Digital Twin and Predictive Maintenance of Cellular Network

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Introduction

The use of cellular communication technologies has made an incredible rise in the last two decades. Billions of people benefit from mobile communications. This traffic density requires good planning and maintenance of these systems.

This project aims to model a Digital Twin of the cellular network in a certain area with a simulation tool and to keep the service quality in the area within certain standards continuously. It will be examined whether machine learning and digital twins can be effective in base station location planning.

Digital Twin

A digital twin uses real data about a real-life object or system as input. It then generates predictions or simulations of how the real object or system will react based on these inputs. In its simplest form, it is a computer program that can simulate.

Cellular Configuration

Several experiments have been conducted in order to develop an unsupervised approach for reducing the number of cells while taking into account coverage, capacity, and power limits. It has been shown that using clustering techniques to configure a network may impove the quality.

Method

User behaviour is simulated in AnyLogic.

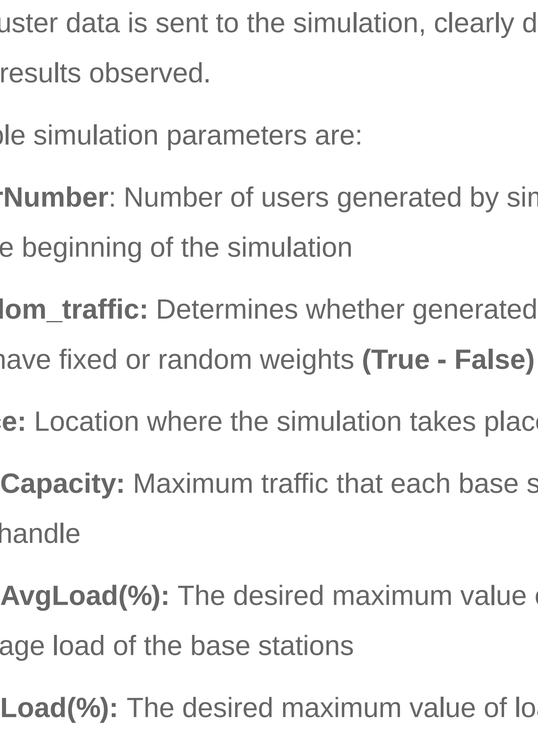
At a certain time interval, the users are converted into data samples and sent to Python via Pypeline.

Using K-means (an unsupervised learning and clustering algorithm), k is given as input by iterating within a certain interval. While iterating, it is checked whether the created clusters meet certain criteria.

A base station is placed in the center of each cluster. [1] Later, cluster data is sent to the simulation, clearly displayed and the results observed.

Adjustable simulation parameters are:

- **userNumber**: Number of users generated by simulation at the beginning of the simulation
- **random_traffic:** Determines whether generated users will have fixed or random weights **(True - False)**
- **Place:** Location where the simulation takes place
- **maxCapacity:** Maximum traffic that each base station can handle
- **maxAvgLoad(%):** The desired maximum value of the average load of the base stations
- **maxLoad(%):** The desired maximum value of load for any base station
- **simulationType:** User behavior used in simulation **(Nomadic - Mobile)**



K-means Clustering (k=46, users=2500) [1]

Data Flow

System can be divided into four parts [2]:

1 REAL WORLD

Data is gathered from the area and sent to the Digital Twin

2 DIGITAL TWIN (ANYLOGIC)

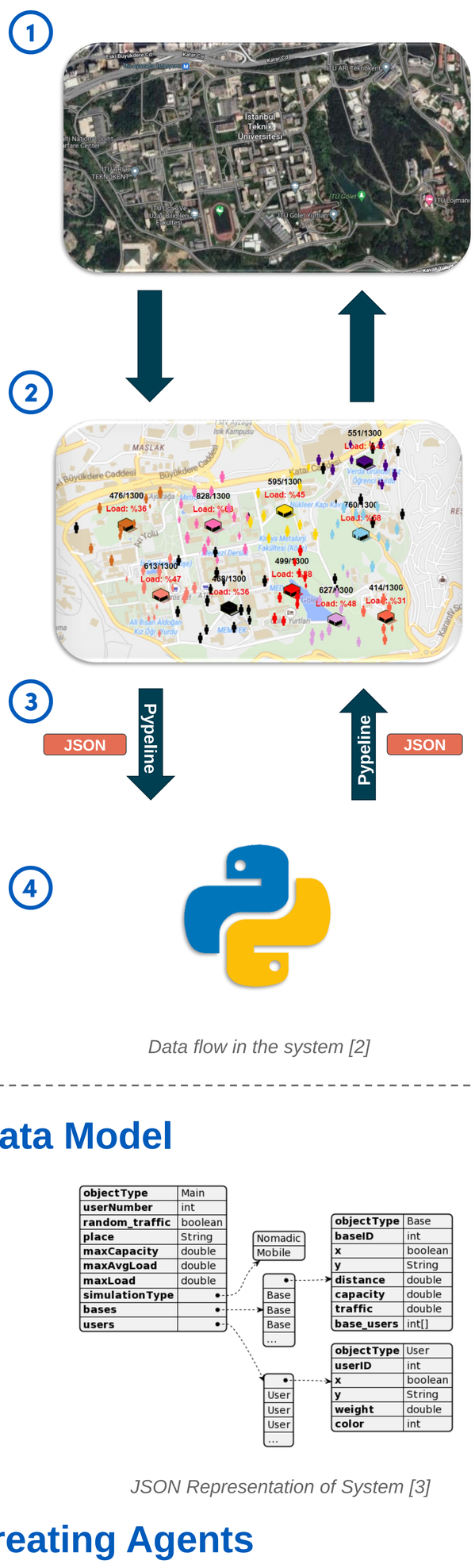
Users and base stations are converted to agents. Their interactions and user behavior is simulated in this part.

3 PYPELINE

Pypeline enables sending and receiving information from a local installation of Python. In addition, Pypeline can convert the agents and populations in AnyLogic to JSON, which is a format both Java and Python can parse. Similarly, it can generate agents and populations from JSON in the same way. Data transfer between Python and AnyLogic was made using Pypeline. [3][4][5][6]

4 PROCESSING (PYTHON)

Creation of random users and base station configuration is made in this part.



Data flow in the system [2]

Data Model

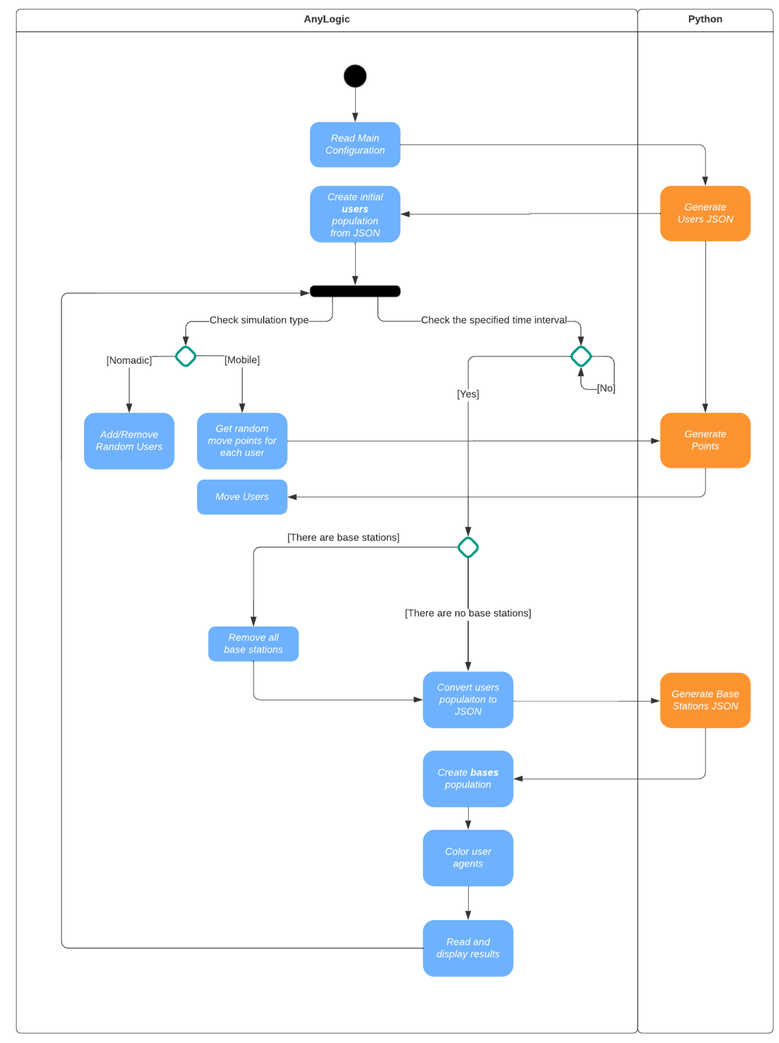
JSON Representation of System [3]

Creating Agents

User Agent Creation from JSON [4]

Base Agent Creation from JSON [5]

Activity Diagram

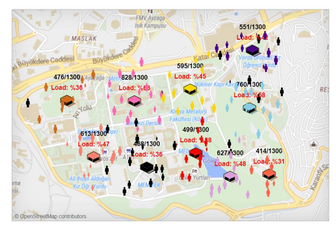


Activity Diagram [6]

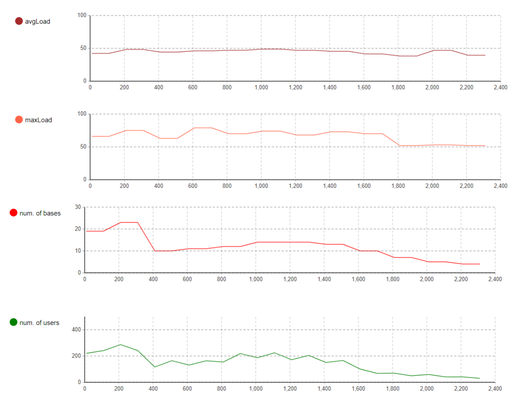
Experiment and Results

- **Number of initial users:** 200
- **Location:** ITU
- **Randomized Traffic:** True
- **Max Capacity:** 1300
- **Max Average Load:** %50
- **Max Load:** %80
- **Simulation Type:** Nomadic

Simulation at time=t [7]



Simulation at time=t' [8]



Experiment results [9]

With he change in the number of users over time, it can be observed how the base stations are reconfigured. [7][8] Looking at the results, it can be seen that Max Load and Average Load values did not exceed the desired value. [9]

Conclusion

It has been shown that the digital twin can bring impovements in many areas in the future, as well as play a role in the predictive maintenance of cellular traffic. This technology may take place in our lives in the future with the development of Internet of Things (IoT) solutions, the development of mobile base stations that can be tuned off and on in smart cities and sensons integrated to them.

References

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