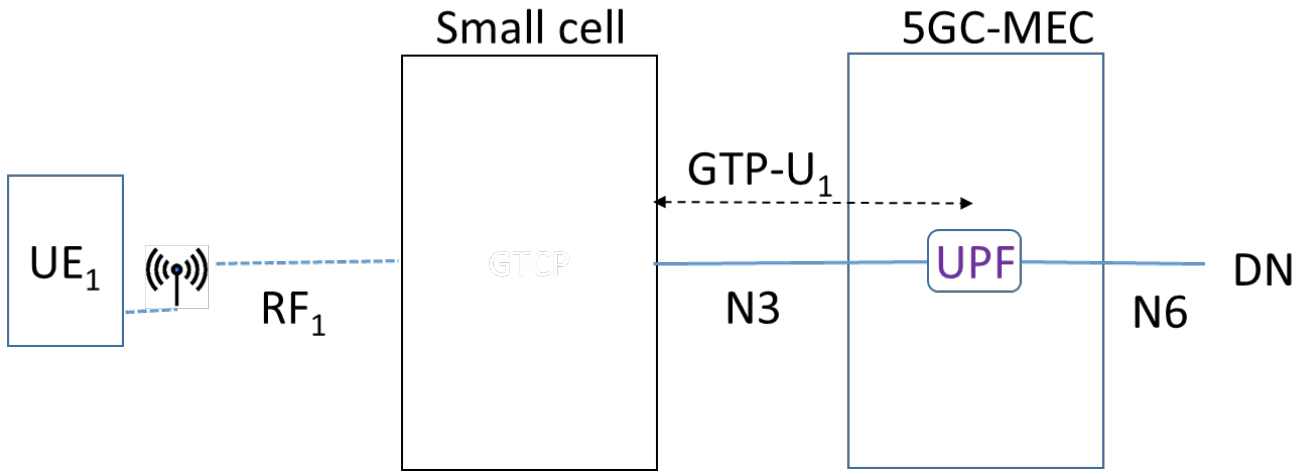



PRINCETON UNIVERSITY

# Aether Basic Operation

Key elements used:

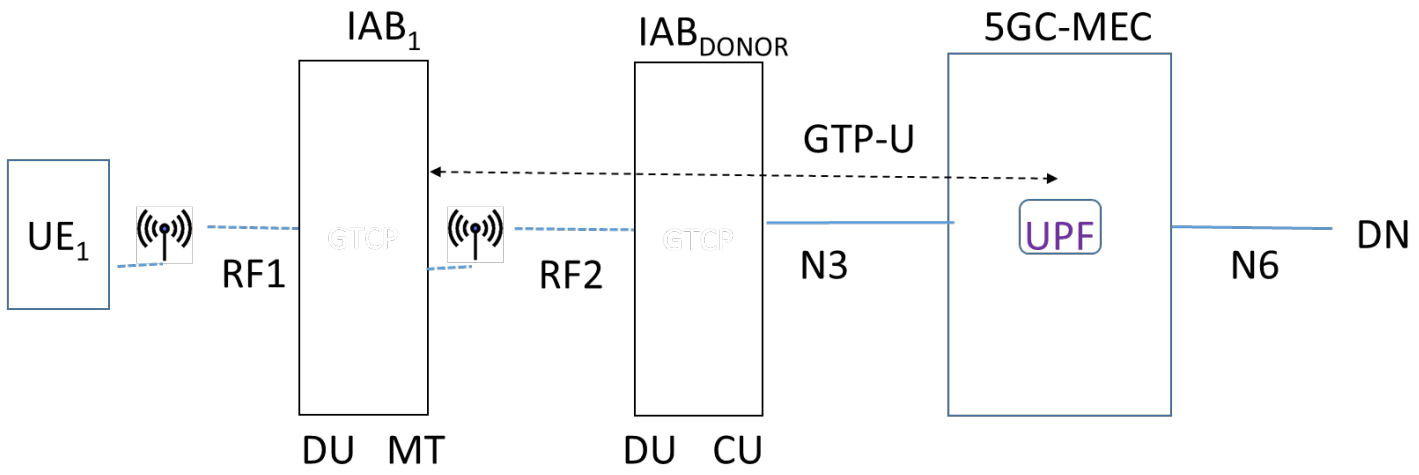
- Local breakout (MEC) to Data Network (DN)
- User Plane Function (UPF) – hardware-based tunnel decapsulation



# Aether Operation with IAB

## Key elements (split RAN compatible):

- UE associates with small cell $IAB_1$
- $IAB_1$'s Mobile Termination (MT) communicates to upstream $IAB_{donor}$ Distributed Unit (DU)
- $IAB_{donor}$ Centralized Unit (CU) communicates to UPF in edge 5G core
- Single GTP-U tunnel end-to-end

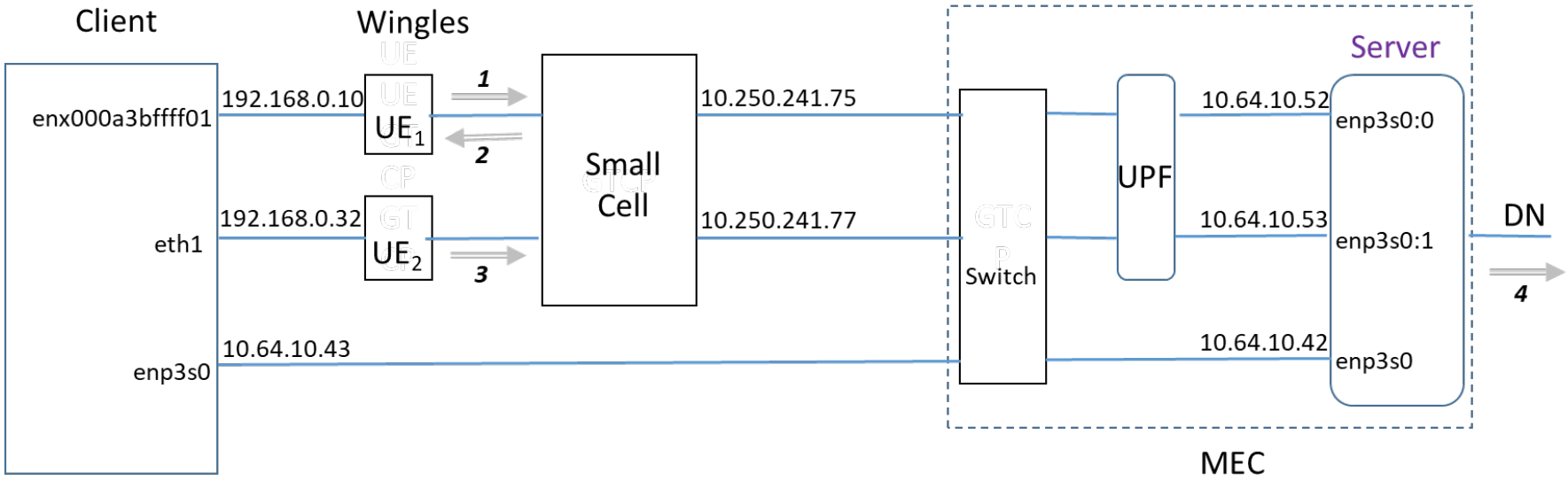



PRINCETON UNIVERSITY

# Implementation

## Highlights:

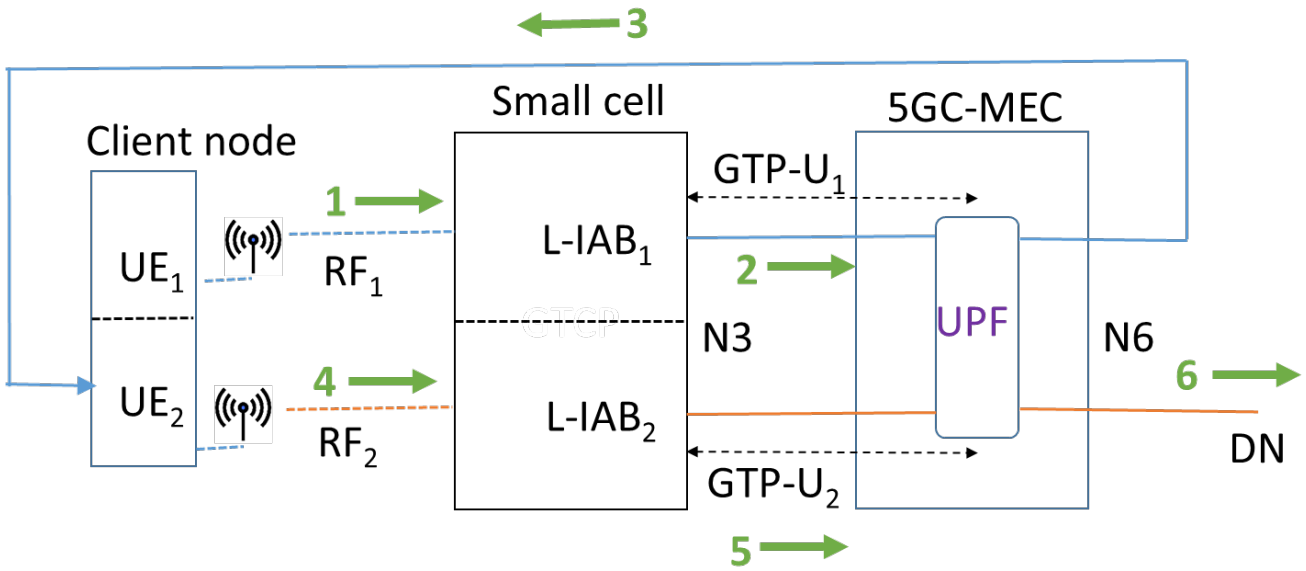
- Access network: Sercomm CBRS radios & small cells
- Measured HTTP performance over 1, 2, 3 wireless hops
- Tested both integrated (CBRS) and out-of-band (.11ac) backhaul
- Project github site describes packet forwarding (iptables, NAT)




PRINCETON UNIVERSITY

# Multihop Backhaul Emulation with Recirculation

- Single client emulates multiple UEs. Each has separate CBRS radio.
- Single small cell emulates multiple IAB nodes
- One GTP-U tunnel/wireless hop
- Packet reaches 5GC-MEC and is returned to client node
- Line speed GTP-U decapsulation via programmable switch HW
- Static routing (e.g., no BAP, dynamic addressing, etc)




PRINCETON UNIVERSITY

# Experiment 1: IAB with CBRS

**Experiment 1: Integrated Access & Backhaul**

*0 wireless hops: ethernet, no proxy*

| Run No. | Downlink (Mbs) | Uplink (Mbs) |
|---|---|---|
| 1 | 426.59 | 466.40 |
| 2 | 426.59 | 351.98 |
| 3 | 426.59 | 498.28 |

*1 wireless hop: proxy; local iperf TCP uplink comparison*

| Run No. | Downlink | Uplink | [iperf: client, server] |
|---|---|---|---|
| 1 | 81.86 | 7.42 | 6.97, 6.66 |
| 2 | 84.19 | 5.81 | 6.05, 5.73 |
| 3 | 82.39 | 7.67 | 6.58, 6.34 |

*2 wireless hops: proxy*

| Run No. | Downlink | Uplink |
|---|---|---|
| 1 | 41.57 | 4.15 |
| 2 | 43.21 | 4.04 |
| 3 | 43.95 | 3.95 |

*3 wireless hops: proxy*

| Run No. | Downlink | Uplink |
|---|---|---|
| 1 | 27.24 | 2.38 |
| 2 | 29.17 | 2.23 |
| 3 | 27.74 | 2.43 |

PRINCETON UNIVERSITY

# Experiment 2: CBRS access with Wi-Fi backhaul

**Experiment 2: Heterogeneous Access & Backhaul**

*2 wireless hops – CBRS with WiFi backhaul: proxy*

| Run No. | Downlink | Uplink |
|---|---|---|
| 1 | 36.78 | 6.46 |
| 2 | 43.35 | 6.73 |
| 3 | 44.90 | 6.28 |
| 4 | 38.51 | 6.05 |
| 5 | 44.40 | 6.67 |

PRINCETON UNIVERSITY

# Conclusion

- Aether 5G testbed effective at emulating various wireless backhaul architectures (and more!)
- Testing at scale
- Fast path for technology transfer
- Next steps:
  - Work towards fully compliant IAB system testing
  - Experimentation with diverse hardware components
  - Study applications beyond wireless backhaul

This material is based upon work supported by the National Science Foundation under Grant No. CNS-1923692 and DARPA under Dispersed Computing HR0011-17-C-0047.

PRINCETON UNIVERSITY