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Synthetic NET: An AI-Enabled 5G and Beyond 3GPP Compliant Simulator

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ABSTRACT

New features, design suggestions, and solutions for the next generation of cellular systems need to be tested in a variety of real-world deployments and use cases. 3GPP-compliant 3GPPcompliant system-level holistic and realistic simulators are urgently needed to evaluate the variety of AI-based network automation solutions that are being suggested in the literature. The Synthetic-NET simulator created at AI4networks Lab is presented in this publication. A python-based emulator that completely complies with 3GPP 5G standards update 15 and can be upgraded to future releases called Synthetic-NET, according to the authors. In comparison to other simulators, Synthetic-NET has a number of key advantages, including: 1) a modular design that makes it easier to cross-validate and upgrade to future releases; 2) a variety of propagation modelling options, including measurement-based, ray-tracing-based, and AI-based models; 3) the ability to import data sheets based on measurements of realistic base [5] station features, including such satellite and energy consumption patterns; and 4) sui generis support for a wide range of wireless protocols. The Synthetic-NET's ability to be utilised to test AI-based network automation solutions is another important feature of the product. Synthetic Net's built-in abilities to analyze and process large amounts of data and integrated access to Applications Of machine learning [12] contribute to this simplicity of use, which is the first python-based 5G emulator. A powerful platform for both academia and industry alike, the Synthetic-NET simulator is a powerful tool for experimenting of not only creative approaches for optimising the operation of both existing as well as starting to emerge wireless connections but also for developing AI-powered deep mechanisation in the years to come.

Index Terms— Network simulator, adaptable frame structure, portability, and edge computing all fall under the umbrella term 5G.

I. INTRODUCTION

A mobile cellular network is one of the most complicated and expensive engineering systems currently in uses in the world today. Since modern base stations (BS) have thousands of configuration options, developing, deploying, then optimising a nation-wide mobile network containing tens or hundreds of thousands of varied sites is already a very difficult and resource-intensive technical problem. Optimal mobile network design and operation is a crucial motor of the rising digital society in the wake of internet-of-everything applications such as e-governance, e-commerce, and e-health. [8] Mobile technology's rapid advancement to 5G and beyond is an important step forward in meeting the capacity crisis, but it also exacerbates the complexity challenge that operators are facing right now. A mobile network is becoming increasingly difficult to design, setup, run, and administer as the number of variables per site and the specific place per unit area increase. System-level assessment tools are needed to investigate a wide range of new system-level features, settings, and deployment options in a variety of deployment and to use case scenarios. [6] Mathematics, such as stochastic geometry, has been used extensively by academic researchers to gain insights on the performance of different deployment scenarios [1–6]. These models, in order to be tractable, must rely on numerous restrictive assumptions and simplifications, such as the distribution of users and BS locations, transceiver design and configurations, and propagation characteristics, just to name a few. Furthermore, static models like these fail to account for the unique dynamics of mobile networks as user mobility and handover (HO).
Only through real-world testing can the merits of a brand-new network design, solution, or feature be fully appreciated and understood. Because of the time, money, and effort involved in conducting field trials, it is impractical to test every design, solution, or feature that is under consideration solely through this method. [4] Because of this, only the most prospective ideas are worthy of the resources and commitment required for field trials. As a result, mobile operators are concerned about minimising the danger of substantial network performance degradation including during the trial period.

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Due to the increased complexity of 5G networks, it will be considerably more difficult to create a network configuration that maximises all of the KPIs (Key Performance Indicators), including coverage, capacity, retention, and energy efficiency. In order to live up to expectations of the much-anticipated 5G networks, network operators must find and maintain the ideal network design. Costly and impractical to deploy new 5G networks, as well as unique network features, such as those suggested in [7]–[9], in the real world without figure showed, will be prohibitively expensive and impractical in the long run. Simulators at the system level are frequently utilised in industry and academics to address this issue. Table 1 summarises the results of a survey undertaken by the authors and determined that no 5G simulator has yet been developed that includes all of the standard's essential components. The simulators offer the unique characteristics and flexibility needed to construct and assess an AI-based design and zero-touch automation framework proposed for emerging networks in [7]. Synthetic-NET, a system-level Python simulator, has been developed to address this issue. The 3GPP Release 15-compliant Synthetic-NET simulation is modular, flexible, tiny, and multifunctional. [3] Adaptive numerology, real HO criteria, and futuristic database-aided edge computing are just a few of the unique features supported by the simulator. An Object-Oriented Programming (OOP) structure like current simulators [11–12] does not support the regularly used database files (such SQL, Microsoft Access, and Microsoft Excel) that Synthetic-NET simulator does. It is possible to immediately input information about the location and users, such as antenna patterns, into the simulator. Consequently, the simulation model is more genuine and comparable to genuine deployments. SON and innovative AI-based network automation solutions can be validated in Synthetic-NET simulator thanks to the Python-based platform and the variety of input/output data formats supported by the software. It can be used by [2] mobile operators to plan, evaluate, and even optimise 5G networks.. The research community can also profit from it by putting the new ideas on realistic 3GPP-based 5G system level simulators.

II. RELATED WORK

Simulators targeting the characteristics of 5G networks have been created in recent years [11–12]. Table 1's analysis demonstrates that every one of those simulators only represents a subset of the 5G standard's features [10]. As far as simulators go, Matplotlib [11] is by far the most advanced 5G link-level simulator because it supports configurable frame structure, a variety of resource scheduling approaches, and the ability to add mmWave channels as well. Except unlike Synthetic-NET, this is not a system-level simulation like that. Simulated mobility and HO mechanisms, categorization of User Equipment (UE) according to QoS Class Identifier (QCI), and cloud-based network deployment are just a few of the characteristics that MATLAB-based 5G simulators do not enable. For academic purposes, there is the open-source system-level simulator Vienna 5G simulator [7], which is built on the Matlab platform. In contrast to [11], cloud computing is supported in Vienna. There is a major problem with this simulator: It doesn't have accurate mobility modelling and the ability to run on any hardware. Simulator also lacks several critical capabilities, such as dynamic system modelling and HO support that are needed to accurately replicate a genuine cellular network.

In addition to ns-3, OMNeT++, and OPNET, several more popular discrete-event 5Generation network simulators are also available. A large chunk of the protocol stack is implemented [3] in event driven simulators, and the packets are included. These simulators are orientated in a very precise manner. Results at the level of individual links. [2] In spite of this, their processing power is quite impressive. Because of the difficulty of deploying big Radio Access Networks (RAN), they are unable to conduct more realistic studies. This type of simulator is better suited to the heart of the problem graphic representations of the side of the model important RAN KPIs like coverage and capacity. The demand big RAN deployments can be hard to implement and test The 5G will have a strong emphasis o a densely packed BS setup with a large number of mobile sensorial devices and self-driven subscribers Cars and other vehicles are included.

III. METHODOLOGY

A new simulators depending on 3GPP (supporting for training data Artificial Intelligence (AI) techniques) that can mimic 5G and certain other cellular services is being developed by the author of this article to overcome the challenge of designing and implementing such services, which require a large infrastructure and a lot of money, and to overcome this problem, the writer is developing a new simulator based on 3GPP that can simulate 5G.

All existing simulators allow 5G simulation, but they lack AI support that can be used to forecast the mobility of cellular users and depending on mobility AI helps in selecting the nearest Base Station, [4] which can minimise energy consumption and boost cellular service quality.

The Python-based Propose Simulator can give the following capabilities.

1) AI algorithm support built-in, which aids in anticipating user movement
2) Has the ability to be updated with new simulation methods.
3) A variety of data sources, such as CSV files and database tables, can be used to import simulation parameters.
4) The way people move about on a daily basis
5) The use of maps to depict the patterns of movement
6) Implementation of the detailed changeover (HO) process
7) Support simulation of the 5G network

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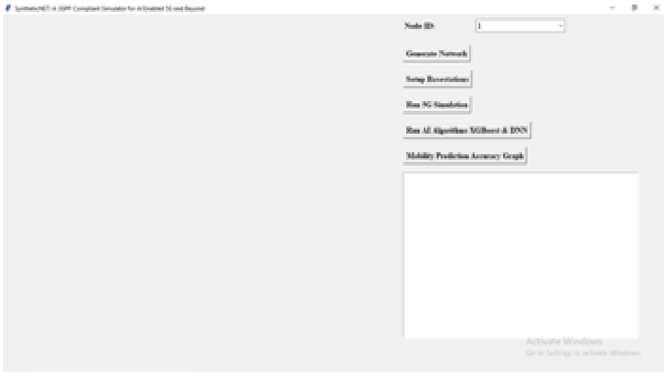
This simulator was under construction and will be released shortly for educational purposes, but it has not yet been published on the internet, as you can see in the rest of the paper. A true implementation of these situations would require a lot of infrastructure and cost, hence the author suggests testing these networks using the Synthetic-NET emulator before moving on to a real implementation.

For this simulator, we created a 5G environment in which nodes can choose the closest network device to get cellular services, and to identify this closest base station software would use an AI algorithm that works like a human brain [5]. The same shortest technique is used by the 5G network to choose the best path to reach a base station, just like the human brain does.

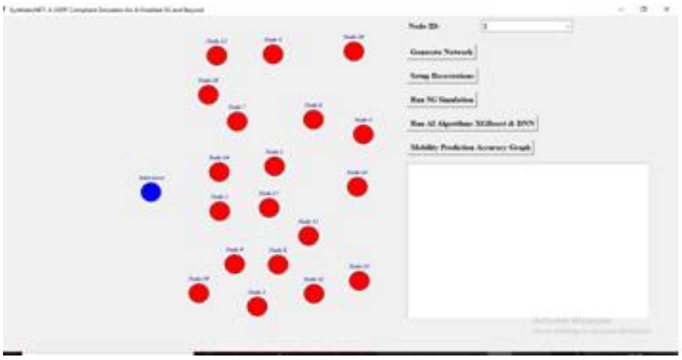
It has been suggested that DNN and XGBOOST algorithms have been used in the proposed paper to predict mobility. We, too, have used these models to detect mobility and have used 5Generation network datasets to calculate the accuracy of these algorithms. This trained model is then used to predict portability from testing data, with the accuracy of algorithm prediction being measured as a percent correct for each test.

IV. RESULT AND DISCUSSION

To run the project to get below result



To construct a simulation network, click on the 'Generate Network' tab in the above outcome.



Here's what you get: All red nodes represent mobile users, while all blue nodes represent the servers that serve them; click on the "Setup Base station" tab to break up your network into cells, and then designate a base station to every one of those cells.

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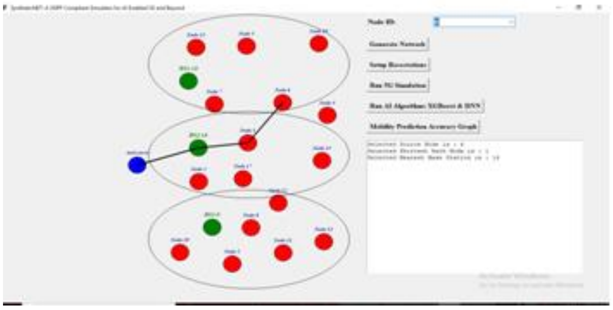
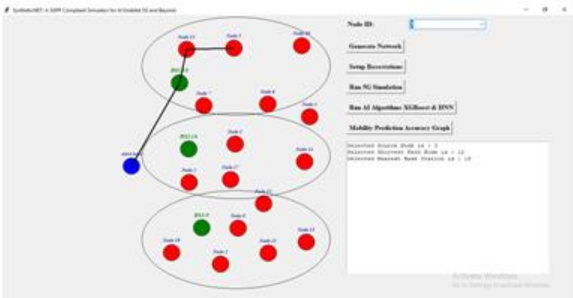
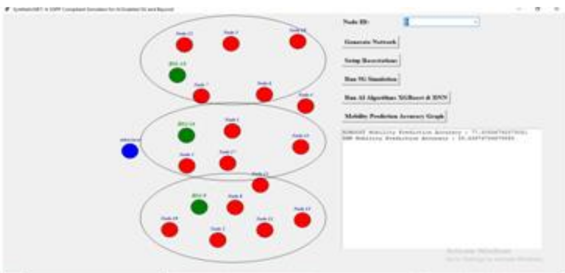
As seen in the above image, the large ovals indicate network cells, and the green nodes represent base stations, which connect the mobile user to the mobile server for services. Selecting 'Node6' from the Node ID drop-down box and pressing the 'run 5g simulation' button will provide the following output, which will allow a cellular user can send a request to a mobile server.



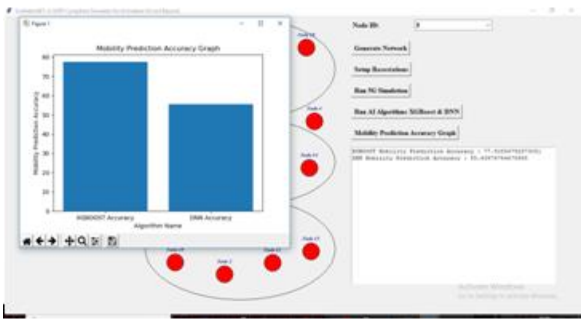
Using the simulation results above, we can see that node 6 selected its nearest neighbour, and then that neighbour selected the nearest base station, BS2-16, which connects this base station to the mobile server, and so on. Node3's base station can be seen on the following result



To begin training Ai technologies with 5G communication networks and calculating accuracy, click the run AI Technology XGBoost and DNN tab.



To see the mobility prediction accuracy graph, click on the 'Mobility Prediction Accuracy Graph' button above. We can see that XGBOOST has a mobility accuracy of 77%, whereas DNN has a mobility accuracy of 55%.



The x-axis shows the name of the algorithm, and the y-axis represents the algorithm's accuracy.

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V. CONCLUSION

Simulators according to the 3GPP standard are essential for cellular networks because of the anticipated complexities of 5G and future networks. Because they lack realistic assumptions and the implementation of critical network elements, the simulators that are now available are unable to capture the full complexity and dynamic nature of a real cellular network. First, we've built Synthetic-NET, a network simulator that is 3GPP 5G standards (Release 15) compliant. Many major network functions can be implemented with Synthetic-NET, which is more realistic and practical than other tools. Since the underlying distribution in prior OOP-based simulators means that BS locations cannot be reassigned, the Synthetic-NET simulator allows each BS and UE to have its own set of hard-coded parameters (such as azimuth, tilt, antenna pattern and height) much like in a real network deployment. [7] Synthetic-NET simulator's modular design makes it easy to add new network features with 3GPP releases 16 and future updates, making this simulator future-proof. Without specialised simulation hardware, large-scale networks with thousands of potential heterogeneity BSs and numerous user kinds can be modelled using Synthetic-NET simulator's flexible approach.

For the first time, a simulator has been developed that models over 20 parameters necessary to implement a whole 3GPP-based HO process. Retention and HO success rates can be accurately measured with the help of logically valid mobility trace data. [10] For precise computation of signal strength and adaptable frame structure to fulfil the needs of various 5G use scenarios (eMBB, URLLC, mMTC), Synthetic-NET simulators contains ray tracing-based models.

Unlike other Python-based simulators, Synthetic-NET has a built-in ability to handle big data sets with ease. There are a broad variety of machine learning algorithms that can be easily accessed. [8] Artificial intelligence (AI) solutions for autonomous setup and optimization of network parameters in a number of co heterogeneous wireless deployments are easier to create and test in Synthetic-NET simulator because of this.

For a realistic evaluation of various machine learning techniques in predicting user mobility that would have been unrealistic or inaccurate using currently available network simulators, the use case on transportation prediction illustrates the potential of Synthetic-NET in offering practical network deployment, handover process and ease of incorporation of believable traffic conditions from other sources.

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