Institute for the Wireless Internet of Things
at Northeastern University

The Road Ahead: An approach to Building an ecosystem for Beyond 5G to 6G Research

Abhimanyu Gosain
SLICES Workshop
March 3, 2021

Who We Are

- Lead the Institute for Wireless Internet of Things at NU
- Co-Manage NSF Platforms for Advanced Wireless Research (PAWR) Project Office
- Lead OpenAirX-Labs
  - OpenAirInterface Software Alliance Board Member
  - O-RAN Alliance Member
  - Open Networking Foundation (ONF) Member
  - Telecom Infra Project (TIP) Member Contributor
  - Magma Foundation Founding Member
- Inherited and Operate DARPA Colosseum
- Organizer of 6GSymposium

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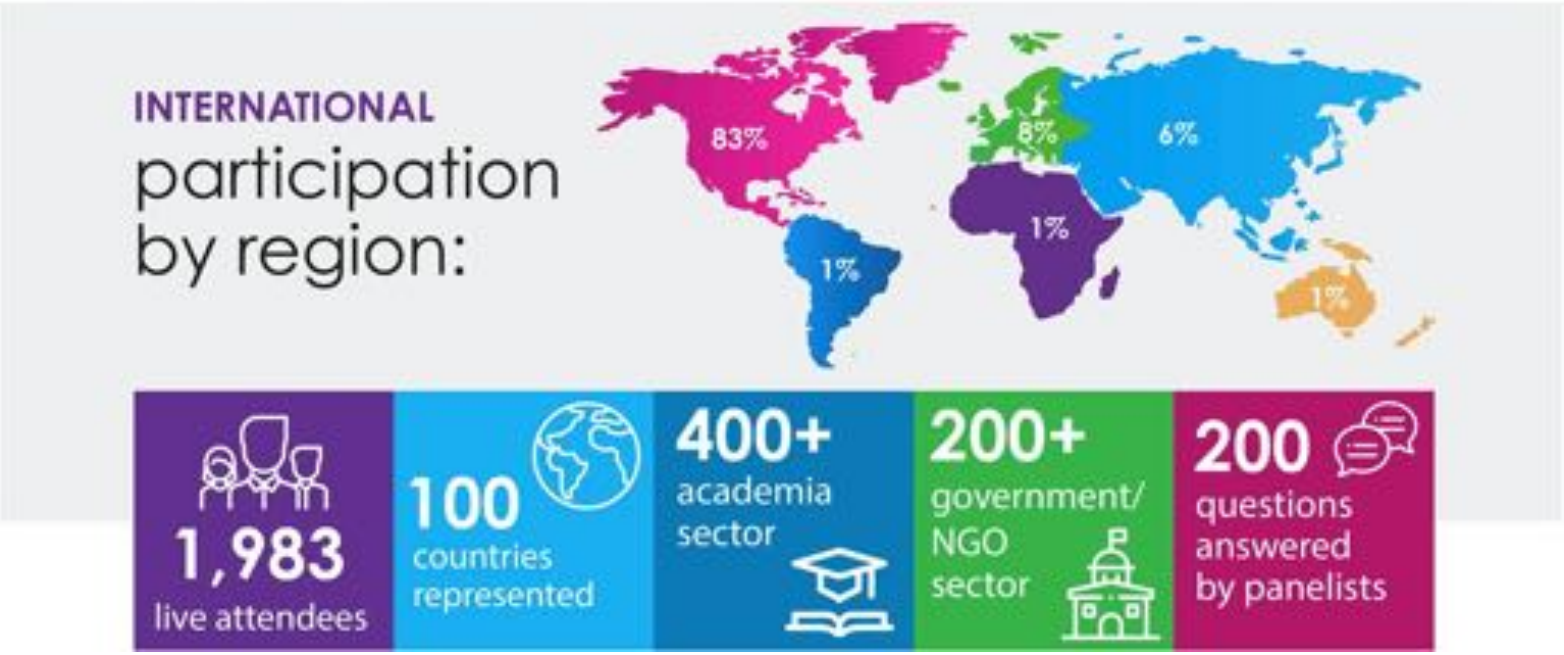
6G Symposium

Save the Date Sept 21-22 !!
6GSymposium 2021

6G Symposium 2020

Drawing highly engaged attendees from around the globe:

4,225 REGISTRATIONS FROM 2,700 COMPANIES



interdigital

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(Some) Limitations of Current 4G and 5G Networks

- Monolithic architectures, hardware based
  - Hard to update, improve, reconfigure
  - Vendor lock-in
  - Geo-Politics

- Hard to programmatically control, especially at large scale

6G Wireless Systems will deliver ubiquitous, ultra reliable, near instantaneous Gbps connectivity between humans and machines

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B5G/6G Enabling Technologies

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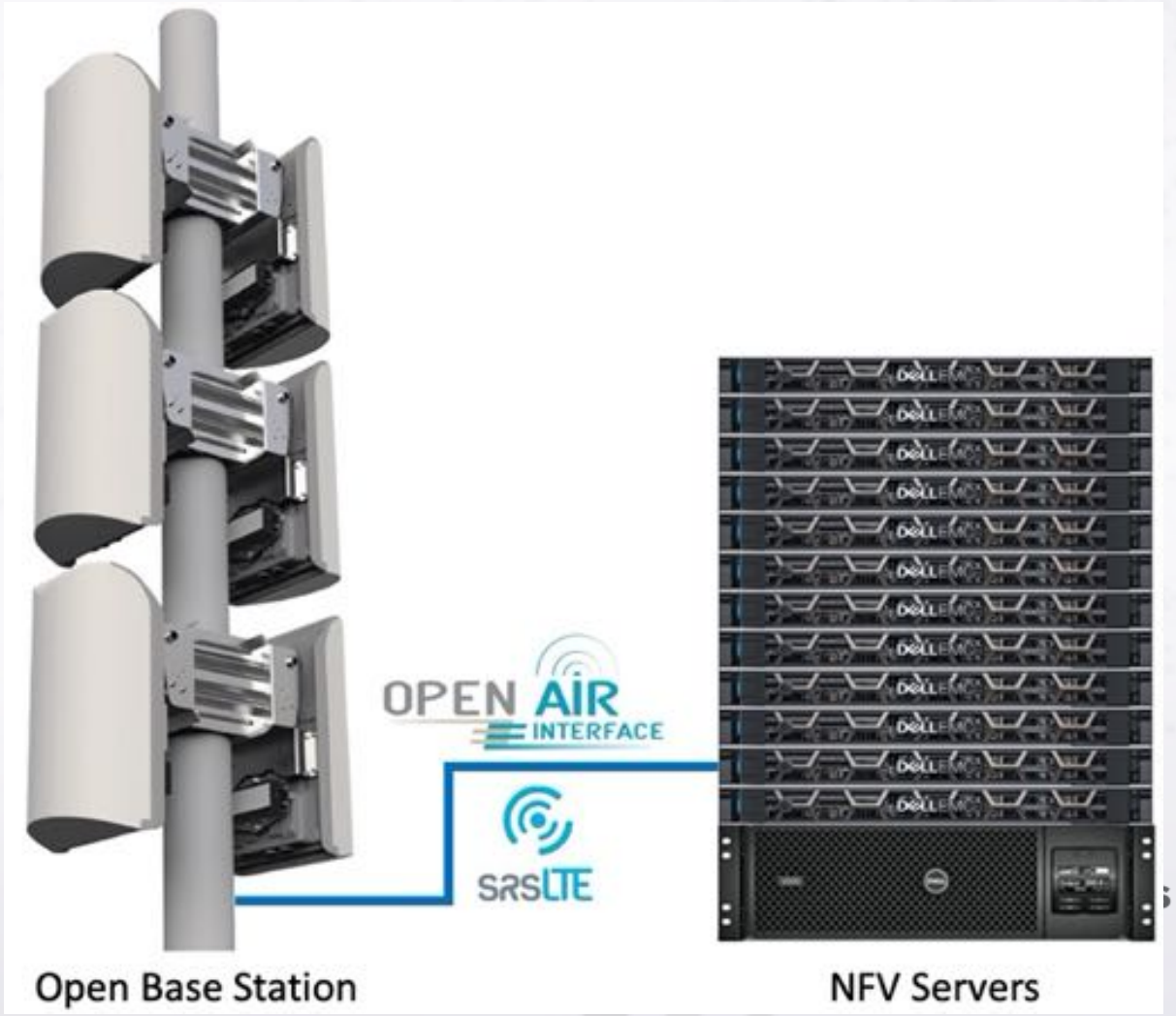
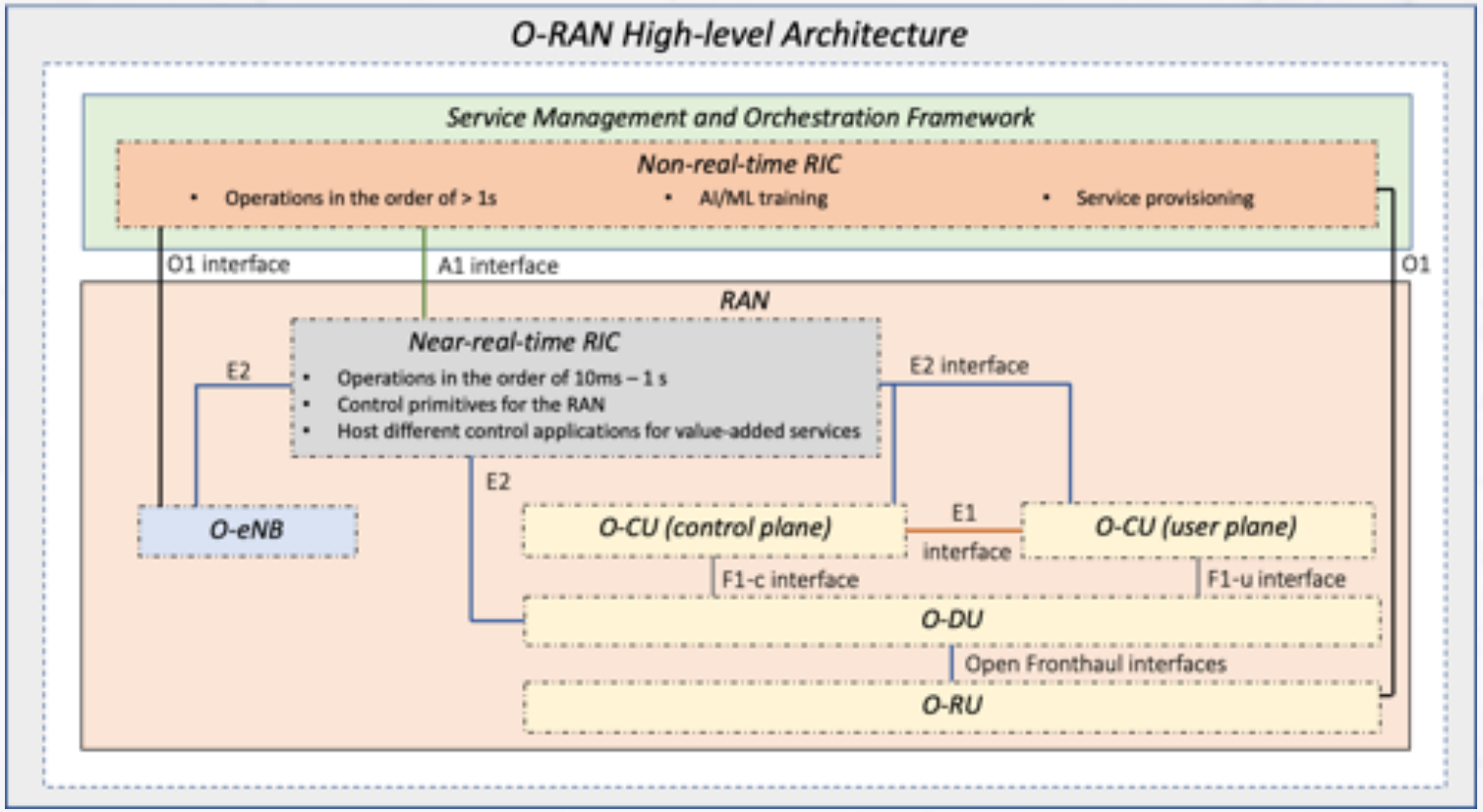
Virtualized RAN Instantiated on Commodity Hardware

Traditional approach

Virtualized RAN



O-RAN – ‘’Horizontal Disaggregation” and Abstraction



O-RAN ALLIANCE

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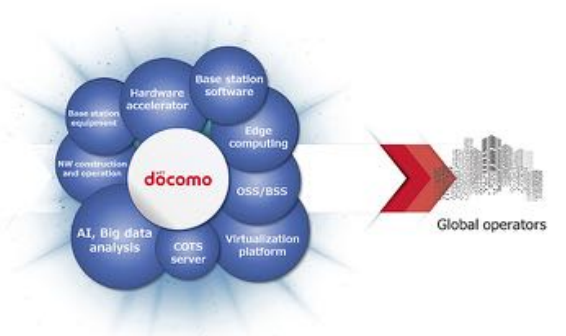
OpenRAN Fragmentation

O-RAN ALLIANCE

NEXT G ALLIANCE

TELECOM INFRA PROJECT



dish NETWORK 5G

SD-RAN

Open RAN POLICY COALITION

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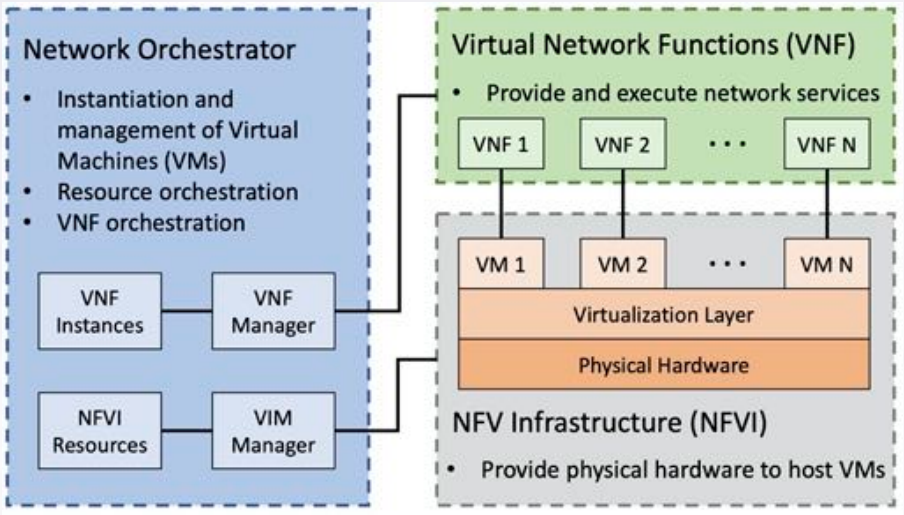
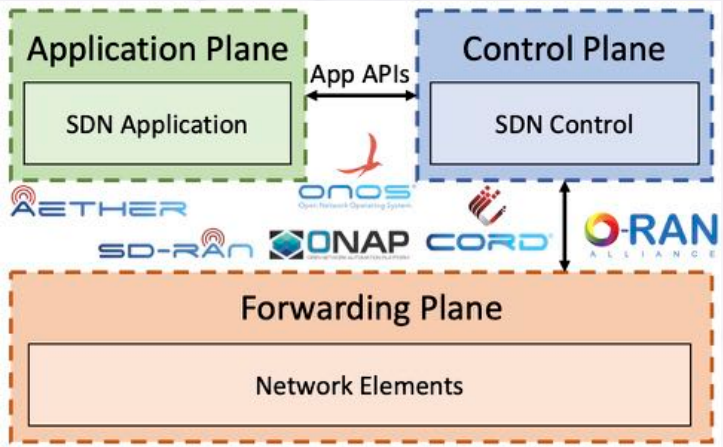
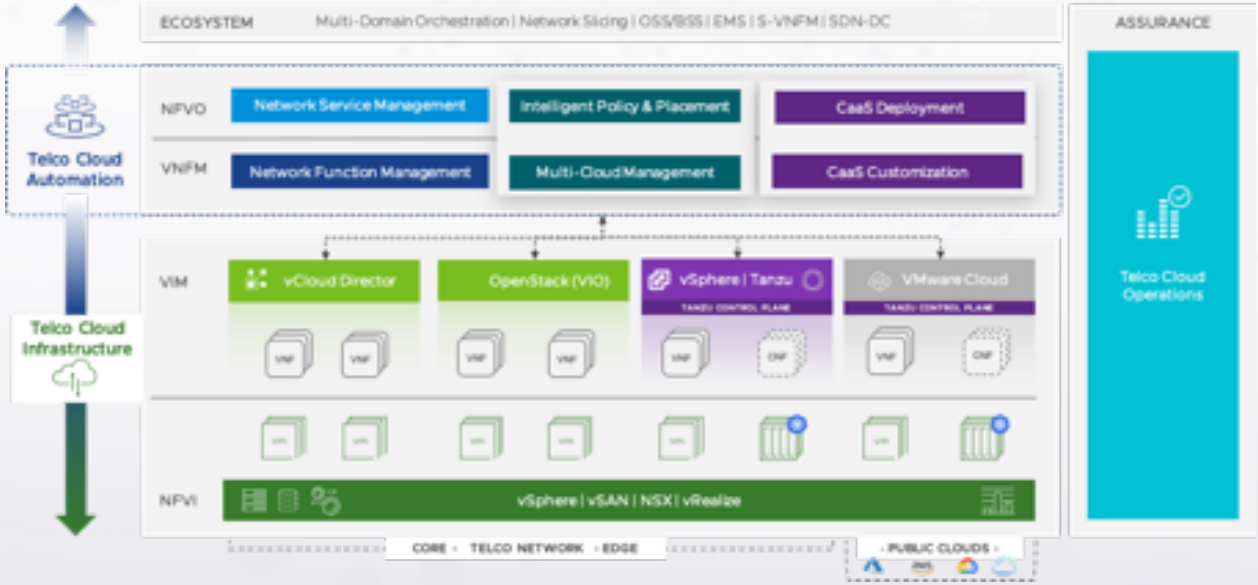
SDN + NFV + Cloud Native







Source: RCRWireless.com

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Conquering the Spectrum

- The need to provide faster connectivity to an ever-growing number of wirelessly connected devices is motivating the exploration of higher frequency bands for communications
  - **Under 95 GHz**
    - **5G:**
      - 3GPP 5G New Radio (NR) – Frequency Range 2 (FR2) with up to 800 MHz of bandwidth
      - (US FCC) **Spectrum Frontiers** Auctions at 24 GHz, 28 GHz, 37 GHz, 39 GHz and 47 GHz
    - **WiFi:**
      - IEEE 802.11ad – 2.16 GHz of bandwidth
      - IEEE 802.11ay – up to 4x2.16 GHz (8.64 GHz) of bandwidth
      - (US FCC) From 57 to 71 GHz = 14 GHz
    - **Others:**
      - Point-to-point links at 71-76 GHz & 81-86 GHz
      - Vehicular radar at 77 GHz
      - …

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Conquering the Spectrum

- The need to provide faster connectivity to an ever-growing number of wirelessly connected devices is motivating the exploration of higher frequency bands for communications
  - **Above 95 GHz**
    - In March 2019, FCC opened **Spectrum Horizons** for new services and technologies
      - Made a total of 21.2 GHz of spectrum available for use by unlicensed devices,
        - 116-123 GHz / 174.8-182 GHz / 185-190 GHz / 244-246 GHz
      - Defined a new category of experimental licenses for use of frequencies between 95 GHz and 3 THz
    - Several major research initiatives are actively developing technologies above 95 GHz:
      - SRC ComSenTer Center: https://comsenter.engr.ucsb.edu
      - EU Ariadne: https://www.ict-ariadne.eu
      - …

The Elephant in the Room

- When moving to higher frequencies, **propagation becomes much more challenging**:
  - **Antennas become smaller:**
    - Their effective area is inversely proportional to the square of the frequency ☹
    - High gain directional antennas are needed to compensate for this
      - But these can also be very compact ☺
  - **Molecular absorption enters the game:**
    - It appears only at discrete frequencies (or absorption lines)
    - The line width changes with distance and atmospheric conditions
      - A dynamic use of the spectrum makes more sense than ever ☺
  - **Blockage, reflections, diffraction are all real:**
    - Signals are easily blocked (partially absorbed, partially reflected) by elements whose size is more than a few wavelengths ☹
    - Easily uncorrelated paths can be exploited for diversity/security ☺

Combine all these with:
- Low power transmitters
- High phase noise oscillators

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AI/ML in 6G Wireless Systems

- AI/ML advances in Deep Neural Networks, Deep Reinforcement learning and Generative Adversarial networks are enabling disruption

- OpenData: Availability of Large Open Datasets for Training
  - Synthesized and OTA Generated

- Not a substitute for modeling and rigor
  1. Need to be used in combination with classical tools
  2. Need to look at system constraints
  3. Need to close the loop with “good data”

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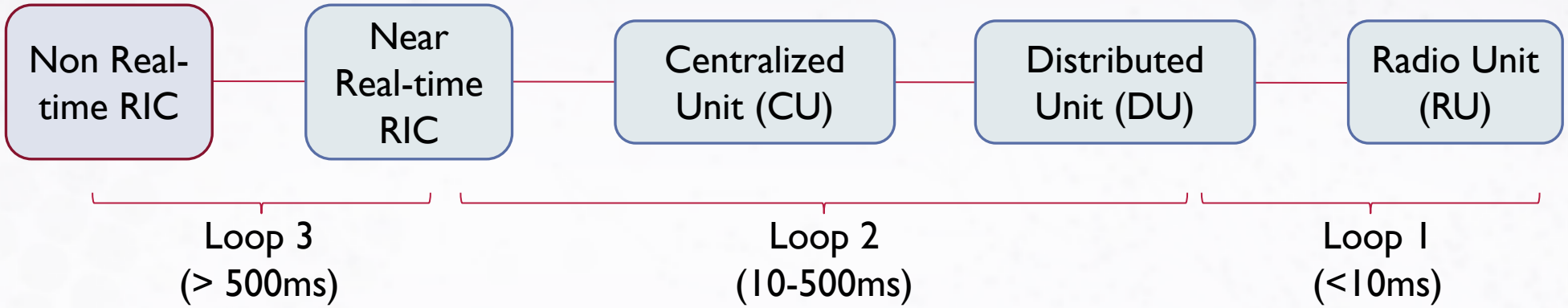
Network Intelligence with O-RAN



- **3 AI-enabled loops** with different:
  - **Time-scales**
  - **Information** available
  - **Control** strategies
    - e.g.: RUs implement low PHY functionalities only

- **Use cases**:
  - Slicing (RAN/core)
  - Beamforming
  - Traffic steering

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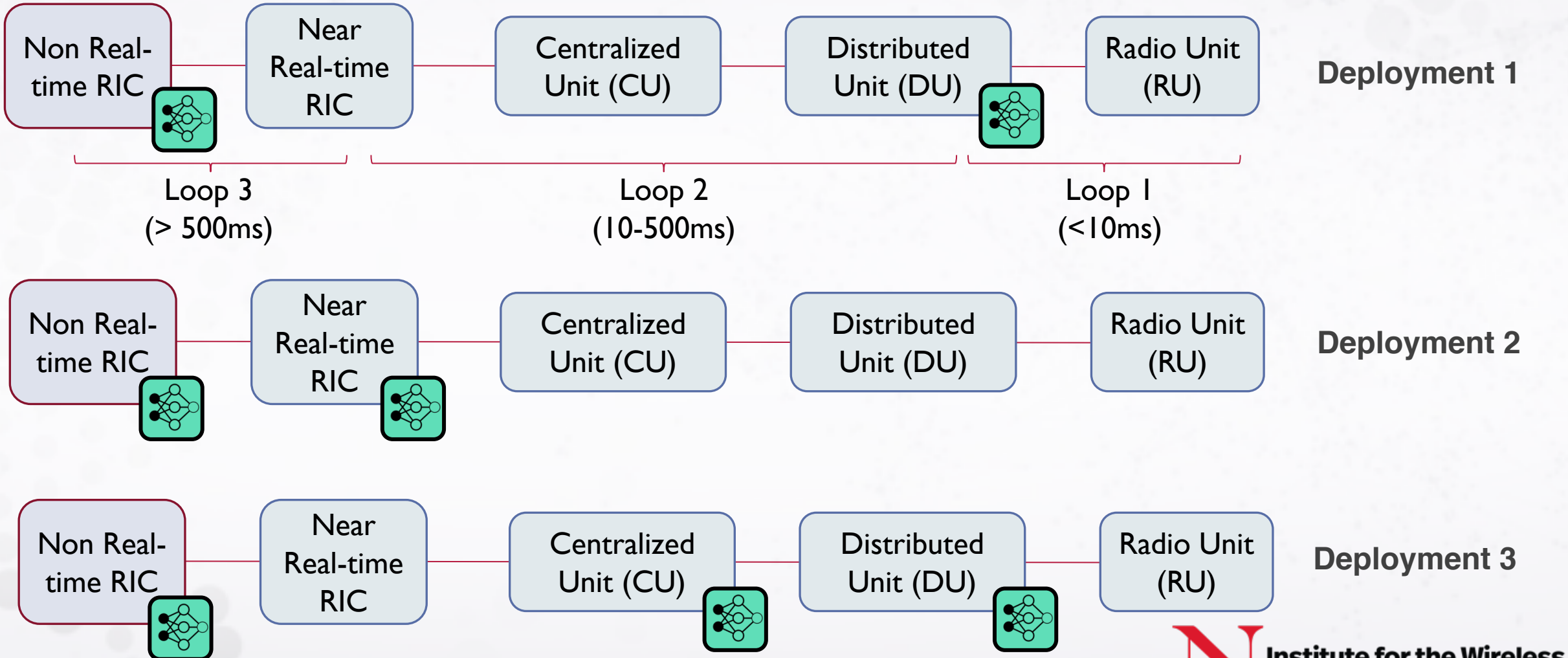
Network Intelligence with O-RAN: deployments



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