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A study on mobile telecommunication systems using OpenAirInterface platform

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Abstract: Significant progress has been made in deploying 5G mobile networks in the last few years, providing rapid connectivity and low-latency communications. This study thoroughly analyzes the deployment of 5G networks utilizing the Open Air Interface (OAI), a free and open-source wireless communication technology. The survey gives a general overview of OAI's various fields and applications. It then looks at numerous uses and industries where OAI-based networks for 5G have been effectively implemented. The paper includes in-depth discussions of OAI's technical features and information on how it supports creating software-defined radio (SDR) platforms for 5G networks. It emphasizes OAI's versatility and flexibility, allowing researchers and developers to test various network setups and protocols. The survey's results show how OAI is becoming increasingly crucial to designing and rolling out 5G networks in various sectors. Researchers and professionals can investigate fresh applications and services that make the most of 5G technology by utilizing the capabilities of OAI. The taxonomy is designed and developed by categorizing the existing proposed solutions using OAI to easily deploy mobile telecommunication networks cost-effectively and flexibly to support various features and functionalities. Each category in the developed taxonomy is discussed and compared regarding multiple parameters.

Introduction

The wireless technology platform OpenAirInterface (OAI) is adaptable to an open LTE environment. The OAI platform is open-source software that supports the E-UTRAN and EPC portions of the 3GPP standard protocol stack. The OAI is the only fully open-source SDR solution that is totally x86-based and offers UE, eNB, and core network functionalities. Additional built-in tools offered by OAI include very realistic emulation options, soft monitoring and debugging features, a protocol analyzer, a performance profiler, and a configurable log system that supports all layers and channels. OAI platform can be utilized in various setups that involve various levels of commercial components given by Nikaien, N. (2015). They are as follows. (1) OAI-UE OAI-eNB + OAI EPC, (2) OAI-UE OAI-eNB + Commercial-EPC, (3) OAI-UE Commercial-eNB + OAI-EPC, (4) Commercial-UE Commercial-eNB + OAI-EPC, (5) Commercial-UE OAI-eNB + Commercial EPC, (6) Commercial-UE OAI-eNB + OAI-EPC.OAI is also virtualizable and accessible through cloud-based technologies. Virtualization and containerization are two cloud computing buzzwords that will be often utilized. Virtualization is the technique of decoupling computational resources from physical hardware so that some apps can share them. While the phrase "application containerization" refers to a way of operating system (OS) level virtualization for executing distributed apps without running every part of the virtual machine. Virtualization based on containers is another name for containerization.

79 research articles in the Google Scholar database with the phrase open air interface exist. We have chosen the last five years' articles, which are 44 in number. The taxonomy is designed and developed based on these 44 contributions using OAI. Classification mainly consists of applications using OAI and applications integrated with other open-source tools with OAI for implementing 5G

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networks. Each classification has been explained by studying the corresponding papers. The comparison of each category is made in terms of various parameters.

Our contributions

Consequently, this significant amount of published research on OAI-based Mobile Telecommunication Systems/Features requires some categorization to provide a convenient overview of the current state of the art. To this end, we have designed a taxonomy to classify the OAI-based Mobile Telecommunication Systems/Features research that is given in Section 2. The presented taxonomy allows us to analyze the OAI-based Mobile Telecommunication Systems/Features research trends over time and the various functionalities supported in the work. To illustrate the usefulness of the provided classification, we discuss a detailed survey of the collected research articles from extensive online databases where OAI-based Mobile Telecommunication Systems/Features-based references can be explored according to the categories of the presented taxonomy. Our specific contributions are as follows:

(1) Design and develop a taxonomy of OAI-based Mobile Telecommunication Systems/Features.

(2) Explain the OAI-based Mobile Telecommunication Systems/Features research as per the developed taxonomy.

(3) Compare each category's discussed research proposals regarding functional and performance parameters.

The remaining part of this article is structured in various sections as follows. Section 2 explains the methodology for creating the OAI-based Mobile Telecommunication Systems/Features research work taxonomy with its categories. Section 3 presents a detailed survey of the key research findings and related comparisons concerning the set of functional and performance parameters concerning OAI-based Mobile Telecommunication Systems/Features. Section 4 addresses the scope of the research on OAI-based Mobile Telecommunication Systems/Features. Finally, conclusions are drawn.

Taxonomy OAI-based Mobile Telecommunication Systems

The taxonomy aims to classify the work carried out in the area of OAI-based Mobile Telecommunication Systems/Features to have an in-depth understanding of the topic. Taxonomy construction varies from topic to topic, but all works in one class given in the taxonomy should be similar in features or properties. The classification categories should be non-overlapping with well-defined limits between them. The taxonomy designed for OAI-based Mobile Telecommunication Systems/Features related research for analyzing the features and performance includes two non-overlapping categories. The presented taxonomy allows us to analyze the OAI-based Mobile Telecommunication Systems/Features research trends over time and various features supported in the work. A given article may not be mutually exclusive to the category as it may belong to one or more categories. The OAI-based Mobile Telecommunication Systems/Features taxonomy illustration in graphical form is given as shown in Figure 1. We have tried to minimize the possible overlap between the existing OAI-based Mobile Telecommunication Systems/Features techniques in this early stage of defining the classification categories.

Figure 1 shows two main categories for designing the OAI-based Mobile Telecommunication Systems/Features taxonomy. The first category is for using OAI for developing Mobile Telecommunication Systems/Features, while the second category is wherein the OAI is integrated with other open-source software to get specific outcomes.

We identified the functional and performance parameters that were not discussed while describing the proposal but compared them in various tables under each category section. All parameters may not be relevant to each category, so only relevant parameters are chosen for comparison under each category in the taxonomy. Table 1 provides the functional and performance parameters that compare the OAI-based Mobile Telecommunication Systems/Features techniques.

Literature Survey on OAI For Mobile Telecommunication Systems

This section discusses the various categories designed in the taxonomy shown in Figure 1. Each subsection discusses the research article identified under the specific category, followed by a comparison of the proposed research work in terms of the parameters given in Table 1. OAI category research articles are further categorized into two classes wherein OAI usage is considered for LTE/4G/mesh/other network classes and 5G network classes. Recent articles in the last five years have used OAI for 5G network research, which this section discusses.

OAI for 5G Network Research

There are several research articles available in the category "5G network," which are split into two categories as follows:

(1) OAI is used for assessing the viability study of existing features

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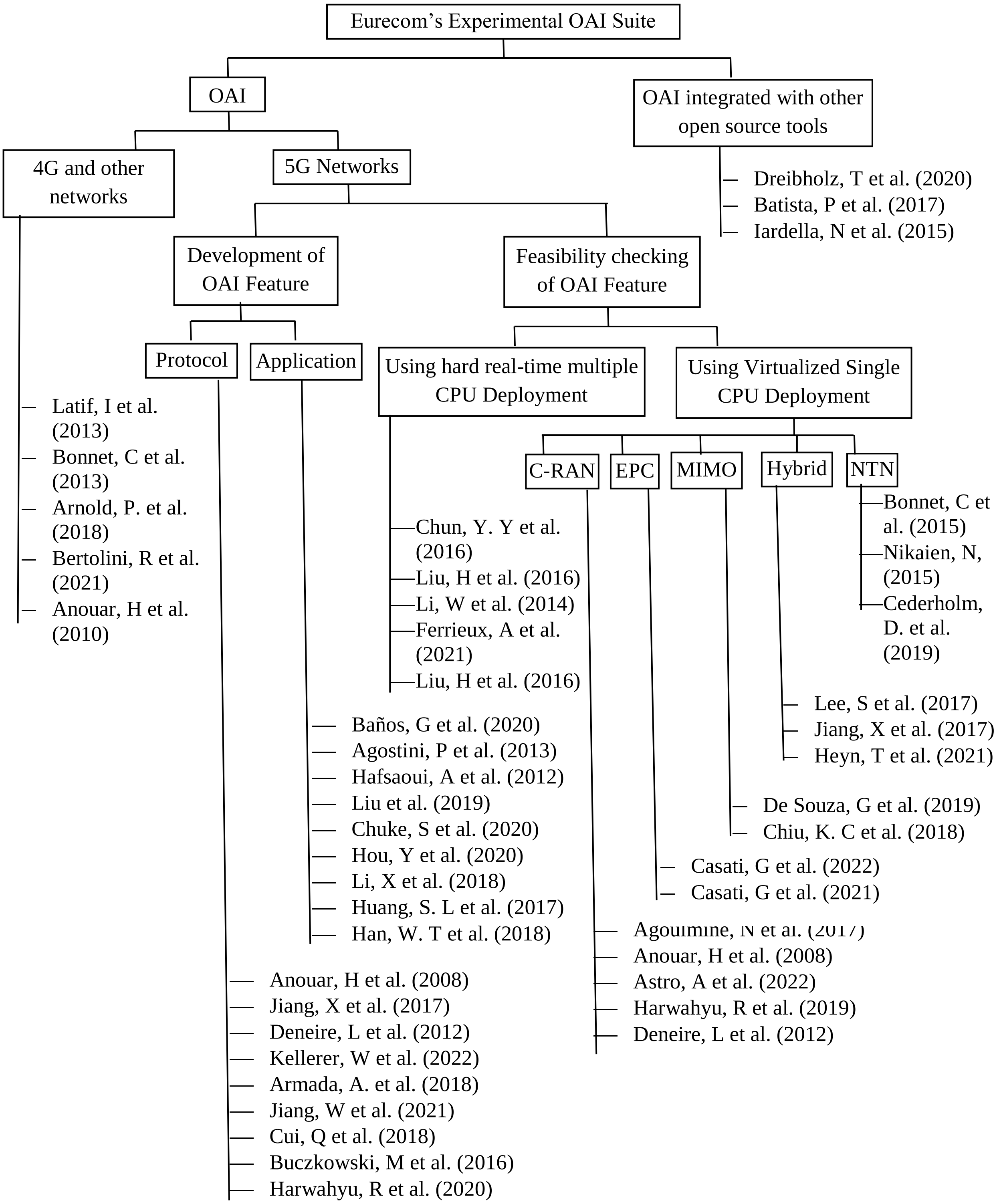

Figure 1. Taxonomy of OAI-based Mobile Telecommunication Systems/Features Techniques

Table 1. Parameters definition used in the following table headings

Sl. No	Parameter	Remark
1	Design	OAI is used to design particular applications/ fields
2	Tool/Method/Technology	Tool or the technology used to deploy the designed applications
3	Applications	Various fields where the design can be implemented
4	Prototype/ Constraints/ Scheduler	Prototype designed for particular applications where it provides better results. Constraints may be particular bandwidth and frequency.
5	Platform	Simulation/Emulation is the platform used by the author for implementing the work.
6	Protocol	A specific layer of the protocol stack used for implementing the work
7	Focus	The specific topic/problem is focused on solving by the author
8	Performance/ Algorithms	Various algorithms are used for designing the solution to the problem
9	Advantages	Benefits arrived for using a particular algorithm or system used to solve the problems.
10	Experiment	Specifications/ Requirements considered while deploying the proposed system
11	Outcome	Results obtained in terms of performance or improving the present outcomes.
12	Approach/Scheme	Explaining the type of environment or scheme applied to the experiment leads to the betterment of results.
13	Use Case	Whether the proposed system is used to build/test/both operations can be performed in Non-terrestrial networks.
14	Network Scenario	Indicates the number of UE's and Base Stations considered for implementation in Non-Terrestrial Networks
15	Antenna	The type of antenna used for experimentation most commonly used is a 4.9m Satellite antenna.
16	Adaptations	Type of satellites used, such as LEO and GEO satellites which help in extending the cellular networks to air
17	Abstraction Type	Abstractions supported at the physical layer, such as full PHY abstraction and PHY abstraction
18	Handover	X2 handover used on both EPC and CN
19	Performance analysis	Performance-based on other open-source tools integrated with OAI, which is used to analyze the real-time packet transfer, monitoring and alerting tools

(2) OAI is used for building new 5G network features.

The development of OAI features is related to adding a protocol in OAI layers or adding a 5G network application or debugging tool. As a result, the development of features for OAI 5G networks is grouped into these two classes as follows: (1) Protocol (2) Application.

The 5G network features are evaluated in two fundamental settings: virtualized single CPU deployment and real-time CPU deployment. Virtualized single-CPU environments consist of many virtual systems for UE and eNB running on the same CPU. In contrast, real-time CPU deployment consists of multiple CPUs connected using software-defined radio devices. Communication between them is established to check the feasibility of the OAI features.

Feature Development in OAI related to 5G network applications

The recently developed prototype tool for V2X communication with the open-air interface disclosed uses the OAI stub interface and provides a flexible API to interact with other modules. Depending on the V2X communication in a mac-to-mac link, TDMA schedulers that are semi-persistent and self-organizing are employed. The experiment by Baños et al., (2020) shows how these schedulers deliver superior outcomes in large-scale settings. The author concludes that as V2X communication density increases on OAI, it verifies the viability of simulating.

In order to implement and test the generated prototype, Agostini et al. (2013) worked on the open-air ITS project, which is open source. DSRC is the prototype utilized for this project. A soft modem is used to reconfigure the setup's components, including the RF front and Express MIMO board. The main focus is DSRC; no coding is done at the lower layer. The interference figure, energy detection threshold, and PER versus SNR are the main restrictions of this prototype's 5MHZ channel BW at 800 MHZ process. The oscillator is the best example for testing the soft modem by altering SNR, several PIN metrics are measured and the Openair ITS tool is used for prototype and experimental validation.

The open-air interface traffic generator is used for testing and performance evaluation of the network and is based on realistic traffic scenarios. Online gaming and M2M are applications of this software or tool, and the development of these applications uses statistical and analytical models. Hafsaoui et al. (2012) have tested for three types of traffic scenarios: stateful, aggregated, and background, and found that certain applications will not support hosting a 4G network. OTG helps us generate human and machine-type traffic with a dual mode of operation, which helps to meet the timing constraints of protocol application. The author concludes that OTG contributes more effectively to creating realistic traffic apps.

When using web-based augmented reality (AR), explain how this helps efficiently use applications because they are best used for storage and processing capabilities. Liu et al. (2019) also discuss the challenges faced in the original app related to latency and other constraints and how they can be solved using web-based AR. Using web face AR for experimenting, F-RAN minimizes transmission latency and improves QOE when compared to the traditional cloud. The performance of traditional and cloud-based web AR is compared. These designed applications have been built on the open-air interface platform.

The use of cellular vehicles for possible use cases, primarily v2v communication examination, is discussed by Chuke et al. (2020). The communication frequency range where v2v facilitates is indicated by the instances where both mode 3 and mode 4 are supported. The author concludes by outlining how the Bumblebee method aids in making wise decisions regarding channel selection. The author focuses on developing dynamic spectrum access solutions for vehicles using the open-air interface platform Bumblebee. The algorithm has been implemented in two broad steps, sampling interval and transmission interval, and it has been tested in scenarios involving relay networks and off-networks. However, the author concludes by noting that latency also changes as memory block size and channel BW change, leading to higher accuracy.

The time-varying features of wireless channels cause security issues that make the problem more difficult to solve. Hou et al. (2020) examine the cross-layer authentication strategy to assess its viability. This retrieves the UE's phase shift information. This results in the fingerprint map being trained for the ensemble learning approach based on OAI. After the experiment is completed, it gives the accuracy of the fingerprint map as a complete prediction at multiple points within the considered area. The developed cross-layer also supports SG, LTE wireless, etc. The author performed on developing and executing a framework on which the narrowband Internet of Things can be examined and provides better results when compared to the previous scenario. In addition to this execution, the author discusses the repetition mechanism, which helps analyze and demonstrate the results.

Li et al. (2018) explore the obstacles faced while evaluating and testing the novel algorithms and techniques, i.e., whether all the algorithms can be used on a single platform for testing. Mobile communication building and real-time operation present some difficulties using the conventional method. Therefore, Huang et al. (2017) gathered a few students and attempted to explain the benefits of using the open-air interface. This project also focuses on several OAI applications, such as voice application services and the cloud radio access network. The author demonstrates an effective mobile communication network on the OAI and investigates the various platform service setups that can be used in this study.

The current 5G bottleneck problem is helped by latency, according to Ronteix-Jacquet. According to Han et al. (2018) suggestion, LatSeq is an open-source tool that can analyze the latency inside a base station. The author describes how the built testbed and open-source software assist in implementing a network scenario with low effect latency. LatSeq is also a debugging tool that analyzes the processing module, visualizes packet information, and optimizes 4G and 5G radio interfaces. The comparison of the 5G network applications developed in the OAI platform is given in Table 2 in terms of the functional parameters given in Table 1.

5G-Network Protocol Development in OAI

The timing requirements for both 4G LTE and 5G NR are described using physical layer protocols by Iardella et al. (2015). When employing trade-offs or adding delay for the execution time, the author concentrates on reducing the timing requirement. This is done by

Table 2. Comparison of 5G network applications developed in the OAI platform

Author	Design	Tool/ Technology	Applications	Prototype/ Constraints/ Scheduler	Platform
Baños et al. (2020)	Prototyping V2X	OAI stub architecture	Large-scale and flexible	SBSP, S-TDMA	Emulation
Agostini et al. (2013)	Testing, and implementation using soft modem	DSRC Technology Openair ITS	Vehicular communication Radio community	5MHz channel 800MHz BW	Simulation
Hafsaoui et al. (2012)	Generating traffic scenario	open arena	Online gaming and M2M	implemented 3 major traffic features - Stateful, aggregated, Background	Emulation
Liu et al. (2019)	Web-based augmented reality	F-RAN cloud-based AR	Web face AR Web space AR	Lower latency in web-based sol than cloud-based sol	Simulation
Chuke et al. (2020)	Cellular V2X	Bumblebee for dynamic spectrum access	LTE mode4 Bumblebee	Increase in latency and accuracy with varying memory block size and channel BW	Simulation
Hou et al. (2020)	Physical channel authentication	Cross-layer authentication	Applicable to LTE, 5G, Wi-Fi and wireless devices.	Effective security prompting	Simulation
Li et al. (2018)	Single platform to validate and test	NB-IOT downlink	Implementing a repetition mechanism increase	NB-IoT downlink communication flow and signal processing	Simulation
Huang et al. (2017)	Basic OAI implementation with hands on	C-RAN architecture is used	cloud radio access network and voice application services	Comparison of VoIP parameters	Simulation
Han et al. (2018)	open-source tool designed to analyze the latency inside the Base Station.	Debugging Tool- LatSeq	Solve 5G bottleneck problem. Analyze processing module and packet statistics visualization	Coding acceleration using data and task parallelisation	Simulation

enhancing parallelism and functional accelerated coding. The master thread executes its tasks and continues to run until all its thread-based employees offer latency as a compromise for slower execution time. The use of task and data parallelism is combined.

Random-access networks are efficient in the 5G network. Anouar et al. (2008) focus on using cloud-based random access networks to solve the issue because they are primarily based on virtualization and centralized. Deploying RAN is becoming expensive and a bit difficult to operate and maintain. The author uses an open-air interface to emulate the suggested system's scheduling methods. Max C/I and Round Robin algorithms, two MAC schedulers that offer better execution time and memory occupancy, are used. Simulators can also be utilized for execution, but when trying to record the computational load on LTE, issues happen. The author noticed that PHY processes take more time to execute than other procedures, so he executed a basic optimization and found that it lowered the execution time in half when compared to earlier studies.

Simulation aids in examining outcomes in big-picture settings. To simulate a wireless network, OpenVZ is a virtualized technology. Jiang et al. (2017) have introduced two simulators: the Real-time simulator and the user-mode simulator. When running in user mode, the real-time simulator uses a virtualized OS ring and real-time kernel coherence. The project concludes that the experiment's results, when run using both simulators, are remarkably similar, with only minor differences.

An overview of cloud-RAN, how it functions in 5G and related fields, and how flexible splits between various radio network processing components take place are covered by Deneire et al. (2012). The architecture of C-RAN, which supports multi-cell distributed MIMO processing as cellular technology evolves to cell-free technology, supports massive MIMO cloud RAN.

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Table 3. Comparison of Feature Development in OAI related to 5G Network Protocol

Author	Protocol layer	Simulation / Emulation	Focus	Performance/ Algorithms	Advantages
Anouar et al. (2008)	Phy	Simulation	Physical layer with pipeline - 1 master 3 workers Threading synchronization	Carabe, Mozart, caracal. Best- Mozart	Provides both task and data parallelization
Jiang et al. (2017)	MAC	Emulation	Memory occupancy and execution time	Round Robin MAC C/I	Simple optimization with reduced execution time.
Deneire et al. (2012)	MAC	Simulation	Non-real-time applications testing of layer2/3 protocols	*Real-time simulator *User mode simulator	Performance, Mobility Scalability, Multihoming multi-modal protocol, Management
Kellerer et al. (2022)	MAC	Simulation	Multi-cell distributed MIMO processing	TDD reciprocity calibration, High frequencies co-located antenna for propagator difficulty	Solution for commodity computing, the flexible interface between RRU and RU.
Armada et al. (2018)	MAC	Simulation	TLS-based calibration technique and beamforming strategy based on channel reciprocity	improved Throughput	Real-time implementation of reciprocity-based TDD CR communication.
Jiang et al. (2021)	MAC	Simulation	Diversity existing in algorithms, First in-depth algorithm	WRR, DRR and PQ scheduling algorithms	Capabilities of existing algorithms.
Cui et al. (2018)	Phy	Simulation	Effectively using OFDM signal for implementing and measuring power for 5G requirements	open-source SDR application-based LTE- Channel measurement	reducing the out-of-band emissions without increasing the ISI with constant backward compatibility
Buczkowski et al. (2016)	MAC	SDR	Open-source SDR application for channel measurement implementing the caching server	Uniform/Gaussian/ Zipf distribution,	Better accuracy on channel prediction Improvement in the downloading speed and latency of the network
Harwahyu et al. (2020)	MAC	Simulation	Carrier Aggregation Femto API	Round Robin Proportional Fair	PF provides higher throughput

By using C-RAN antenna processing, large portions of physical processing can be combined at the central server. The author concludes that massive MIMO distribution is a promising fix for the problem at lower frequencies. Still, it is challenging to construct big MIMO systems that are related. The remote radio unit is constructed using inexpensive computer and radio components, and channel reciprocity is utilized for a distributed massive MIMO system.

A secondary connection with multiple inputs and single outputs can be used to tackle the calibration and beamforming design problems without affecting the original SISO system. These procedures have all been implemented using the OAI by Kellerer et al. (2022).

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Throughput is enhanced when the chosen MIMO calibration method and beamforming procedure are utilized after the experiment. Inference avoidance is mostly accomplished at secondary transmitters and principal receivers using CR systems.

PA OFDM might lower out-of-band emissions without raising ISI while maintaining backward compatibility. The channel prediction system assesses the OAI using actual LTE channel measurements. Both Z-score normalization and forecasting with intervals of 7-time symbols are used for channel estimation. After experimenting, Cui, Q et al. (2018) conclude that the suggested measuring system is workable and can produce superior results based on OAI and USRP.

Table 4. Comparison of OAI Feature Feasibility Checking using Hard real-time Multi-CPU

Author	Method	Simulation/Emulation	Description	Experiment	Outcome
Chun et al. (2016)	UE tracing and profiling using Linux-based Intel x86-64	Emulation	Emulation of the LTE comprising 1 UE and 1 eNB for FDD and TDD using OAI	Code profiling GTKwave analyzer emulation for band 5 FDD and Band 38 TDD	CPU seconds more time for physical layer processing
Liu et al. (2016)	Multi-Threading	Simulation	Identify the problem in single threading for UE	Freq band 7 schemes QPSK, 16QAM, 64QAM	Improving the baseband signal makes UE work properly
Li et al. (2014)	Multi-machine mode, PHY abstraction	Emulation	Comparison of simulation and emulation on execution time	Round-robin scheduling multipath channel.	UE linearly increases with execution time.
Ferrieux et al. (2021)	User plane data flow for LTE	Emulation	Accelerating the C-RAN	Code profiling GTKwave analyzer emulation for band 5 FDD and Band 3 TDD	Optimization method to reduce the number of data copying in the LTE protocol stack.
Liu et al. (2016)	USRP B210 GPRS and LTE Open TS-OAI	Emulation	GPRS+LTE in emergency for Telecom services	Delay, packet loss, browsing quality, Jitter, Throughput	GPRS for low QOS req LTE performance depends on the quality of the PDN connection

Resource scheduling employs additional OAI-based scheduling techniques. Armada et al. (2018) suggest a system that diversifies the scheduling algorithms by doing the first in-depth examination. Flex RAN is employed to carry out the task, and OAIsim is the simulator. The weighted Round Robin, the deficit Round Robin, and the priority queue are the three scheduling algorithms that the author describes in his work. Following an experiment, the author concludes that the PQ method is the most effective for low-latency applications, whereas the DRR approach is based on user-specific quantum.

OFDM signals can be used to implement and measure power using an open-air interface. In order to meet the needs of 5G, Jiang et al. (2021) propose a system that uses a power-adapted OFDM signal. The author built a testbed for this system where the OFDM signal could be experimented with using both narrow-band and wide-band signals. After completing an experiment and analysis, it was discovered that the e-LTE signal using

Buczkowski, M et al. (2016) discuss OAI's value in implementing the caching server. Here, user behaviour and request profiles are compiled and examined for the best outcomes. Utilizing this server in the test network reduces latency and speeds up downloads. In order to analyze this performance, the author employs a variety of distributional approaches, including uniform, Gaussian, and Zipf distributions. In terms of downloading speed and latency, the Zipf distribution offers a higher likelihood of being hit than the others.

Exploiting carrier aggregation is bad, as CA struggles with load balancing, dynamic carrier activation/deactivation, and other issues. Harwahyu et al. (2020) suggest two OAI additions: carrier aggregation and femto API. These additions help to improve control over how the trials are carried out. While simulating the

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Table 5. Comparison of OAI C-RAN Feature Feasibility Checking

Author	Based	Approach/ Scheme	Applications	Outcome	Emulation/ Simulation
Agoulmine et al. (2017)	Virtualization of OAI components	2 UEs connected and accessing the internet at the same time	Evaluate realistic scenario performance	pinging the UE from the P-GW through its gtp0 interface and "google.com" through the oip1 interface	Emulation
Anouar et al. (2008)	Multi-cell distributed MIMO processing	TDD reciprocity calibration	High frequency co-located antenna deployment to overcome propagation difficulty	Solution relay on 1) radio components and commodity computing for building RRV 2) Flexible RRU and RU interface	Simulation
Astro et al. (2022)	Virtualizing the C-RAN	Docker	adaptations and extensions in OAI for 5G-NTN	Automate the configuration of RRH and BBU using containers with commercial UE	Simulation
Harwahyu et al. (2019)	Virtualize components of OAI	OAI sim	Easy and flexible deployment	realistic scenarios Performance evaluation	Emulation
Deneire et al. (2012)	Prototyping Scheduling algorithms	MAC Schedulers 1)Max C/I 2) Round Robin	System-level and link-level simulators	Optimization to reduce the execution time.	Emulation

experiment, round-robin and proportional fair scheduling techniques are employed. Throughput at the peak and edge is a little bit higher with PF. The comparison of the 5G-network protocol development on the OAI platform is given in Table 3 in terms of the functional parameters given in Table 1.

OAI Feature Feasibility Checking using Hard real-time Multi-CPU

This section discusses the feasibility of developing features in OAI using hard real-time Multi-CPU deployment. 3GPP compliant scenario consisting of 1-UE and 1 eNB is emulated using OAI for FDD band 5 and TDD band 38. Chun et al. (2016) consider the EPC that is connected to eNB, which consists of MME, PGW and SGW. Code profiling identifies CUP's time-consuming parts, such as the physical layer. Simple optimization reduces the data copying in the LTE protocol stack, saving 1.5ms for the maximum PDCP SDU size.

OAI and open BTS platforms are used for building networks that provide services required for emergency services. Liu et al. (2016) combine open BTS with GPRS and LTE and analyze the performance based on delay, jitter, throughput packet loss, etc. Both GPRS and LTE provide better telecommunication services in emergencies. After conducting the experiments and analyzing the performance of the parameter, it is concluded that only using GPRS will provide services only for low QOS requirements, whereas using LTE provides better services depending on the connection of PDN.

The LTE testbed implementation experiment utilized an open-air interface. Li et al. (2014) give an overview of the value of 5G networks and their benefits and discuss how virtualization and cloudRAN are crucial to developing 5G networks. The fundamental concept of the author is how baseband processing can be transferred to the data center and how we can run RAN levels L1, L2, and L3 on commodity hardware. In order to simulate restrictions in the FDD and TDD bands, the author builds a 5G network with one UE and one eNB. Results are reported under OAI execution time profiling. The user data plane code profiling is done using the GTKwave Analyzer. The author employs FDD band 5 and TDD band 38 to reduce the amount of data copying in the LTE protocol stack.

The benefits of employing emulation for performing experiments and information on different emulation modes, including single machine and multimachine

Table 6. Comparison of EPC OAI Feature Feasibility Checking

Author	Focus	Description	EPC Type	Outcome
Casati et al. (2022)	5G-NR is running on an SDR using highly optimized LDPC and Polar decoders.	Features available in OAI 5G NR and its Future enhancements, gNB software architecture and interfaces are discussed	EPC	The current and future status of 5G NR is known
Casati et al. (2021)	Resource allocation methodology of multiple CPU cores for vEPC and LW-EPC slicing	Usage of containers and NFV functions for lightweight EPC. The algorithm used is specifically assigned cores (SAC) to achieve better utilization of CPU cores.	vEPC	SAC outperforms the default scheme, randomly assigned cores (RAC), in terms of lower CPU load and less packet loss.

modes, are used. Ferrieux et al. (2021) argue why emulation is preferable to simulation. As the author further notes, using PHY abstraction with SINR mapping allows for increased efficiency and the construction of multi-node, large-scale emulation systems. The author compares execution times for various transmission modes vs. PHY abstraction and full PHY after experimenting and concludes that PHY is the faster option. The experiment setup includes a multipath channel model, ENB and UE, working mode, etc. The author has discussed the advantages and disadvantages of using single virtual multi-machine emulation around Robin. Abstraction reduces the emulation time based on accuracy. Finally, the author concludes that PHY abstraction speeds up emulation depending on correctness.

The comparison of the OAI Feature Feasibility Checking using Hard real-time Multi-CPU is given in Table 4 in terms of the functional parameters given in Table 1.

OAI C-RAN Feature Feasibility Checking using Virtualized single-CPU Deployment

The feasibility of developing a feature in OAI using Virtualized single-CPU deployment is discussed with C-RAN, EPC, MIMO and hybrid environment subclasses. Virtualized C-RAN can be used to evaluate realistic scenario performance with flexible deployment in cloud computing infrastructure, is discussed by Agoulmine et al. (2017). The mobile cloud allows offloading UE processing on C-RAN directly. Security was activated, and the UE and MME connections to the BBU in the virtualized C-RAN were successful. Downlink and uplink information are displayed for analysis. In order to set up the C-RAN testbed environment, Astro et al. (2022) integrate Cloud-RAN with docker and an open-air interface. The authors examine how computing functions and how well it might employ C-RAN resources.

After experimenting, the author concluded that containers make it simple to deploy components and that these components are flexible enough to produce superior

Table 7. Comparison of MIMO OAI Feature Feasibility Checking

Author	Design	Experiment	Advantages
De Souza et al. (2019)	Open source LTE compliant base station equipped with large antenna array for direct transmission	TDD channel Reciprocity calibration Scheme	Establish communications directly with commercial UEs and possibly use massive MIMO in LTE.
Chiu et al. (2018)	5G MIMO into OAI. Real-time system supports up to 2 layers with a 2 × 4 MIMO system	PHY layer and RF Simulator with real-time systems	Increases the processing capabilities

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results when tested on a testbed. As a result, RRH and BBU are automatically configured utilizing containers to connect to a commercial UE.

Table 8. Comparison of the hybrid environment of RAN-EPC OAI Feature Feasibility Checking

Author	Description	Areas
Lee et al. (2017)	A system that solves the inefficiency of configuration by combining SDN technology with a 4G network system constructed through OAI.	A remote controller allows control over eNodeBs and UEs in the physical plane.
Jiang et al. (2017)	OAI is a flexible platform for an open cellular ecosystem for 4G experiments and 5G research.	How feasible OAI is in these areas is massive MIMO, cloud RAN, and alternative waveforms.
Heyn et al. (2021)	OAI can be used as a simulator and Emulator with hardware and software platforms. Comparison of various SDRs	Real-time indoor/outdoor experimentation, demonstration, and large-scale system emulation.

The simulated open-air interface platform studies done by Harwahyu et al. (2019) describe the experience of virtualizing components to enable the quick construction of a simulated 5G network. The primary emphasis was on cloud mobile, which enables dumping a portion of UE straight to C-RAN for processing. C-RAN separates the capabilities of the eNB as a remote radio head and baseband unit, pooling the BBU of numerous base stations. For simulation and emulation purposes, OAISim is employed as a platform. The OAI architecture is virtualized for deploying any configuration, configuring the C-RAN, and assessing its performance in many plausible scenarios. The comparison of the C-RAN Feature Feasibility Checking using Virtualized single-CPU Deployment is given in Table 5 in terms of the functional parameters given in Table 1.

explanation. The document explains each layer's features and functionalities and offers suggestions on how researchers could use open-air interfaces to continue their research in the future 5G. In his explanation of the 5G network virtualization that leads to the open-air interface-based container-based design of the EPC,

The user can successfully access video streaming from the Internet due to the vEPC slice with an ENB's. In order to efficiently allocate numerous CPU cores for the Long-Term Evolution (LTE) slicing and virtual Evolved Packet Core (vEPC) protocols, a new approach called Specifically Assigned Cores (SAC) is introduced in this study by Casati et al. (2021). Based on preliminary findings, SAC outperforms the RAC default regarding CPU burden and packet loss as traffic volume rises, and SAC's advantages grow. The comparison of the EPC OAI Feature Feasibility Checking using Virtualized single-CPU Deployment is given in Table 6 in terms of the functional parameters given in Table 1.

Table 9. Comparison of NTN Feature Feasibility Checking

Author	Use case	Network scenario	Satellite antennas	Adaptations
Bonnet et al. (2015)	Testing	1 UE, 1 BS	4.9M	5G-LEO
Nikaien (2015)	Building	2 UE, BS	4.9M	5G-GOA
Cederholm et al. (2019)	Features and Future of 5G in NTN	2 UE, 1 GS	3.6M	Both 5G-GOA, 5G-LEO

OAI EPC Feature Feasibility Checking using Virtualized single-CPU Deployment

An overview of the open-air interface using the 5G new radio, its current and existing features, and the applications offered for implementation are explained by Casati et al. (2022). The evolving packet core has been the primary topic of a detailed 5G network architecture

OAI MIMO Feature Feasibility Checking using Virtualized single-CPU Deployment

The system is implemented from the physical layer to the network layer, as described by De Souza et al. (2019), who also discuss the massive MIMO techniques employed. A realistic environment for exploring large MIMO LTE capabilities is provided via the

OpenAirInterface-based testbed, which enables direct connectivity with commercial user equipment. This allows scientists and engineers to assess and create 5G technology.

5G NEW Radio features and their benefits for effectively implementing 5G networks are outlined. Chiu et al. (2018) explain the effective planning and execution of the MIMO 5G network feature in the open-air interface. Their research demonstrates that the extension / maximum available channel supports 4 layers, which results in a 4X4 MIMO transmitter and receiver channel. However, the actual or real-time implementation supports two layers with a 2X4 MIMO system. The proposed system is evaluated using the OAI physical layer simulators, RF simulators, and real-time systems. The results are presented based on MIMO channel estimation, log-likelihood ratio and QAM demodulation and execution is based on a downlink shared channel.

The comparison of the MIMO OAI Feature Feasibility Checking using a virtualized single-CPU Deployment is given in Table 7 in terms of the functional parameters given in Table 1.

OAI Hybrid Environment of RAN-EPC Feature Feasibility Checking using Virtualized Single-CPU Deployment

The solution developed using SDN and OAI by Lee et al. (2017) handles the difficulties of setting up 4G networks. The eNodeBs and UEs may be configured and monitored using this technology. In order to address the problem of configuration inefficiencies, a system has been developed that uses SDN (Software Defined Networking) technologies and the 4G network system built with Open Air Interface (OAI). The user equipment (UE) and evolved Node Base station (eNodeB) settings are managed by this system's central controller and a module. As a result, the eNodeB and UE's physical plane can be remotely controlled. The viewpoint of advanced technologies in the 5G network, such as cloudification, radio network programmability, M2C, etc. is elaborated by Jiang et al. (2017). The authors also look at how an open-air interface effectively conducts open LTE experiments. The author discusses how inexpensive, commodity hardware is compatible with LTE devices in the study. Because the virtualization process has a greater impact on C-RAN performance, the Authors attempt to address the issues created by it. The author concludes that MIMO, cloud RAN, and other alternative waveforms are just a few study areas where OAI can be effectively applied.

The open-air interface as a simulator and emulator is described in depth. Heyn et al. (2021) describe the network scenario construction procedure in detail to recreate or emulate the experiment. The overview and comparison of several Software Defined Radios using OpenAirInterface are also included. The proposed platform offers a reference software implementation of a 3GPP-compliant LTE system, including a subset of LTE-A functionalities. It can be used for system emulation and real-time indoor and outdoor experimentation.

The comparison of the hybrid environment of RAN-EPC OAI Feature Feasibility Checking using a virtualized single-CPU deployment is given in Table 8 in terms of the functional parameters given in Table 1.

OAI NTN Feature Feasibility Checking using Virtualized single-CPU Deployment

Using an open-air interface to create 5G NTN networks is effective while conducting a field trial for satellite communication. Bonnet et al. (2015) give evidence of the behavior of the NTN network and discuss the viability of the 5G NTN. The author discusses the standalone, non-standalone, and NOS1 components of the 5G NTN. One UE and one gNB are used for testing, and an NR link connects them. A geosynchronous satellite is utilized for presentation on the ground; the UE and GNB both employ the uu air interface protocol stack, which supports bidirectional IP. Using 5GNR and modem traffic across broad guard bands on GEO satellites will lessen in-band interference.

The 5G roadmap discussed by Nikaien, N. (2015) shows how non-terrestrial networks can support the expansion of the 5G network. The UE and GNB utilized in these trials are completely authorized and software-defined based on an open-air interface. Allocating the temporal domain, enabling random access response, and deactivating HARQ are some adjustments in the environmental setup that are mentioned to have significantly longer satellite propagation delays. 5G NTV and HTTP-based live footage streaming will be provided to showcase the possibilities. It is a direct satellite link between the two networks.

The special characteristics of the open-air interface and talks about ongoing and finished initiatives that are related to the technology are outlined by Cederholm et al. (2019). The 5G-Goa and 5G-LED projects, two major OAI-based non-terrestrial network initiatives, are discussed. The author examines the various OAI platforms, including GNU Radio, SRS RAN, and Open LTE, which, when used, produce effective results. Additionally, the author talks about the OAI-based finished projects 5G-ALLSTAR and 5G-EMUSAT and the OAI-based current projects 5G-LEO and 5G-GOA. Finally, in the paper's conclusion, the author says that non-terrestrial networks offer better service than the competition and go beyond 5G technology.

The comparison of the NTN OAI Feature Feasibility Checking using a virtualized single-CPU deployment is given in Table 9 in terms of the functional parameters given in Table 1.

Table 10. Comparison of OAI usage for Other mobile-network research

Author	Simulation/Emulation	Abstraction Type	Approach	Description	Handover
Latif et al. (2013)	Simulation	PHY and Full PHY abstraction	EESM	Supports both SISO and MIMO. Better accuracy BLER, Simulation time increased by factor 30	NA
Bonnet et al. (2013)	Emulation	Full PHY abstraction	ESM Full PHY	OAI In-lab system used to evaluate and validate	NA
Arnold et al. (2018)			FlexRAN interface between the controller and agent	Evaluating Bandwidth part adaptation and Processing time	NA
Bertolini et al. (2021)	Simulation		Applied handover on both EPC and CN	Comparison of throughput and latency	Same latency for experiments X2 handover and real handover
Anouar et al, (2010)	Simulation		max-log MAP receiver	Implementation of OpenAirMesh with its Specifications. The proposed synchronization is feasible for small-scale networks in indoor and medium-range outdoor scenarios.	NA

OAI for Other Mobile Network Research

PHY (Physical) abstraction and full PHY abstraction are discussed as possible LTE implementations by Latif, et al. (2013). Since the majority of system-level simulators rely on PHY abstraction methods due to the high computational complexity of physical layer algorithms, it has been developed into a single tool that enables the compilation of the entire PHY and PHY abstraction and uses a technique for signal-to-noise and interference-to-signal mapping that is believed to be effective for an OAI LTE system. The proposed system supports communication via SISO and MIMO. For improved accuracy and scalability, link abstraction is validated on both a link-level and system-level basis. Partial PHY abstraction results in a 30 times longer simulation time than full PHY abstraction while maintaining the same accuracy.

Using the OAI SDR platform, the performance of the eMBMS is validated and evaluated. It focuses first on the differences between the OAI in-lab system and emulation/simulation tools to enable high-level integration and performance validation for real-time performance by Bonnet et al. (2013). The first scenario employs a software framework for OAI implementation via full PHY abstraction in the emulator tool. The second case examines a hardware implementation. BLER is employed in ESM as a second method of providing effective links for higher layers to achieve better outcomes in the emulation tool. The same physical machine uses direct memory transfer and several physical machines are used when using dependable multicast IPs.

An overview of cloud-based RAN and NFV employed in the 5G mobile new radio network. Arnold et al. (2018) also discuss the implementation of an interface between DU & CU in a 5G new radio emulation platform, with the main focus on the bandwidth part adaptation and processing time. This architecture shows how the RAN is split into centralized and distributed units, giving mobile network operators more efficient energy and computational power. OAT uses the Flex RAN framework, which is implemented separately for the data plane's control and data planes. Processing tile is assessed based on downlink resource scheduling, transport block encoding, scrambling, and modulation using Flex RAN agents and control plane Flex RAN controllers. But in the current work, spatial precoding is not used. The result is that the physical layer processing time grows linearly when the bandwidth is utilized for downlink transmission.

OAI usage for other mobile networks is given in Table 10 in terms of the functional parameters given in Table 1.

OAI Integrated with Other open-source software

When setting up the 4G/5G network utilizing tools like the operator interface and open source, Dreibholz et al. (2020) begins by discussing the benefits of employing the virtual network function. The author of Maco created the virtual network function tool, Simumet EPC. They also highlight how the proposed VNF produces superior results and the key characteristics offered by the VNK. Juju Charms is a container used for managing virtual deployment units; results are visible through Prometheus monitoring, which aids in performance analysis across some criteria. This arrangement simplifies using the insatiable Mobile Broadband testbed for network research and mobile edge computing.

Table 11. Comparison of Feature Feasibility of OAI in Integration with other open-source tools

Author	Simulator / Emulation	Testbed/environment	Performance analysis based on
Dreibholz et al. (2020)	Simulation SIMULAMET EPC	Open-source mano openair interface	Prometheus
Batista et al. (2017)	Emulation	Openair interface system emulator	Trace route
Iardella et al. (2015)	Simulation	OAI physical layer simulator, RF simulator, Real-time software modem	QAM demodulation IMO Channel estimation Log likelihood ratio

Bertolini et al. (2021) begin with a summary of the handover procedure before concentrating on implementing handover for end-to-end architecture. There have been relatively few experiments on the handover procedure that consider both RAN and CN in OAI for effectively implementing the handover procedure. Throughput and latency comparisons are made for the performance analysis with X2 handover. Regarding outcomes (latency), both handover and X2 handover are comparable to actual experiments. Because the HO in the OAI experiment is implemented using COTS user equipment, various constraints may be overcome by using Software Defined Radio.

The use of OAI to create a single-frequency mesh network was investigated by Anouar et al. (2010). With OAI, cellular and mesh networks can be used. For 4G wireless networks, the physical layer employs OFDM and MIMO methods, and the MAC layer is in charge of two-way signaling. The experiment examines the performance of two methods, distributed network synchronization and MIMO when utilized in computer simulation and real-time implementation. Because the max-log MAP detector performs significantly better in diversity and coding gain than the linear MMSE receiver, divisions are unnecessary for implementation, leading to more effective outcomes than the linear MMSE receiver. The comparison of the

The exploration of the various communication systems given by Batista et al. (2017) notes that emulators offer a superior trade-off regarding realism and adaptability. The author then focuses on using an open-air interface as an emulator to achieve better outcomes. The constructed network uses OAI modules and open-air interface system emulation to carry out OAI, which aids in real-time network monitoring. Simulation and emulation are both offered by OAI system emulation. The traceroute tool is used to examine the packets of the request. Emulation offers additional benefits over simulation in terms of more capable outputs that are more realistic.

The advantages of the 5G NEW Radio features for the effective deployment of 5G networks are described. Iardella et al. (2015) cover effective planning and implementation of MIMO 5G network feature in an open-air interface. The analysis demonstrates that the extension / maximum available channel supports 4 layers, resulting in a 4X4 MIMO transmitter and receiver channel. The proposed system is evaluated using the OAI physical layer simulators and RF simulators, and real-time system results are discussed based on MIMO channel estimation, log-likelihood ratio, and QAM demodulation. Implementation is based on a downlink shared channel. However, the actual or real-time implementation supports two layers with a 2X4 MIMO system.

The comparison of the feature feasibility of OAI in integration with other open-source tools is given in Table 11 in terms of the functional and performance parameters given in Table 1.

Discussion and Conclusion

One of the key findings of our survey is the widespread adoption of 5G networks in the telecommunications industry. Open Air Interface has played a crucial role in enabling the deployment of 5G networks by providing an open-source platform that allows for flexible and customizable network implementations. The survey's findings demonstrate how OAI is crucial to developing and deploying 5G networks across numerous industries. By leveraging the capabilities of OAI, scientists and other experts can examine novel services and applications that benefit from 5G technology. In order to facilitate the deployment of mobile communications networks with affordability and flexibility to accommodate a range of features and capabilities, the taxonomy is built and developed by categorizing the existing offered solutions using OAI. The developed taxonomy's categories are examined and contrasted in terms of some different factors.

In conclusion, the research done on the OpenAirInterface (OAI)-based 5G mobile network and its varied applications in numerous industries offers important insights into the potential of this technology. By providing an open and adaptable architecture for creating and deploying 5G networks, the OAI platform enables quick innovation and adaptation to satisfy the unique needs of various applications. The poll highlighted the wide range of industries—including healthcare, transportation, smart cities and entertainment, where 5G and OAI can have a disruptive effect. The results underlined how 5G with OAI can offer increased network capacity, low latency, and high data rates, opening doors to revolutionary improvements in these fields. The survey indicates a promising future for 5G mobile networks, backed by continued research and development.

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Conflict of Interest

The authors declare no conflict of interest.

References

Agostini, P., Härri, J., Haziza, N., & Knopp, R. (2013). Implementation and test of a DSRC prototype on OpenAirInterface SDR platform. *Proceeding of IEEE International Conference on Communications workshops (ICC)*, Budapest, Hungary, pp. 510-514. https://doi.org/10.1109/ICCW.2013.6649287.

Agoulmine, N., Chabbouh, O., Chendeb, N., Neji, O., & Rejeb, S. B. (2017). Experience deploying a 5G C-RAN virtualized experimental setup using OpenAirInterface. *In 2017 IEEE 17th International Conference on Ubiquitous Wireless Broadband (ICUWB)*, Salamanca, Spain, pp. 1-5. https://doi.org/10.1109/ICUWB.2017.8250996.

Anouar, H., Bonnet, C., Câmara, D., Filali, F., & Knopp, R. (2008). OpenAirInterface simulation platform. *ACM SIGMETRICS Performance Evaluation Review*, *36*(2), 90-94.

Anouar, H., Bonnet, C., Ghaffar, R., ltenberger, F., & Knopp, R. (2010). Design and implementation of a single-frequency mesh network using openairinterface. *EURASIP Journal on Wireless Communications and Networking*, *2010*(1), 719523. https://doi.org/10.1155/2010/719523.

Armada, A. G., Chen-Hu, K., & Kaltenberger, F. (2018). Implementation and measurement of Power Adapted-OFDM using OpenAirInterface. *Proceeding of IEEE 19th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, Kalamata, Greece, pp. 1-5. https://doi.org/10.1109/SPAWC.2018.8445894.

Arnold, P., Charaf, M. B., Einhaus, & M., Kim, I. (2018). Bandwidth part adaptation and processing time evaluation with openairinterface. *Proceeding of IEEE 88th Vehicular Technology Conference (VTC-Fall)*, Chicago, IL, USA, pp. 1-5. https://doi.org/10.1109/VTCFall.2018.8690902.

Astro, A., Chatzinotas, S., Kumar, S., Meshram, A. K., Querol, J., Kaltenberger, F., & Schlichter, T. (2022). OpenAirInterface as a platform for 5G-NTN Research and Experimentation. *Proceeding of IEEE Future Networks World Forum (FNWF)*, Montreal, QC, Canada, pp. 500-506. https://doi.org/10.1109/FNWF55208.2022.00094.

Baños, G. G., Härri, J., Manco, J., & Sepulcre, M. (2020). Prototyping v2x applications in large-scale scenarios using openairinterface. *Proceeding of IEEE Vehicular Networking Conference (VNC)*, New York, NY, USA, pp. 1-4. https://doi.org/10.1109/VNC51378.2020.9318327.

Buczkowski, M., Kaltenberger, F., Roux, C., & Wewior, M. (2016). The openairinterface application programming interface for schedulers using carrier aggregation. *Proceeding of International Symposium on Wireless Communication Systems (ISWCS)*, Poznan, Poland, pp. 497-500. https://doi.org/10.1109/ISWCS.2016.7600955

Bonnet, C., Gauthier, L., Kaltenberger, F., Knopp, R., Nikaein, N., & Nussbaum, D. (2015). OpenAirInterface: Open-source software radio solution for 5G. Proceeding of European Conference on Networks and Communications (EUCNC), Paris, France.

Bonnet, C., Knopp, R., Nikaein, N., & Nguyen, N. D. (2013). Implementation and validation of multimedia broadcast multicast service for LTE/LTE-advanced in OpenAirInterface platform. *Proceeding of 38th Annual IEEE Conference on Local Computer Networks-Workshops*, Sydney, NSW, Australia, pp. 70-76. https://doi.org/10.1109/LCNW.2013.6758500

Bertolini, R., & Maman, M. (2021). Evaluating Handover Performance for End-to-End LTE Networks with OpenAirInterface. *Proceeding of IEEE 94th Vehicular Technology Conference (VTC2021-Fall)*, Norman, OK, USA, pp. 1-5. https://doi.org/10.1109/VTC2021-Fall52928.2021.9625562

Batista, P., Klautau, A., Nahum, C., & Soares, J. (2017). Emulation of 4G/5G network using OpenAirInterface. *In XXXV Brazilian Communications and Signal Processing Symposium*, São Pedro, Brazil, Article 6.

Chuke, S., Gill, K. S., Gegear, R. J., Haider, A., Heath, K. N., Ryder, E. F., & Wyglinski, A. M. (2020). Bumblebee-inspired c-v2x dynamic spectrum access testbed using openairinterface. *Proceeding of IEEE 91st Vehicular Technology Conference (VTC2020-Spring)*, Antwerp, Belgium, pp. 1-5. https://doi.org/10.1109/VTC2020-Spring48590.2020.9128871

Cui, Q., Hou, Y., Liu, Y., Tao, X., & Wang, W. (2018). Content-based caching network using openairinterface system. *Proceeding of 24th Asia-Pacific Conference on Communications* (APCC), Ningbo, China, pp. 3-4. https://doi.org/10.1109/APCC.2018.8633555

Chun, Y. Y., Mokhtar, M. H., Rahman, A. A. A., & Samingan, A. K. (2016). Performance study of LTE experimental testbed using OpenAirInterface. *Proceeding of 18th International Conference on Advanced Communication Technology* (ICACT), PyeongChang, Korea (South), pp. 617-622. https://doi.org/10.1109/ICACT.2016.7423494

Chiu, K. C., Lai, W. P., & Wang, Y. H. (2018). Containerized design and realization of network functions virtualization for a light-weight evolved packet core using OpenAirInterface. *Proceeding of Asia-Pacific Signal and Information Processing Association Annual Summit and Conference* (APSIPA ASC), Honolulu, HI, USA, pp. 472-477. https://doi.org/10.23919/APSIPA.2018.8659522

Cederholm, D., Nahum, C., Novaes, C., Patra, G., Klautau, A., & Trindade, I. (2019). C-ran virtualization with openairinterface. arXiv preprint a*rXiv*, 1908.07503. https://doi.org/10.48550/arXiv.1908.07503

Casati, G., Heyn, T., Kaltenberger, F., Knopp, A., Schlichter, T., Schwarz, R., & Volk, F. (2022). Field Trial of a 5G Non-Terrestrial Network Using OpenAirInterface. *IEEE Open Journal of Vehicular Technology*, *3*, 243 – 250. https://doi.org/oi: 10.1109/OJVT.2022.3175308

Casati, G., Heyn, T., Kaltenberger, F., Knopp, A., Schlichter, T., Schwarz, R., & Volk, F. (2021). Building a 5g non-terrestrial network using openairinterface open-source software. *EuCNC/6G Summit*, 2021.

Deneire, L., Ghauri, I., Kaltenberger, F., Knopp, R., Kouassi, B., Slock, D., & Zayen, B. (2012). Software implementation of spatial interweave cognitive radio communication using OpenAirInterface platform. *Proceeding of International Symposium on Wireless Communication Systems* (ISWCS), Paris, France, pp. 401-405. https://doi.org/10.1109/ISWCS.2012.6328398

De Souza, G., Kaltenberger, F., Knopp, R., & Wang, H. (2019). The openairinterface 5g new radio implementation: Current status and roadmap. Proceeding of 23rd International ITG Workshop on Smart Antennas, Vienna, Austria, pp. 1-5. VDE.

Dreibholz, T. (2020). A 4G/5G Packet Core as VNF with Open Source MANO and OpenAirInterface. *Proceeding of International Conference on Software, Telecommunications and Computer Networks* (SoftCOM), Split, Croatia, pp. 1-3. https://doi.org/10.23919/SoftCOM50211.2020.9238222

Ferrieux, A., Hamchaoui, I., Lagrange, X., Ronteix–Jacquet, F., & Tuffin, S. (2021). LatSeq: A Low-Impact Internal Latency Measurement Tool for OpenAirInterface. *Proceeding of IEEE Wireless Communications and Networking Conference* (WCNC), Nanjing, China, pp. 1-6. https://doi.org/10.1109/WCNC49053.2021.9417345

Hafsaoui, A., Nikaein, N., & Wang, L. (2012). OpenAirInterface traffic generator (OTG): A realistic traffic generation tool for emerging application scenarios. *Proceeding of IEEE 20th International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*, Washington, DC, USA, pp. 492-494. https://doi.org/10.1109/MASCOTS.2012.62

Hou, Y., Tao, X., Tang, X., & Zhao, Z. (2020). Demo abstract: Cross-layer authentication based on physical channel information using OpenAirInterface. *Proceeding of IEEE Conference on Computer Communications Workshops* (INFOCOM WKSHPS), Toronto, ON, Canada, pp. 1334-1335. https://doi.org/10.1109/INFOCOMWKSHPS50562.2020.9162893

Huang, S.L., Li, X.Y., & Lin, P.C. (2017). Teaching and learning next generation mobile communication networks through open source openAirInterface testbeds. Proceeding of Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC), Kuala Lumpur, Malaysia, pp. 1475-1478. https://doi.org/10.1109/APSIPA.2017.8282266

Han, W. T., & Knopp, R. (2018). OpenAirInterface: A pipeline structure for 5G. *Proceeding of IEEE 23rd International Conference on Digital Signal Processing* (DSP), Shanghai, China, pp. 1-4. https://doi.org/10.1109/ICDSP.2018.8631835

Harwahyu, R., Nugroho, Y. N., & Sari, R. F. (2020). Performance Comparison of GPRS and LTE Telecommunication Network using OpenAirInterface and OpenBTS with USRP. *Proceeding of 2nd International Conference on Industrial Electrical and Electronics* (ICIEE), Lombok, Indonesia, pp. 197-204. https://doi.org/10.1109/ICIEE49813.2020.9277396

Harwahyu, R., Rekoputra, N. M., & Sari, R. F. (2019). Performance study of OpenAirInterface 5G System on the Cloud Platform Managed by Juju Orchestration. *Proceeding of International Seminar on Research of Information Technology and Intelligent Systems* (ISRITI), Yogyakarta, Indonesia, pp. 211-216. https://doi.org/oi:10.1109/ISRITI48646.2019.9034647

Heyn, T., Saaifan, K. A., & Schlichter, T. (2021). NR MIMO Feature Implementation into OpenAirInterface. Proceeding of 25th International ITG Workshop on Smart Antennas, French Riviera, France, pp. 1-6.

Iardella, N.,Sabella, D., Stea, G., & Virdis, A. (2015). Performance analysis of OpenAirInterface system emulation. *Proceeding of 3rd International Conference on Future Internet of Things and Cloud*, Rome, Italy, pp. 662-669. https://doi.org/10.1109/FiCloud.2015.77

Jiang, X., Kaltenberger, F., & Knopp, R. (2017). From massive MIMO to C-RAN: the OpenAirInterface 5G testbed. *Proceeding of 51st Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, USA, pp. 608-612. https://doi.org/10.1109/ACSSC.2017.8335413

Jiang, W., & Zhou, Q. (2021). Implementation of OpenAirInterface-based real-world channel measurement for evaluating wireless transmission algorithms. *arXiv preprint arXiv*, 2101.04608. https://doi.org/10.48550/arXiv.2101.04608

Jiang, X., & Kaltenberger, F. (2017). An LTE compatible massive MIMO testbed based on OpenAirInterface. *Proceeding of 21th International ITG Workshop on Smart Antennas*, Berlin, Germany, pp. 1-2.

Kellerer, W., Papa, A., & Ursu, R. M.. (2022). Experimental Evaluation of Downlink Scheduling Algorithms using OpenAirInterface. *Proceeding of IEEE Wireless Communications and Networking Conference* (WCNC), Austin, TX, USA, 84-89. https://doi.org/10.1109/WCNC51071.2022.9771597

Liu, Y., & Mai, S. (2019). Implementation of web ar applications with fog radio access networks based on openairinterface platform. *Proceeding of 5th International Conference on Control, Automation and Robotics* (ICCAR), Beijing, China, pp. 639-643. https://doi.org/10.1109/ICCAR.2019.8813710

Li, X., Wang, C., Wang, X., Wang, W., & Zhang, Y. (2018). Design and Implementation of the NB-IoT Downlink System on OpenAirInterface Platform. *Proceeding of IEEE 4th International Conference on Computer and Communications* (ICCC), Chengdu, China, pp. 880-884. https://doi.org/10.1109/CompComm. 2018.8780852

Liu, H.,Liu, Y., Shen, H., Wei, X., & Zheng, K. (2016). Design and implementation of an LTE system with multi-thread parallel processing on OpenAirInterface platform. *Proceeding of IEEE 84th Vehicular Technology Conference* (VTC-Fall), Montreal, QC, Canada, pp. 1-5. https://doi.org/10.1109/VTCFall.2016.7880957

Li, W., Peng, Y., Qu, H., Wang, R.,Wu, B., & Zhao, H. (2014). OpenAirInterface-An effective emulation platform for LTE and LTE-Advanced. *Proceeding of Sixth International Conference on Ubiquitous and Future Networks* (ICUFN), Shanghai, China, pp. 127-132. https://doi.org/10.1109/ICUFN.2014.6876765

Lee, S., & Koh, S. (2017). Implementation of OpenAirInterface control software for 4G network. *Proceeding of Ninth International Conference on Ubiquitous and Future Networks* (ICUFN), Milan, Italy, pp. 747-749. https://doi.org/10.1109/ICUFN.2017.7993891

Latif, I., Kaltenberger, F., Knopp, R., & Nikaein, N. (2013). Large scale system evaluations using PHY abstraction for LTE with OpenAirInterface. In SimuTools, pp. 24-30.

Nikaien, N. (2015). OpenAirInterface Simulator/ Emulator. White Paper.

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