A simulation framework for mobility use case oriented RAN dataset generation

Anthony Kiggundu, Ihab Alzalam,
Michael Zentarra and Hans Dieter Schotten

28. VDE ITG Fachtagung Mobilkommunikation Osnabrück

Michael Zentarra

michael.zentarra@dfki.de

15.05.2024

Content

- Motivation
- Intelligence in the RAN
- System Design
- Simulation
- Resulting Dataset
- Conclusion and Outlook

Motivation

- Artificial Intelligence (AI) techniques to be introduced into the RAN
- Development and training of AI algorithms requires high quality and quantity data
- Experimental setups are often limited in complexity
- Real world data of complex scenarios difficult to obtain for research
  - ➢ Simulations enable customizable dataset generation in complex mobility scenarios
  - ➢ Integration of mobility simulator into network simulator

Intelligence in the RAN

Traffic Steering

Proactive re-distribution of connected devices

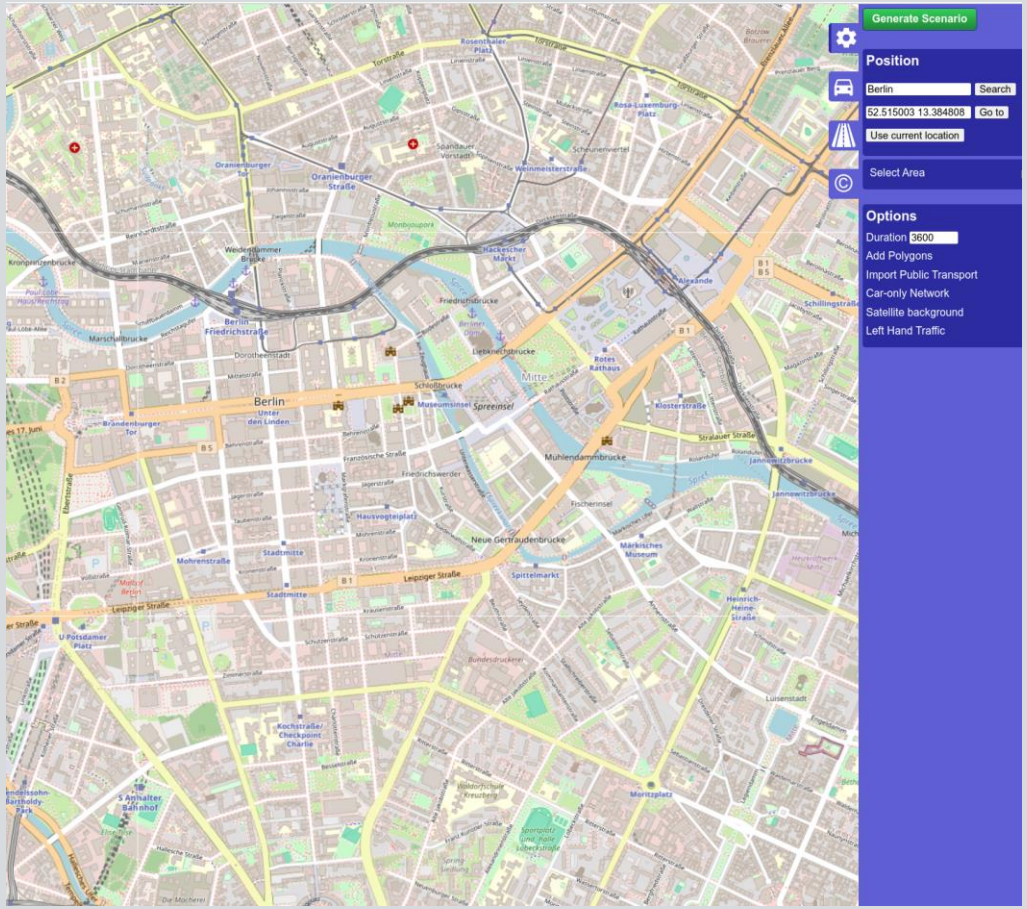
Beamforming

Steering antenna beams towards devices

Network Slicing

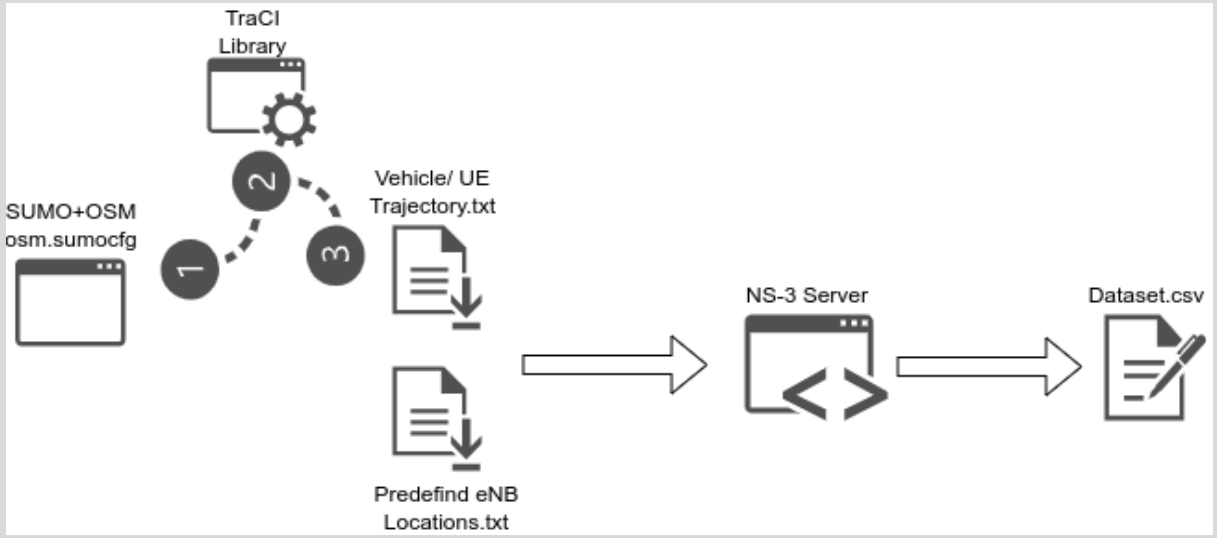
Differentiate service level based on use case requirements

System Design



- Not location specific – OpenStreetMaps can be deployed to capture location of interest
- SUMO (Simulation of urban mobility) ships with a script to trigger the integration of the desired location
- Define mobility profiles of entities of interest

System Design



- City map with mobility profiles of all entities generates SUMO configuration file (*osm.sumocfg*)
- The configuration file is fed into the traffic control interface library
- Speed and position metrics are read out into a trajectory text file
- BS positions are defined in text file
- Both text files are fed into ns-3
- ns-3 outputs the dataset as csv file

Simulation

- The whole simulation setup can be customized to the respective use case
- For an exemplary dataset we simulated 600 mobile entities traversing through 3 BSs
- 1 hour of UDP on-off application traffic was captured for all entities
- Custom enhancements:
  - log user positions together with their communication metrics
  - number of connected devices to all BS and the distance between user and BS

Simulation

- For each arriving user IP, the connected BS is tracked
- Each user IP is associated with a random network temporary identifier in a given cell ID to generate a key-value configuration mapping
- Connected BS is updated based on the HandoverStart and HandoverEnd handlers
- Position and velocity are extracted by a callback function
- Distance to BS is calculated based on the respective positions
- Communication metrics are handled by ns-3 callback functions

Generated Dataset

- Features: UE position, UE velocity, source & destination IP, distance to BS, Connected BS ID, Number of users connected to this BS, Transmitted and received packets, throughput, avg delay & jitter, RSRQ, RSRP

PoseX	PoseY	Velocity_X	Velocity_Y	SourceIP	DestinationIP	Transmitted	Received	Throughput	AverageDelay	AverageJitter	NumberLostPackets	DistanceToEnB	CellIDAttachedTo	AttachedToEnB	NumberOfUesConnected	RSRQ	RSRP
1987.34	2488.78	3.08289	-12.0876	1.0.0.2	7.0.0.3	11000	533	398.924	0.192664	0.00200188	990	2287.972064	1	10.0.0.5	5	-6.556672	-84.941277
1774.29	2095.84	13.5399	3.0022	1.0.0.2	7.0.0.2	12000	591	404.808	0.191218	0.00128257	1930	1877.318649	1	10.0.0.5	5	-5.499973	-80.811385
553.415	1866	2.92615	-7.18909	1.0.0.2	7.0.0.5	11997	410	281.261	0.27495	0.00335122	1943	917.614659	1	10.0.0.5	5	-5.000198	-77.017778
1787.83	2098.84	14.1228	3.13159	1.0.0.2	7.0.0.2	13000	644	407.615	0.191453	0.00127484	2876	1890.071547	1	10.0.0.5	5	-5.499973	-80.811385
2529.23	806.609	-6.84961	-2.02405	1.0.0.2	7.0.0.4	12999	428	271.042	0.286292	0.00239019	2911	2287.419828	1	10.0.0.5	5	-5.825013	-83.025678
2491.77	795.072	-6.98438	-2.18823	1.0.0.2	7.0.0.4	17999	608	277.856	0.287103	0.00226974	7731	2251.117104	1	10.0.0.5	5	-5.825013	-83.025678
2090.93	2206.94	-0.965332	6.75366	1.0.0.2	7.0.0.7	19000	1128	489.031	0.17234	0.00568883	8485	2170.164056	2	10.0.0.9	6	-6.203796	-83.293175
2011.95	2392.72	3.01404	-11.6616	1.0.0.2	7.0.0.3	19000	953	412.278	0.196292	0.00367366	8553	2245.915582	1	10.0.0.5	4	-6.585643	-84.779639
1268.5	763.107	9.38232	7.29773	1.0.0.2	7.0.0.6	18992	859	371.898	0.220521	0.00399302	8591	1045.686637	2	10.0.0.9	6	-6.50393	-83.608992
1883.76	2120.39	13.8698	3.10718	1.0.0.2	7.0.0.2	20000	1011	415.853	0.192763	0.00149951	9498	1981.021325	1	10.0.0.5	4	-5.499973	-80.811385
2089.96	2213.7	-0.932617	6.52295	1.0.0.2	7.0.0.7	20000	1173	482.358	0.174585	0.00575107	9421	2174.416357	2	10.0.0.9	6	-6.192541	-83.260575
601.211	1855.28	7.33783	3.08118	1.0.0.2	7.0.0.5	19997	768	315.811	0.257074	0.00305599	9642	924.582633	1	10.0.0.5	4	-5.050231	-77.047499
866.1	1986.91	9.75482	10.7255	1.0.0.2	7.0.0.5	47997	3392	580.832	0.147997	0.00123379	35521	1163.430513	1	10.0.0.5	4	-5.466118	-79.029889
1325.41	923.177	7.71057	10.7614	1.0.0.2	7.0.0.6	47992	2644	452.891	0.186698	0.00155295	35944	1078.150473	2	10.0.0.9	6	-6.563598	-84.516572
2138.81	2200.43	7.36011	11.6106	1.0.0.2	7.0.0.2	49000	2289	384.114	0.21478	0.00125426	37123	2237.998079	1	10.0.0.5	3	-5.595142	-81.488193
2072.47	1345.29	9.75366	7.26794	1.0.0.2	7.0.0.10	49000	1971	330.768	0.249825	0.00137798	37447	1637.011816	2	10.0.0.9	7	-6.633579	-84.841603
1955.7	1172.59	-9.15991	-6.42493	1.0.0.2	7.0.0.9	48999	2014	338.156	0.244807	0.00173436	37403	1460.248745	2	10.0.0.9	7	-5.974016	-82.007314
2275.98	780.341	-6.10547	1.32666	1.0.0.2	7.0.0.4	48999	2459	412.614	0.202643	0.00113623	37124	2037.853046	1	10.0.0.5	3	-5.881017	-82.554064
844.75	2420.67	4.83691	-0.546875	1.0.0.2	7.0.0.11	48997	3227	541.355	0.158362	0.00144128	36473	1807.318901	2	10.0.0.9	7	-5.758169	-81.054207

Conclusion and Outlook

- An open-source framework integrating a mobility simulator into a network simulator was developed
- Custom functionality was added to ns-3 to enable the generation of datasets with important features for RAN AI applications
- An exemplary simulation was carried out with 600 mobile devices
- Utilization of the data for diverse AI applications in the direction of quality of service sustainability are planned
- Further enhancements will be implemented as needed

Thank you for your attention!