Digital Twin for Network Energy Consumption

Intern(s):

Andy Garcia

Hanshal Chandrashekara Reddy

Jinun Kim

Siddhant Sengupta

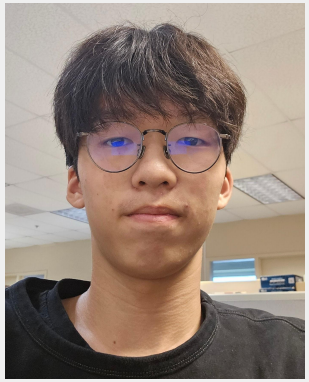
Mentor(s): Zhuohuan Li, N.K. Shankaranarayanan, Ivan Seskar

Who we are?

Andy Garcia

Rutgers University

Electrical and Computer Engineering



Jinun Kim

HS Student

Siddhant Sengupta

HS Student

Hanshal Chandrashekara Reddy

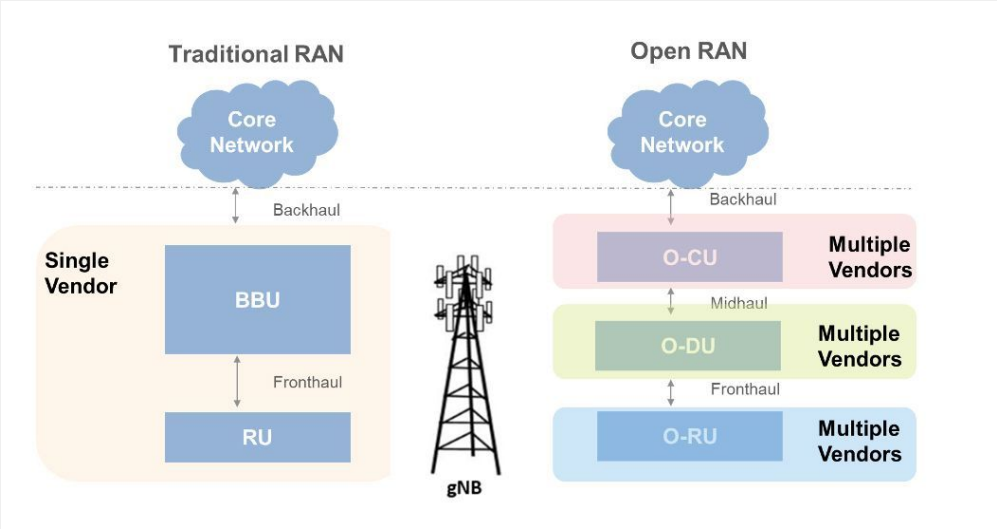
Rutgers University

Computer Science

O-RAN Review

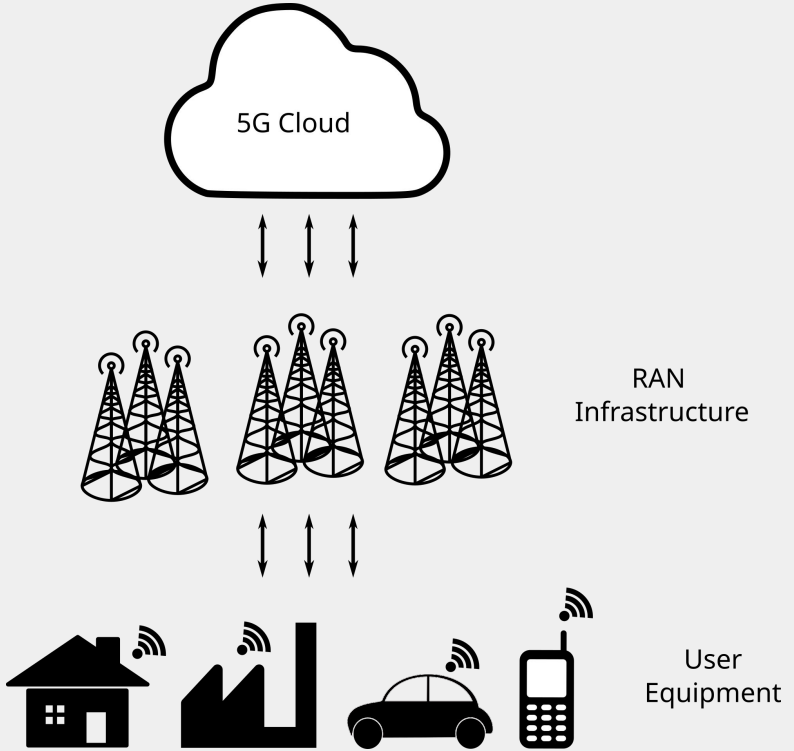
- An Open-Radio Access Network (O-RAN) is a telecommunication system that connects devices to the core network using radio signals

- Components of O-RAN
  - Radio Unit (RU)
    - Sends and receives wireless signals
  - Distributed Unit (DU)
    - Processes data
  - Centralized Unit (CU)
    - Manages data and network traffic



Project Overview

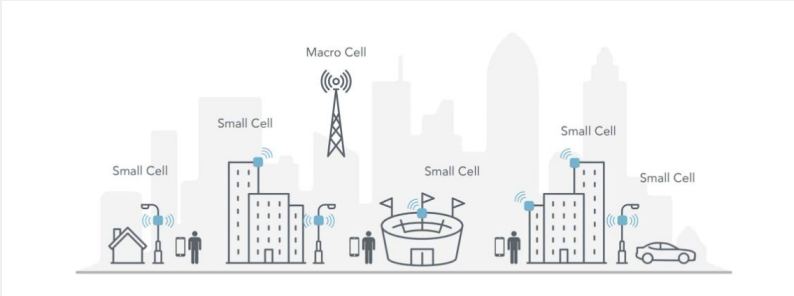
- Rising demand for 5G and 6G in cellular networks has led to increased energy consumption and operating expenses
- A digital twin[1] model will simulate network traffic to identify low-traffic periods
- Maximize energy efficiency
  - Implement sleep mode on specific O-RAN components during low network traffic periods



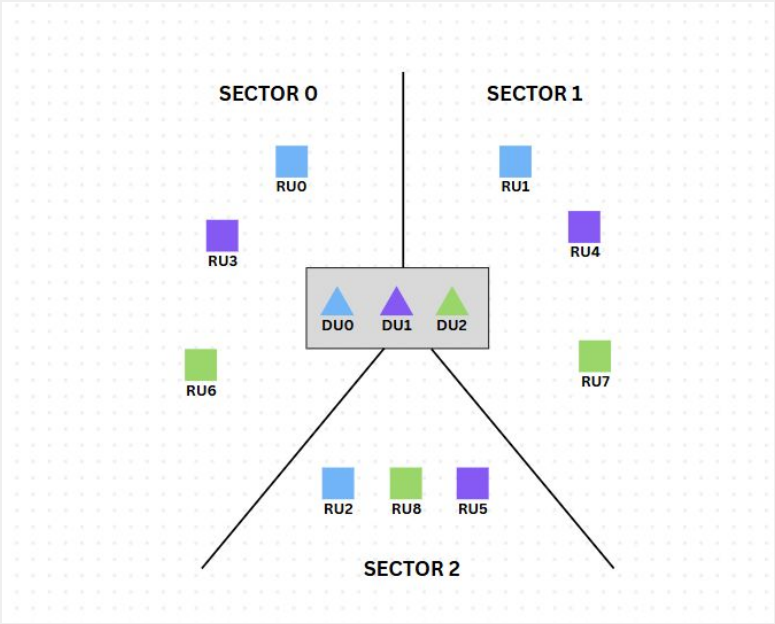
1. A virtual representation of a real-world object, process, or system

Andy Garcia

Network Reconfiguration



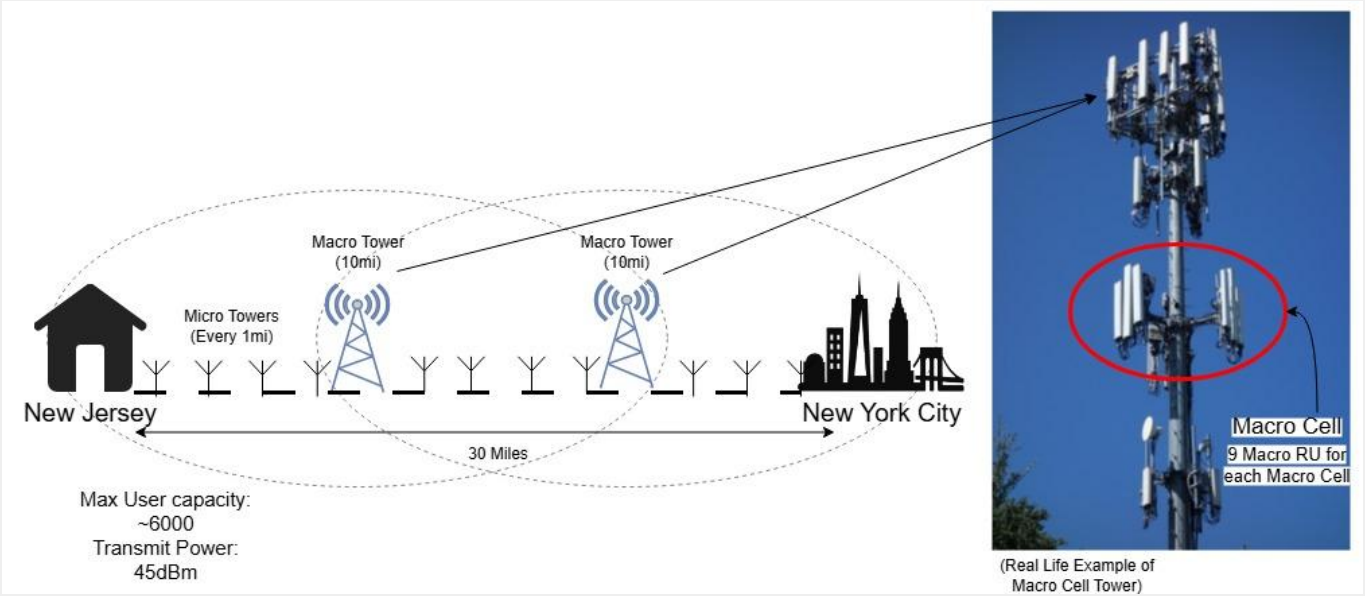
	DU0	DU1	DU2
RU0-2	Macro		
RU3-5		Micro	
RU6-8			Pico



- Explored and experimented with several network configurations including small cells
  - Small cells are used to enhance wireless networks capacity and coverage
  - Sectors are a coverage area supported by several RUs

Highway Scenario

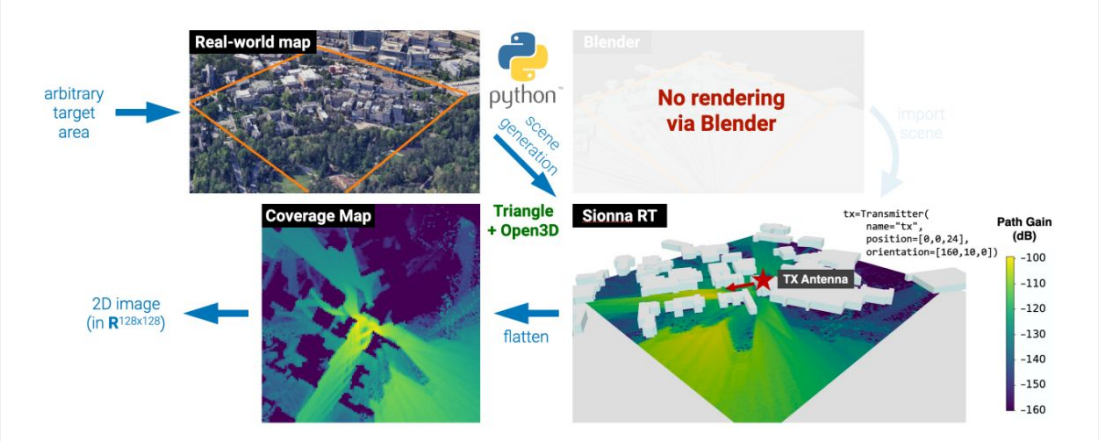
Commute between New Jersey and New York



- 2 Macro Towers
  - Provides Basic Coverage
  - 9 Macro RUs per tower
- 30 Micro Towers
  - Enhance performance
  - Higher traffic load capacity
  - 1 Micro RU per tower

Network Coverage with Sionna

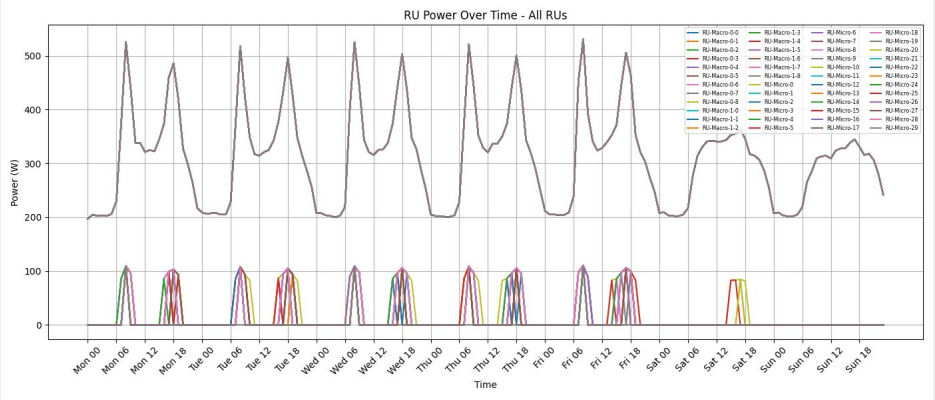
- Turns real-world maps into 3D network simulations
- Helps test how cell tower placement changes signal coverage
- Creates 2D coverage maps to compare different scenarios



RU Power Consumption Over Time

- Generated accurate plots displaying the power consumption of both RUs
  - Macro hit peak at 500 W
  - Micro hit peak at a little above 100 W
- RU Power Ranges
  - Macro: 197 W to 531 W
  - Micro: 59 W to 100 W

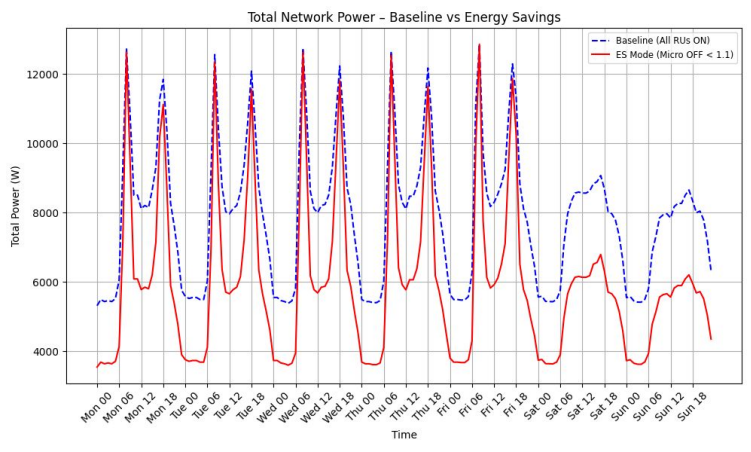
- RU Power Model:
  - ruPower = minWatts + (maxWatts - minWatts) x percentage of Traffic Load

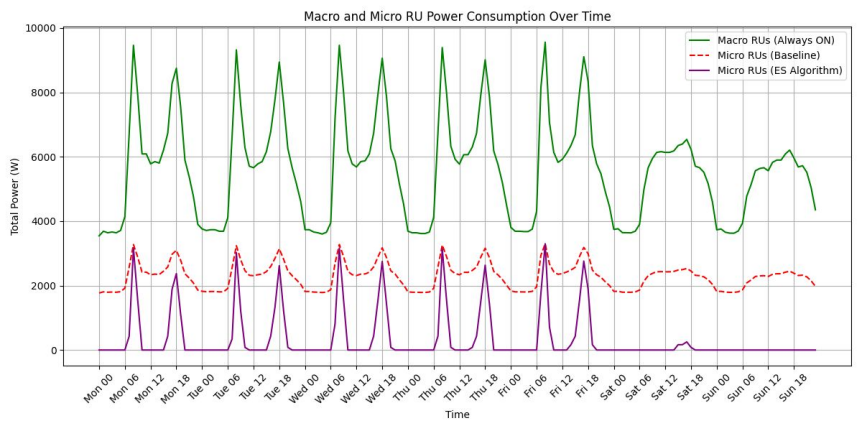


Algorithm 1 Number of Micro RU needed Algorithm

1: rangeAboveThreshold ← **maxTraffic − threshold**
2: trafficRange ← **traffic − threshold**
3: percentageOfMicroRU ← **trafficRange/rangeAboveThreshold**
4: neededMicro ← **percentageOfMicro · numberOfMicros**

Total Power Usage For Radio Units



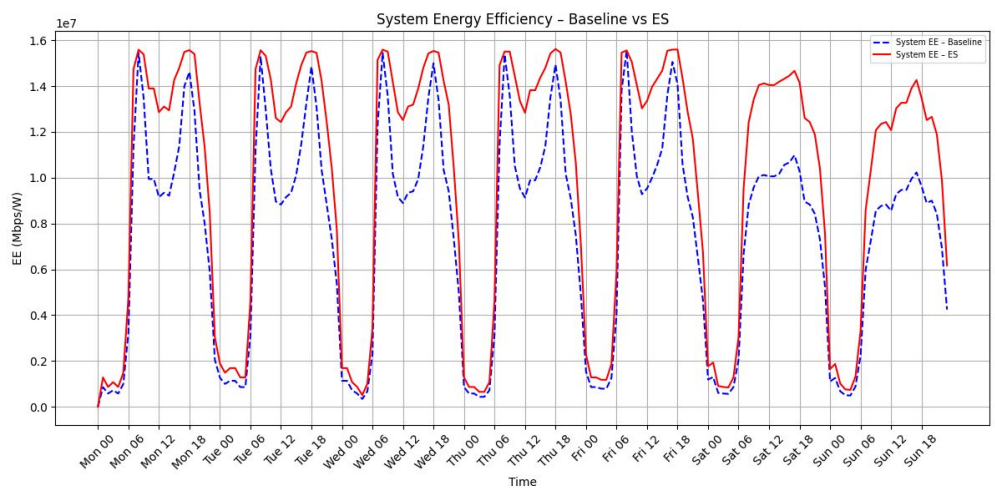


- Accurately depicts the total power usage for both Macro and Micro RUs
- ES mode saves a considerable amount of energy
    - Close to 2000 W in the morning, afternoon, and evening

- Created chart visualizing total power usage of Macro RUs, Micro RUs that are on, and during Micro ES mode
- Considerable energy savings for Micro RUs

Energy Efficiency

- Calculated energy efficiency of this simulation
  - Measured EE in Mbps/W
- Goal: To get as big of a difference between the two lines as possible
- Large gap on Saturday and Sunday emphasizing saved energy



$$EE = \frac{Data\ Volume(DV)}{Energy\ Consumed(EC)}$$

(bits/joule)

Thank You!