SliceSim: A Simulation Suite for Network Slicing in 5G Networks

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Introduction

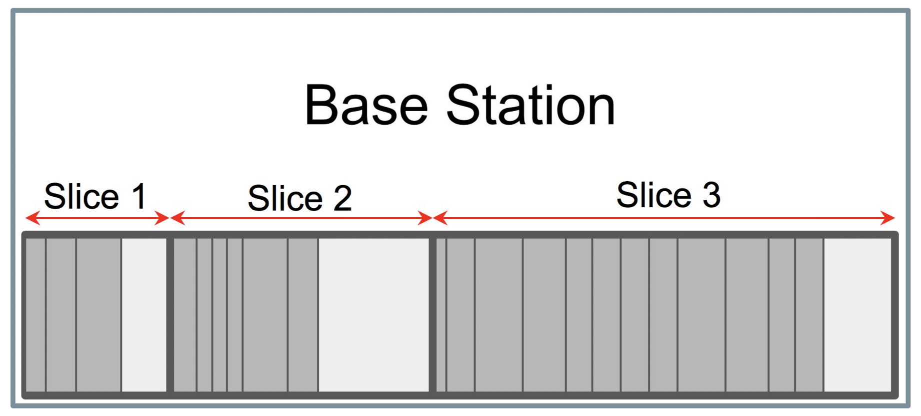
5G widely defines network slicing concept which aims to provide different and separate dedicated logical networks that can be customized to respective services. All slices under a cloud infrastructure are put together with their different requirements, e.g. bandwidth, latency

The purpose of this project is to provide a simulation suite for a network consisting of base stations and clients that possible scenarios of 5G can fit into and make analysis of different concepts easier.

Approach

- Discrete event simulation
- Using **Python 3.7**, **Simpy**, **Matplotlib**, **KDTree**
- **YAML** for reading input configurations
- Asynchronous programming
- Definitions:
  - **Clients**: Simulation consumers. Generates consume requests by given distribution parameters.
  - **Slices of Base Stations**: Simulation resources.

Structure



A base station has slices in it tailored for different needs:

- Guaranteed bandwidth for each customer
- Max bandwidth limit for each customer
- Allocated throughput for a slice
- QoS class
- Delay tolerance

Input Format with Example

Slices

Name	Guaranteed Bandwidth	Maximum Bandwidth	QoS Class
x_eMBB*	-	100 Mbps	5
x_mMTC**	1 Mbps	10 Mbps	2
x_URLLC***	5 Mbps	10 Mbps	1
x_voice	500 Kbps	1 Mbps	3
y_eMBB*	-	100 Mbps	5
y_eMBB_p****	100 Mbps	1 Gbps	4
y_voice	500 Kbps	1 Mbps	3

** Enhanced Mobile Broadband*
*** Massive Machine Type Communications*
**** Ultra Reliable Low Latency Communications*
***** Prioritized Enhanced Mobile Broadband*

Mobility Patterns

Name	Distribution	Parameters	Client Weight
Car	Normal Dist.	$\mathcal{N}(\mu = 0, \sigma = 7)$	0.1
Walk	Random Integer	$min = 0, max = 7$	0.4
Stationary	Normal Dist.	$\mathcal{N}(\mu = 0, \sigma = 0.1)$	0.2
Tram	Random Integer	$min = -4, max = 4$	0.1
Slack Person	Random Integer	$min = 0, max = 1$	0.2

Base Stations

ID	Coverage (x,y),r *(in meters)*	Throughput	Slices
1	$(182, 1414), 224$	20 Gbps	[...]
...	...	...	...
5	$(126, 1016), 384$	30 Gbps	[...]
...	...	...	...
20	$(44, 1916), 368$	50 Gbps	[...]

Clients Info

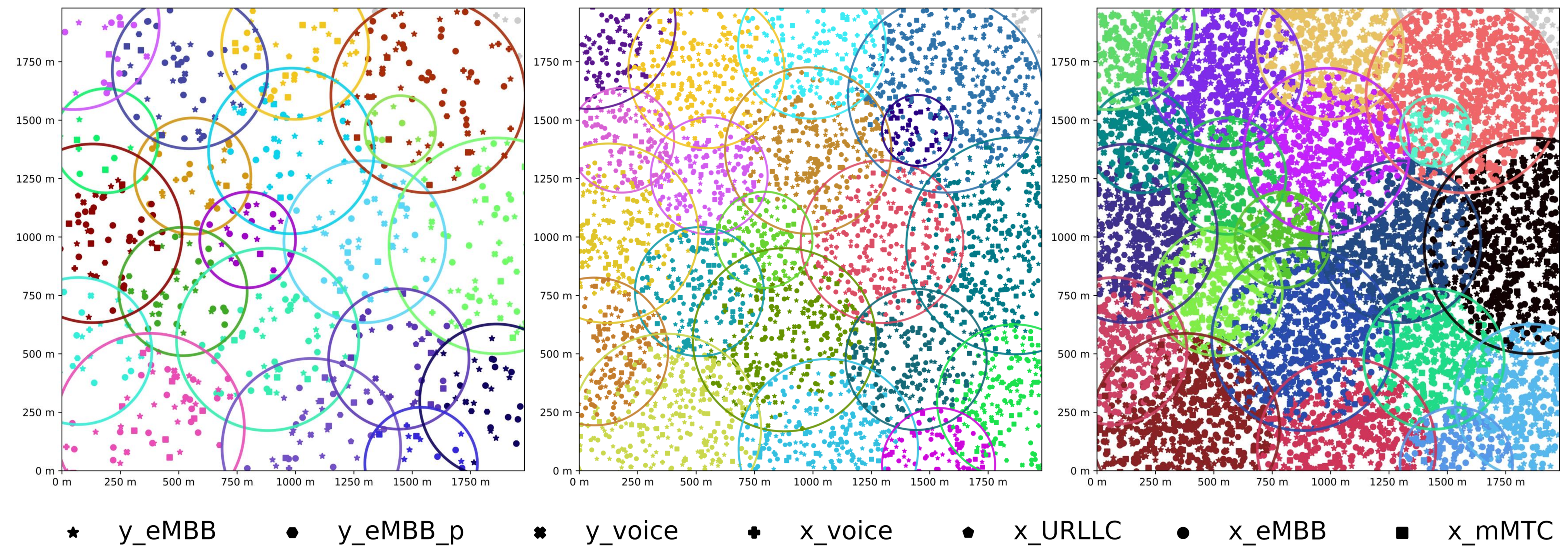
Name	Distribution	Parameters
x	Random Integer	$min = 0, max = 1980$
y	Random Integer	$min = 0, max = 1980$
Usage Frequency	Random	$min = 0, max = 0.1$

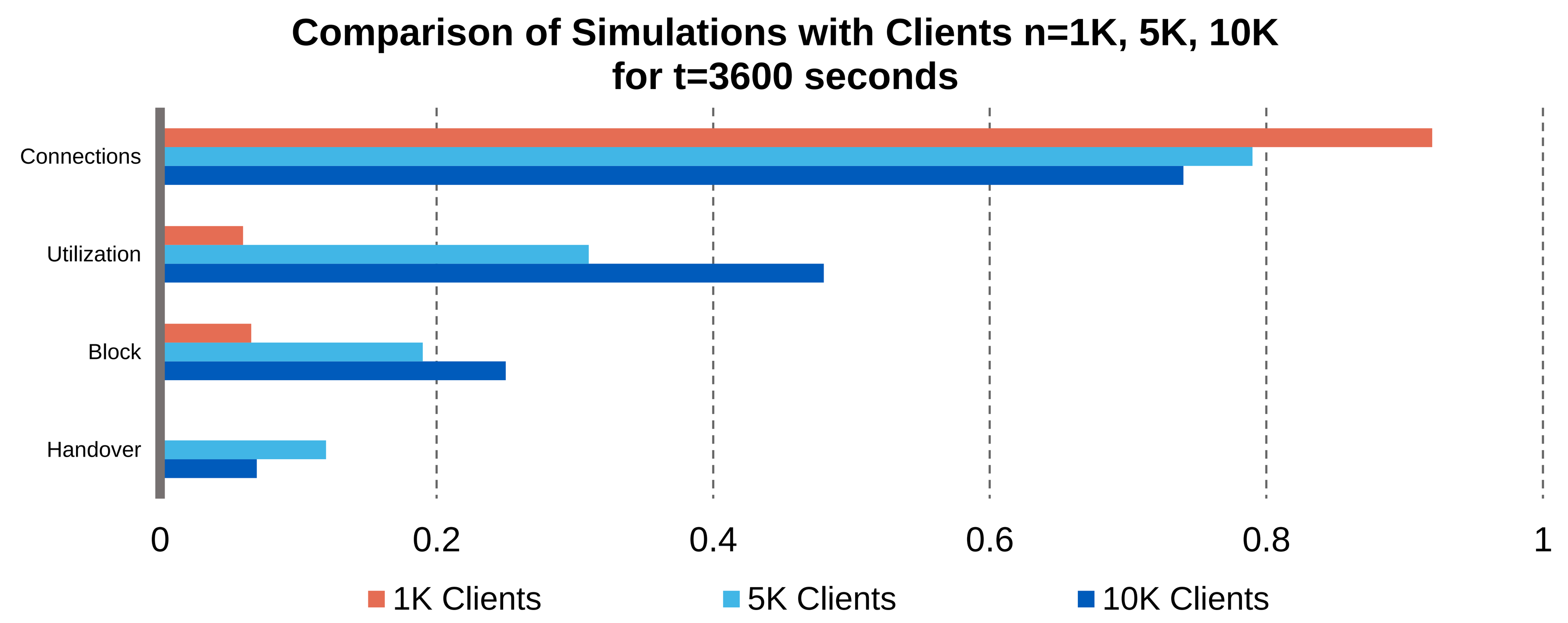
Example Simulation: Istanbul Old City (Fatih) Area

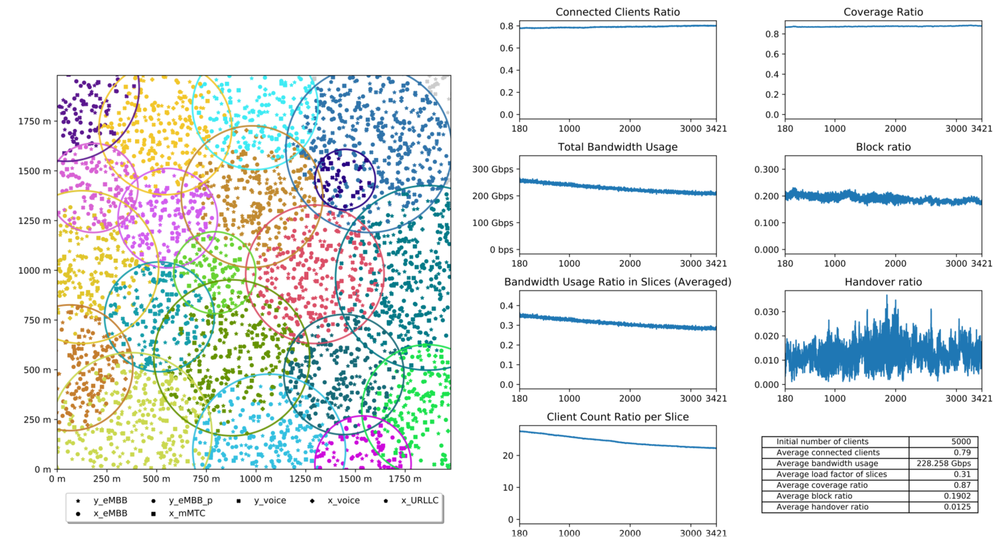
- Istanbul Old City Area is chosen as a geographical area sample because of high mobility and crowd population in that area.
- The area spanned is a square with 2 km side lengths.
- Base stations are modeled as circles and pinned on the map with respect to the real locations.
- The simulation is run for 1 hour (3600 seconds) with 1 second time units.
- 5% warmup and cooldown periods are set and statistics are collected between these interval.
- Statistics are collected from the clients who are in the canvas only. Clients being outside of the map are ignored.
- Final positions of clients and base stations are drawn:

Fatih, Istanbul, Turkey

A 4 km² area having touristic places, a grand bazaar, a university, a train station, living areas, etc.







Example output screenshot of the SliceSim simulation software.

```
python -m slicesim <input-file.yml>
```

Conclusion

- Increasing number of clients increases used bandwidth, and yet the simulation showed that block ratio also elevates for this specific configurations.

This simulation tool can be used for such scenarios as well:

- Testing the effect of different dynamic slicing algorithms on block and handover ratios.
- Analyzing various mobility patterns of clients using different statistical distributions.
- Observing the effect of usage frequency of clients and the effect of clients those are distributed unequally.
- Various Proof of Concepts like common base stations for multiple service providers.

Future Work

- Customizable shapes for base station coverages
- Improvements of the software performance
- Dynamic slicing mechanism
- Generation of more test configurations
- Video output of a running simulation

References

1. 5GPPP Architecture Working Group. View on 5G Architecture. Version 2.0, December 2017
2. CellMapper - https://www.cellmapper.net (10.05.2019)
3. Fatih Municipality Geographic Information System - https://gis.fatih.bel.tr/webgis (13.05.2019)
4. https://venturebeat.com/2018/12/12/decoding-5g-a-cheat-sheet-for-next-gen-cellular-concepts-and-jargon/ (17.03.2019)

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