An ns3-based Energy Module of 5G NR Base Stations for Millimeter wave Networks

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Introduction

- MmWave communication leads to higher device energy consumption
- Resulting in faster battery drainage.
- Energy efficient algorithms needed to improve energy consumption.
- To design and test such algorithms simulators like ns3-mmWave module are used.
- ns3 lacks well defined BSs radio energy consumption model.

In this work:

We have developed an Energy model and have tested that with the ns3-mmwave framework.

Base Station Power Consumption

BASE STATION POWER CONSUMPTION IN 2020 TECHNOLOGY. SLEEP MODES 1 TO 4 CORRESPOND TO OFDM SYMBOL, SUB-FRAME, RADIO FRAME AND STANDBY, RESPECTIVELY.

BS power consumption [W]	Load		Sleep mode (partial deactivation)			
	Full	None	1	2	3	4
			71.4 μs	1 ms	10 ms	1 s
2x2 macro	702.6	114.5	76.5	8.6	6.0	5.3
4x4 macro	742.2	138.9	86.3	12.4	7.3	6.2
pico	6.9	2.3	1.5	0.4	0.3	0.2
femto	2.2	1.0	0.6	0.2	0.2	0.1
LSAS	40.5	32.2	21.0	4.1	2.4	1.6

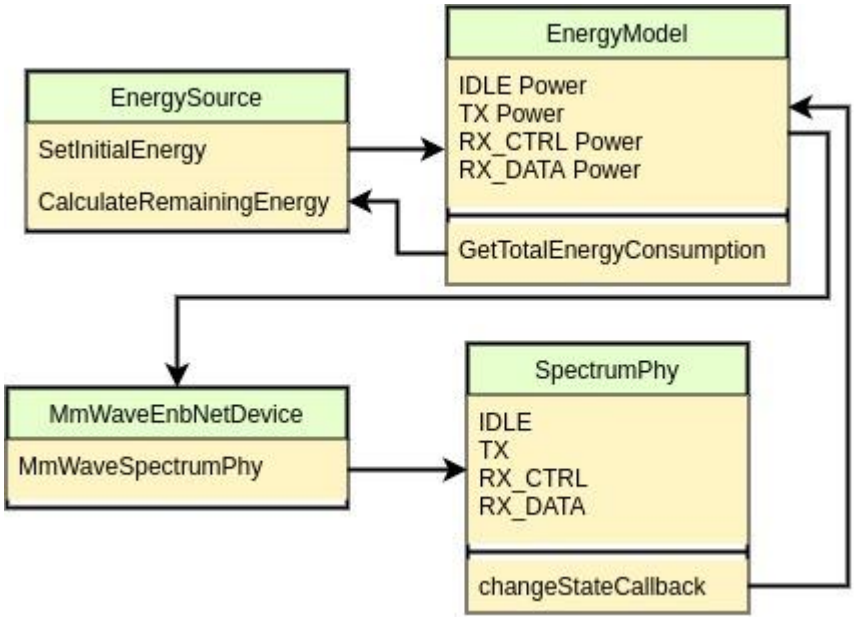
Source: IEEE VTC'15

- BS has 4 PHY States
  - RX_CTRL
  - RX_DATA
  - TX
  - IDLE
- For a 4x4 macro
  - P_{RX_CTRL} : 138.9W
  - P_{RX_DATA} : 138.9W
  - P_{TX} : 742.2W
  - P_{IDLE} : 12.4W

- We have used Sleep Mode 3 as: 1ms < $time\_taken_{IDLE}$ < 10 ms.
- Energy Consumption $E_{total} = \sum_{\mathcal{S} \in \mathbb{S}} (P_{\mathcal{S} \times t_{\mathcal{S}}})$, where $\mathbb{S} \in \{\text{IDLE}, \text{RX\_CTRL}, \text{RX\_DATA}, \text{TX}\}$
- NOTE: *The power values are taken from IEEE VTC'15 paper. One can change the power values as needed.*

Flow Diagram

Maintains the power supply of the BS

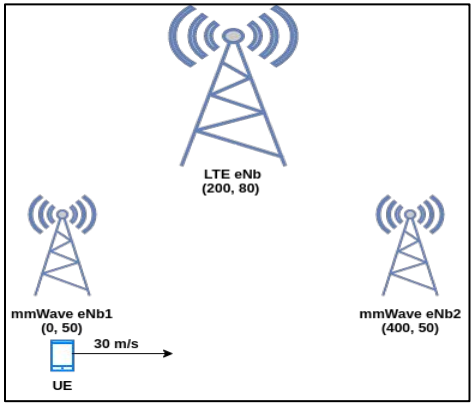


Modify E based on state change

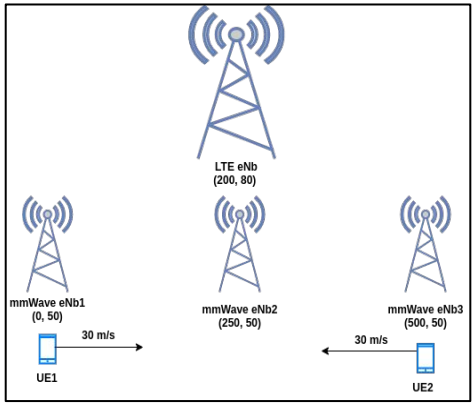
Installed over BS Node

Notify State Change

Simulation Scenario



Scenario 1

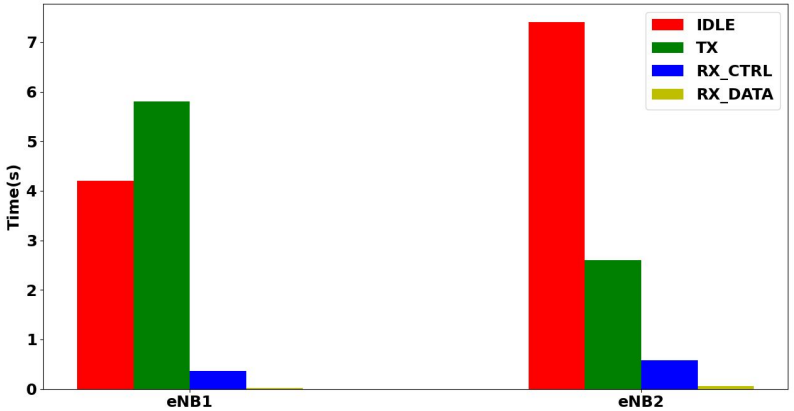


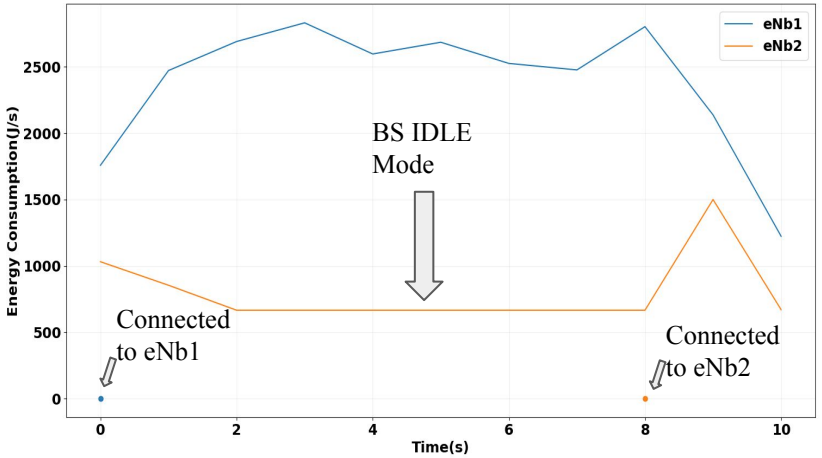
Scenario 2

- Start : (0,-5)
- End : (300, -5)
- Speed of UE : 30m/s
- Num of UEs : 1 or 2
- Num of BSs : 2 or 3
- Simulation Time : 10s
- No. of Buildings : 4
- App : UDP Socket

Results: Energy Consumption for Scenario 1

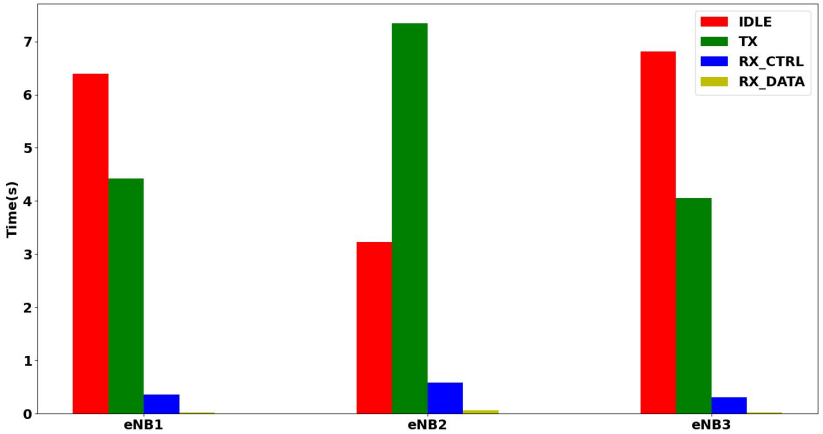
1. UE initially gets connected to eNb_1.
2. At simulation time 8s the UE gets connected to eNb_2.
3. $E_{eNb1} > E_{eNb2}$, as UE is connected to eNb1 for most of the time.
4. eNb_2 stays IDLE initially.

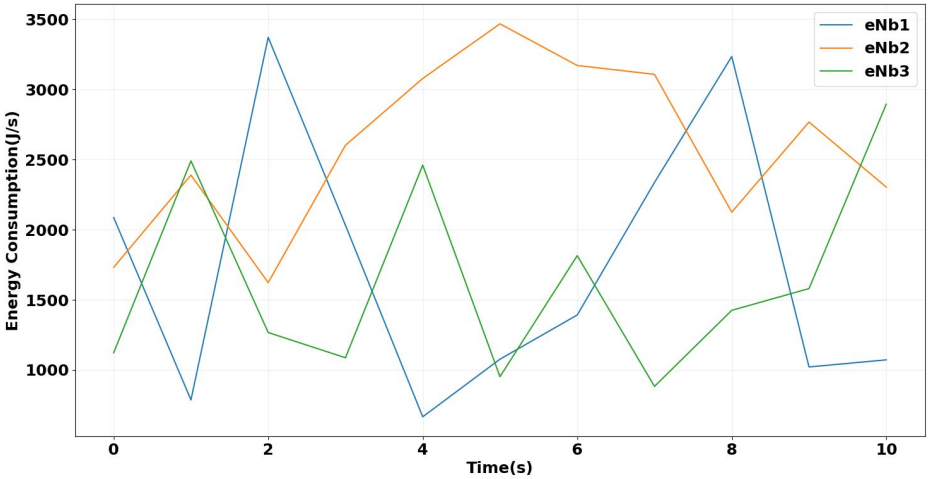




Results: Energy Consumption for Scenario 2

1. UE_1, UE_2 initially gets connected to eNb_1, eNb_3 respectively.
2. Initially eNb_2 stays IDLE.
3. In the middle of the simulation both UEs get connected to eNb_2





Summary

1. Designed and developed mmwave BSs energy module for NS3.
2. Evaluated the module on static and mobile scenarios.
3. Evaluation with different number of base stations.
4. Can nicely characterize the energy consumption.
5. Useful to test energy-efficient algorithms for 5G NR base stations.
6. Made the source code open in github.

Link:
https://github.com/arghasen10/ns3-mmwave/tree/base_station_energy_final

Thank You