ORAN-B5G: A Next-Generation Open Radio Access Network Architecture With Machine Learning for Beyond 5G in Industrial 5.0

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***Abstract*—Autonomous decision-making is considered an intercommunication use case that needs to be addressed when integrating open radio access networks with mobile-based 5G communication. The robustness of innovations is diminished by the conventional method of designing an end-to-end radio access network solution. Through an analysis of these possibilities, this paper presents a machine learning-based intelligent system whose primary goal is load balancing using Artificial Neural Networks with Particle Swam Optimization-enabled metaheuristic optimization mechanisms for telecommunication industry requests, like product compatibility. We increase the proposed system's reliability by using third-generation partnership project standards to automate the distribution of transactional load among various connected units. This intelligent system encloses the hierarchy of automation enabled by artificial intelligence. Conversely, AI-enabled open radio access control explores the barriers to next-generation intercommunication, including those after 5G. It covers deterministic latency and capabilities, physical layer-based dynamic controls, privacy and security, and testing applications for AI-based controller designs.**

***Index Terms*—Open radio access network (ORAN), artificial intelligence, green technology, beyond 5G, machine learning, intelligent system.**

I. Introduction

THE OPEN Radio Access Network (O-RAN) has become one of the hot research areas due to its disaggregated approach for designing and deploying mobile midhaul and fronthaul networks, which has been implemented on cloud-native building blocks [1]. It is considered a non-proprietary version that evolves from the Next Generation Radio Access Network (NG-RAN) architecture. It is the first Global System for Mobile Communications Association's 3rd Generation Partnership Project (GSMA 3GPP)-based network infrastructure that allows interoperation between cellular network tools provided by third-party vendors [1], [2]. However, this technology involves certain specifications of TS 38.401, which is associated with decomposing the running baseband unit splits into the central unit (CU) and distributed unit (DU) [3]. It is because of converting traditional controls to modern controls for user plane separation and constructs. At the same time, the objective of CU is to transform the unit by decoupling it into further control plane functions and user planes. This technology redirects the current monolithic baseband unit with the CU to ensure the centralized package processing and functional features, a new paradigm of the cellular network model deployment [3], [4]. While the revolution of radio signals in the network environment for remote access is applied, the system lays the groundwork for splitting baseband units, along with their functionality for long-range connectivity, as shown in Figure 1. By analyzing all such scenarios, O-RAN is the better solution for nationwide networks, such as Radio Access Networks (RAN), where multiple vendors are typically connected to provide mobile-enabled network services [4], [5], as shown in Figure 1. On the other hand, the O-RAN alliance was created to enhance NR-RAN concepts, such as adding the role of the original outline of 3GPP and their control hierarchy [6]. Regarding the concern, the O-RAN integrates almost 180 enterprises as an alliance that specifies and releases tools under the auspices, like open-source platforms introduced by the Linux Foundation.

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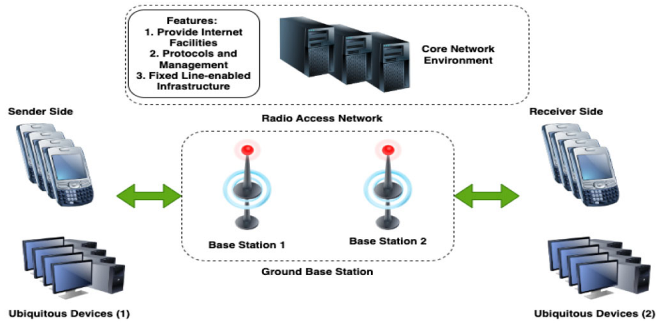

Fig. 1. The Working Sequences of Radio Access Network (RAN).

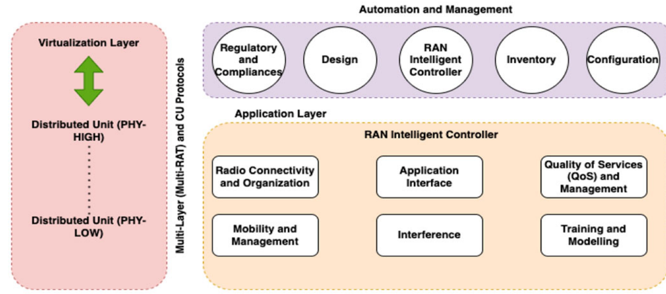

Fig. 2. The Proposed Pre-Defined Architecture of O-RAN.

In the Fifth Industrial Revolution (Industrial 5.0), a new paradigm of mobile network architectures has been proposed, such as O-RAN, that evaluates the robustness of network consumption by means of bandwidth and by reducing the complexity and expense associated with the Open Radio Access Network-powered networks [6], [7]. E-UTRAN is a practical example that simplifies the adoption of technological requirements and specifications. The primary objective of this technology is to provide transaction facilities between information technology and open technological infrastructures, where it delivers customers private mobile network facilities in collaboration with 5G-LAN-enabling solutions [7], [8]. Due to this, the current architecture makes deploying a private cellular LTE, which means 5G mobile wireless interconnectivity, as simple as configuring a wireless-fidelity (Wi-Fi) and related network operations [9]. Centralized management of mobile core operations and organization of package deliverance in the platforms are pre-designed to provide end-to-end 5G network services as tailored to the customers.

After analyzing all such prospects, the advantages of private 5G drive at the enterprise level which is the easiest translation between enterprises' node-to-node connections, privacy and security, and operational activities [9], [10]. These are the undeniable features provided to enterprises. However, availing this is quite a complex task because it requires a complete transformation from RAN to O-RAN, as shown in Figure 1 to Figure 2. A streamlined integration with predefined packaging and connectivity helps achieve the O-RAN transformation solution [11], [12]. Such a revolution in hardware and software, especially in cellular network environments, is necessary to interoperate securely and seamlessly regardless of its originating vendors, as shown in Figure 2. There may be multiple vendors connected in the future. However, the origin of the radio unit is connected to the same software provided by the company, which is provided by the manufacturing components. On the other hand, the centralized and distributed units can be connected by different enterprises, such as Cisco and Huawei [13], [14]. Another reason behind replacing RAN with O-RAN is that the traditional one has close-segmented network property, while the last subset of the 5G network is considered predominantly proprietary [12], [14]. However, recently, this technology has emerged as an excellent candidate to replace the RAN infrastructure but needs to maintain technological flexibility in terms of architectural association of 5G mobile network, agile modeling and related processes, scalability, load management, scheduling, privacy and security, and optimization with cost-effective manner.

A. Motivation and Major Contributions of This Research

The communications service providers estimate that almost 2%-3% of energy generation is scheduled against global demand and consumption while processing and executing network services among users [12], [13], [14]. In addition, the demand is fluctuating drastically, with orders increasing day to day. These advances significantly come from the industrial side; an energy optimization mechanism is required to maintain energy efficiency and their adoption. Although, it would only improve the margin of operational controls and quality of experience. However, with the integration of green technology into the radio access network, the system not only receives improvement in the evolution of radio signals and hardware antenna but can drive 25% cost-cutting in RAN energy usage [13], [14].

In this paper, we initially highlight the current gaps involved in the RAN architecture, such as fixed line-enabled connectivity, privacy and security issues (fine-grained access), and load management and scheduling. On the other end, the concept of O-RAN alliance is introduced, which devises a new paradigm in terms of improved RAN architecture featuring the open and software-driven virtual radio access network infrastructure, which is intelligent, including load distribution and management. The distribution of this architecture is elaborated as follows: (i) First, distribute the functions of the physical network and virtual network; (ii) Second, the notion of intelligent RAN controller is defined, like resource allocation and scheduling, load optimization, mobility management, and virtualization. In O-RAN, the designed intelligent RAN controller enforces the decision via an applicational interface using the inbuilt open RAN functions. To enable an agnostic solution for such network services, there is a need to associate it with artificial intelligence techniques, especially machine learning, to manage the load of customer-enabled services and organizations. However, the traditional design of RAN-based operation execution, working cycle, and service delivery hierarchy between end-to-end access network solutions is required to reduce the complexity and robustness of innovations. Behind all these, machine learning techniques help foster solutions that make deploying the intelligent controller of O-RAN more flexible by associating the requirement of Quality of Service. The enhancement of such developments raises the technological adaptation and envisions 5G mobile communication, cellular networking, and beyond-network services in the future. For instance, different kinds of sub-O-RAN architectures are proposed: (i) C-RAN, (ii) vRAN, and (iii) OvRAN. Visualization, power consumption, edge support, AI support, control management, and organization are the primary criteria for evaluating these individuals' performance and architectural investigation. The main objectives and contributions of this research are discussed as follows:

- In this paper, we propose a novel and secure architecture for an industrial environment, namely "ORAN-B5G", which disaggregated the hierarchy of O-RAN into Virtual Network Function (VNF) and Physical Network Function (PNF).
- This proposed architecture solves the load-balancing issues that occur during the distribution of resource allocation using a metaheuristic algorithm, specifically PSO.
- To tackle the traffic of industrial requests, this proposed ORAN-B5G uses ANN to classify the telecommunication data to make the environment more reliable in distributing the load of data transactions into different connected nodes, along with the capability of intelligent decision-making.
- This paper proposes a lifecycle of AI-enabling industrial operational execution automation designed to enclose intelligent functionality for O-RAN controllers.
- Finally, this paper investigates the O-RAN technology and discusses its proposed architectural gaps. We also present a few possible solutions to such challenges and limitations and drive a good design for future developments.

B. Sections Outline

The remaining outline of this paper is aligned as follows: In Section II, a detailed description of O-RAN and their collaborative strategies, like machine learning with 5G, to improve the working hierarchy by studying, evaluating, and analyzing the state-of-the-art previous publications. The problem-related prospects and preliminaries, along with the formulation are discussed in Section III. The presentation of the proposed architecture, named "ORAN-B5G", and the results of this architectural simulations are illustrated in Section IV. However, in Section V, the possible solutions that involve open challenges and limitations are highlighted and discussed. At the end, this paper concludes with the description of future direction in Section VI.

II. Related Work

The concept of a mobile service provider has defined the current design of RAN proprietary, such as O-RAN and OvRAN. Both categories ensure that all the features are commonly provided to the individual or enterprises, where the critical aspect is to ensure network prevention across and consistent user experiences [15]. For instance, a critical question is addressed in this paper: Are the features only executed in a specifically designed environment, just like region-based? Thus, it is only allowed to make it happen in another environment with infrastructural support. The in-depth discussion of the mentioned challenging prospects is highlighted in the subsections as follows:

A. Revolution of Open Radio Access Network (O-RAN)

The discussion of O-RAN initiated with the explainable role of OvRAN is proposed; the technology allows the service providers to be at the next level, where it simply removes vendors' lock-in scenarios [15], [16], [17]. It ensures privacy and security concerns while designing possible implementation-enabled solutions. Better authors [16], [17], [18] highlighted the concept of automation and orchestration in OvRAN technology. These additional prospects instantiate the monitoring of performing lifecycle evaluation and their management and compare this with RAN. This zero-trust environment provides a cost-efficient resource management platform in the industrial domains. However, another concerning factor presented by [18], [19], [20] is securing the open radio environment, which is the most critical prospect faced by the service providers. Because of the nature of close proprietary, the OvRAN is becoming an ongoing hot topic that invites expert concerns regarding architectural security and its transaction privacy. It is worth noting that this technology provides an excellent option for managing visibility throughout compared to RAN. Such highlights indicate the criticism of architectural security because of how it is possible to protect from what cannot be seen.

The vendors offer 5G, which means they created open radio to offer network connectivity for different scenarios, such as internal, eternal, micro, and macro interconnectivity and communication. The authors of [15], [19], [20] present their discussion, where various Tier 1 and Tier 2 carriers have used different enterprises to lead and initiate rollouts and related announcements. This is because of the intentionally and unintentionally developed OvRAN infrastructure built on a 5G mobile communication network.

B. Collaborative Strategy of Open Radio Access Network With Machine Learning and 5G

The 5G mobile communication network introduces the NG-RAN, which divides the actual stake of RAN protocols into different disaggregates options, probably eight sub-portions integrated with the three network units, distributed unit, central unit, and radio access unit [21], [22]. However, these disaggregated units have reached a completely interoperable environment on the O-RAN. The authors of [22], [23], [24] mentioned the benefits that the technology allows for the intelligent controller of RAN, which means an application to visualize the systems' working hierarchy on the general-purpose hardware. This is because it enables the management of disaggregated protocols and units placed as radio functions. In addition, the organization of such designed functions and related load management is created a challenging problem since this technology was introduced; in order to highlight

TABLE I
COMPARATIVE ANALYSIS OF STATE-OF-THE-ART METHODS

References	Lack of Systems' Integration in the O-RAN Architecture	Possible Solutions/ Proposed Solutions	Detail Description
[25]	Privacy preservation with the decentralized approach for training Intelligent RAN controller-enabled smart decision making and disaggregation Standard of federated learning application is required for provide network functions to hierarchical, distributed, and aggregated related services of O-RAN	Federated learning-enabled intelligent RAN controller design is one of the possible solutions to handle load balancing and efficient decision-making	This paper discussed the major key area of O-RAN technology, which is the join selection of local trainers and resource allocation in accordance with the protocols of intelligent RAN controller.
[26]	The multi-band 2 tier network is designed, which is heterogeneous in nature. It requires more computational cost throughout the process in the 5G wireless mobile communication environment Large scale multiple antennas are required It is hard to manage heterogeneous cloud radio access network (H-CRAN)	In order to provide a cost-efficient open radio access network, there is a need to propose/present a standardized network hierarchy while designing architecture of future O-RAN	The topic of power consumption and related analysis involving in the open access network in 5G mobile communication architecture is discussed by A. Israr et al. In this paper, they present a novel design of an analytical-based quantitative model for monitoring usage of computation cost.
[27]	Automate control and optimization functionality of intelligent RAN controller and related network protocols Fine grained access authentication problem in the current O-RAN architecture	Close loop control protocol is one of the solutions that inherent in the recent architecture of O-RAN technology	A. Lacava et al. proposed a programmable with customize intelligent RAN controller that handle steering traffic in 5G wireless mobile communication network using the predefined protocols of O-RAN architecture.
[28]	The list of inherent complexity highlighted, such as design of RAN ecosystem, system realization, privacy, preservation protection, and security related A lack of end-to-end open-source fully developed network environment Interoperability issue between interconnected nodes of different chains Intercommunication security problem	With the collaboration of IoT, AI, and blockchain with O-RAN, we can design a secure interoperable environment that provides a protected infrastructure with reliability, vast connectivity, flexibility, and a cost-efficient platform for future designs	The author of this paper proposed a close-loop RAN architecture, namely NexRAN, for transactional slicing open-source RAN in the real time, especially in the environment of industry 5.0.
[29]	The transactional redundancy between the end-to-end interconnected network Homogenous cached content related problem A minimal fronthaul load management facility is required	Multi-casting opportunity to design redundant coded package	In this paper, the author mentioned the integration of joint MDS codes and weighted graphical coded caching strategy allows to design of a secure and smart open access network in the fog computing environment.
[30]	Integration of central and distributed units connectivity Commercial-Off-The-Shelf deployment is required Scope of data privacy issue Ledger distribution related problem	The current O-RAN architecture requires the support of effective Quality of Service (QoS) to evaluate and provide a better technological environment for industries	X. Wang et al. proposed a self-play learning strategy for O-RAN's resource management, allocation, assessment, and monitoring. This learning strategy is designed for the management of industrial platforms in real-time.

these constraints, the state-of-the-art papers [21], [23], [24] categorized it as follows: (i) stack split issue, (ii) routing path and related hierarchy, (iii) network topology limitations, (iv) limited bandwidth, (v) computational resources, and (vi) latency-based. Most recent publications do not deal with the general integration problem of split functions with stake analysis, respectively. In this manner, this paper addresses the overall challenging prospects that occur during the execution of O-RAN in real-time, especially in the industrial environment, such as manufacturing, production, and industrial internal transactions (as mentioned in Table I).

III. PRELIMINARY

This section elaborates on the primary knowledge required to understand the current problem raised in the proposed O-RAN technology, especially load balancing, scheduling, organization and optimization, intelligent controls by RAN policies, and resource distribution and allocation. In addition, the formulation of such involving problems, along with the notation and related description, is discussed as follows.

A. Notation and Problem Description

In the current environment, RAN architecture is also called a Distributed RAN (D-RAN), where the individual broadband unit is designed to interconnect with nodes. These nodes are the corresponding remote radio head via a transport network. Both fiber and optical microwaves are designed by the complete process of deployment, which allows the creation of a connection between the broadband unit and the remote radio head. This mentioned process is known as fronthaul. However,

TABLE II
SYMBOLIC DISCUSSION OF THE PROPOSED ARCHITECTURE

Symbols	Description
RAN	Radio access network
D-RAN	Distributed radio access network
QoS	Quality of service
C-RAN	Cloud radio access network
vRAN	Virtual radio access network
O-RAN	Open radio access network
ORAN-B5G	Open radio access network-Beyond 5G
Industry 5.0	Fifth generation of industrial revolution
ML	Machine learning
AI	Artificial intelligence
PSO	Particle swam optimization
NFV	Network functions virtualization
OvRAN	Open virtual radio access network
$\boldsymbol{Ti}$	The chosen operation in the list of n executor
$\boldsymbol{An + Ai}$	Estimate response with respect to time
On-chain	For implicit architectural transaction
Off-chain	For explicit architectural transaction
r	Range
Bi	Calculate consumption of computational energy
x	Actual cost
y	Estimated cost
Bi (m)	The actual cost of energy consumption.
Bi (n)	The estimated cost of energy consumption
Near RT-RIC	Near-Real Time RIC (RAN Intelligent Controller)
Non RT-RIC	Non-Real Time RIC (RAN Intelligent Controller)

the rate of data traffic increases by increasing the node's connectivity from the vendor side. There is a need to place Quality of Service (QoS) measurements; to tackle this, we enhance the requirement of QoS in the proposed architecture, along with the description of cellular network actors that follow the regulatory compliances of cloudification and centralization of the broadband end. Because of this extensibility, the technology contains overall resource constraints, especially a pool of networks. Integrating this enhancement with cloud computing transforms it into cloud-RAN architecture (C-RAN), as mentioned in Table II. In this scenario, remote radio heads connect by centralization, cloudified, and shared pool of broadband resources.

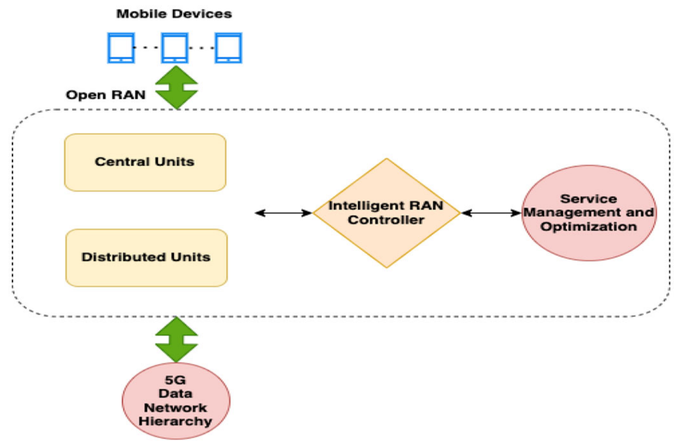

Fig. 3. Primary Working Hierarchy of the ORAN-B5G.

The architectural design of O-RAN is derived in two ways: centralization from the baseband and virtualization. Thus, this factor reduces power utilization but maximizes the usage of network throughput, scalability, load distribution, and cost of preservation-related prospects. To equalize a load of resources in the current structure of O-RAN, ML must be involved throughout the virtualization process (such as ANN for virtualized resource allocation). With this association, many 5G users are entertained; low latency communication and reliable high data throughput can be managed. In order to extend such requirements in the existing scenario, network vendors are leveraging updates on Network Functions Virtualization (NFV) technology. Then, a system can distribute the load by virtualizing (called OvRAN) all the O-RAN services and functionalities using resource distribution. In addition, by such tunning, the architecture can decouple controls over the data plane, supporting proper resource allocation and virtualization.

However, the highlights of O-RAN-based architectural improvement are presented in the above section. One of the OvRAN features that needs to be addressed is the connectivity of the digital cloud unit and remote radio unit over the ethernet links. In the distributed unit, the baseband units are virtualized and create multi-NFV, which aims to provide processing to the baseband for managing running functionalities. Almost all virtualized basebands are connected with a joint strategic solution on the data link layer to share data and exchange signaling aspects among the virtual baseband units. The high specification of the hardware is required for designing OvRAN in a standard manner that efficiently scales up and down the resource allocation and balancing. It includes storage,

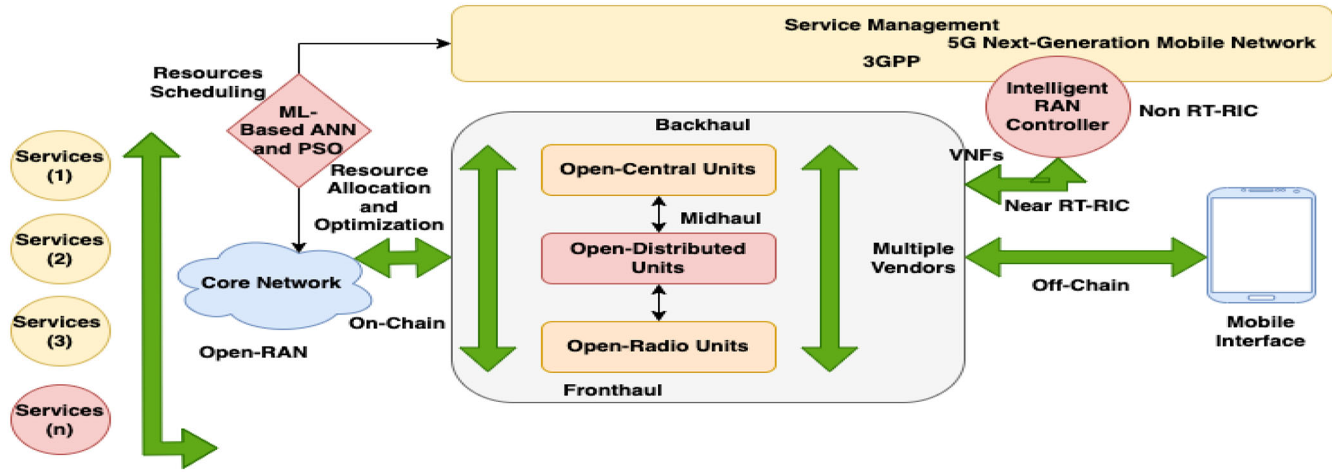

Fig. 4. The Proposed ORAN-B5G.

processing, I/O resources, network connectivity, and other services that meet user demands. In order to achieve an effective, functional, and fully potential environment, the proposed ORAN-B5G addresses the achievable prospects by applying this architectural solution in real-time, such as (i) low energy consumption, (ii) dynamic elasticity, (iii) cost-efficient network distributions, and (iv) reliability and quality services.

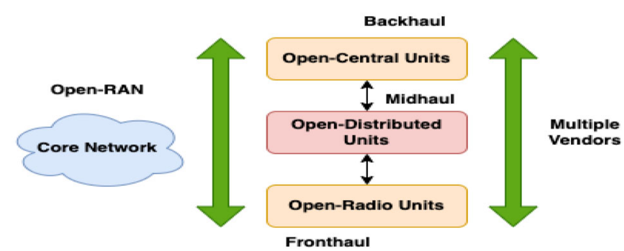

Fig. 5. Working Operation of Core Domain.

B. Problem Formulation

In the process of resource management, a load balancing method is introduced, which is based on Machine Learning (ML)-enabled Artificial Neural Networks (ANN) in the context of metaheuristic—Particle Swam Optimization (PSO) that seeks to leverage the recent technique of Intelligent RAN Controller for handle and operate service of cellular network, especially 5G wireless mobile communication network for industry 5.0, namely ORAN-B5G (as shown in Figure 3).

The proposed ORAN-B5G extends the 5G for industry with advanced monitoring and analytics of network fluctuations introduction, which mainly summarizes the metrics plane. With the integration of QoS, the system can analyze the network and predict the performance of O-RAN by dividing traffic, determining behaviors, and measuring bandwidth and latency. In addition, the ORAN-B5G includes the training of ANN, which can analyze and pick the shortest path with minimum load, as shown in eq. (1).

$$Ti = \min\{An + Ai : n \rightarrow \{1,\ 2,\ \ldots,\ n\}\} \tag{1}$$

where Ti = the chosen operation in the list of n executor; An+Ai = estimate response with respect to time; n = number of requests; and i = index of the request.

$$Bi = \left\{ \frac{Bi(x)}{Bi(y)} \right\} \tag{2}$$

The primary objective is to design an intelligent RAN controller with a cost-efficient redirect operation for transferring incoming requests within a minimal amount of time.

Calculate computational energy consumption during resource allocation, scheduling, management, and optimization-related requests, as mentioned in eq. (2). The response is evaluated as a transmission between the requesting nodes and an ML-enabled AAN-based intelligent RAN controller, as defined in eq. (3). Likewise, the range of request-response is tunned between $\mathrm{r} = \{0, 1\}$, which is defined in eq. (3) and eq. (4).

$$Bi\ (n)\ = \sum_{i=1}^{n}\sum_{j=1}^{n}((\mathrm{ni}-\mathrm{nj})+\mathrm{r}) \tag{3}$$

where r = range; Bi = calculate the consumption of computational energy; x = actual cost; y = estimated cost; Bi (n) = the estimated cost of energy consumption; and Bi (m) = the actual cost of energy consumption.

$$Bi\ (m)\ = \sum_{i=1}^{m}\sum_{j=1}^{m}((\mathrm{mi}-\mathrm{mj})+(\mathrm{mj}+\mathrm{r})) \tag{4}$$

Conversely, we propose two channels designed to split down the load of transactions occurring in the systems' environment, such as implicit and explicit transactions. An off-chain intercommunication channel is created to handle the explicit request, as defined in eq. (5). An on-chain intercommunication channel is deployed to tackle requests of implicit architectural transactions, elaborated in eq. (6). By proposing this, the load of network resources is reduced

TABLE III
DESIGN, CREATE, AND DEPLOYMENT PSEUDO-IMPLEMENTATION OF THE PROPOSED WORK

Input Constraints: $\boldsymbol{Ti = \min\{An + Ai : n \rightarrow \{1, 2, \ldots, n\}\}}$
Compliances: Vendors are only stakeholder who manages and updated the O-RAN architecture;
List of networks services;
Collaborative algorithmic functionality of ANN and PSO;
Multi-vendors distribution -> Backhaul, Midhaul, and Fronthaul;
Declaration and Initialization:
int main()->File[x]:
network management of multi-request, Net();
on-chain channel, on_Chain();
off-chain channel, off_Chain();
resource allocation, rA();
resource scheduling, rS();
resource optimization, rO();
intelligent RAN controller, IRANC();
timestamp O-RAN [execute];
Conditions:

TABLE III
(Continued.) DESIGN, CREATE, AND DEPLOYMENT PSEUDO-IMPLEMENTATION OF THE PROPOSEDWORK

If request != Net() -> True:
then, Add and schedule request in Net();
if request == belongs to implicit:
then, on_Chain();
or, off_Chain();
add other activities rA(), rS(), rO();
$\boldsymbol{Bi\ (m) = \sum_{i=1}^{m} \sum_{j=1}^{m}((\mathbf{mi} - \mathbf{mj}) + (mj + \mathbf{r}))}$,
and, IRANC(decision making);
$\boldsymbol{Bi\ (n) = \sum_{i=1}^{n} \sum_{j=1}^{n}((\mathbf{ni} - \mathbf{nj}) + \mathbf{r})}$.
else: save state, exchange, terminate;
stop;
else: save state, exchange, terminate;
stop;
Output: Net(); rS(); on_Chain(); off_Chain(); and IRANC();

because of intercommunication division down to 3.19%, as briefly discussed in section results and discussion.

$$Off - Chain = \{Explicit\ (requests)\} \tag{5}$$
$$On - Chain = \{Implicit(requests)\} \tag{6}$$

IV. PROPOSED ARCHITECTURE

Figure 4 presents the design of the proposed extensible architecture, namely ORAN-B5G for industry 5.0, which is derived from the four different prospects. First, the side of the mobile interface that is created for intercommunication purposes. In this scenario, the users need to join first (which is based on a fine-grained access control mechanism, especially two-way authentication), then send a request for mobile-enabling services works on the application layer, as shown in Figure 4. Secondly, the design of the Intelligent RAN controller is based on a function of orchestration and automation that lies in the Non-Real Time-RIC, where its initial task is to handle requests and schedule resource allocation and distribution virtually. To do this, we improve the strategy of current O-RAN-enabled Virtual Network Functions (VNFs) for resource virtualization by applying $Bi = \{\frac{Bi(x)}{Bi(y)}\}$. Behind all this implementation, the existing strategical steps of Near Real Time-RIC are involved, such as $Ti = \min\{An + Ai : n \rightarrow \{1,\ 2,\ \ldots,\ n\}\}$. However, in this Near-Real Time RIC domain, the working hierarchy is defined into three sub-categories, like Backhaul (Open Central Units), Midhaul (Open Distributed Units), and Fronthaul (Open Radio Units). Whereas multi-vendors are involved in the VNFs and services of resource allocation and optimization with on-chain channels in order to tackle requests implicitly, as shown in Figure 5. While creating an off-chain channel, the ORAN-B5G is able to handle and organize the requests of the application layer, most probably display and interface-related.

Conversely, the list of services is managed in the core domain of Open-RAN networks, where resource allocation, scheduling, and optimization occur, as shown in Table III and Figure 4. The role of AI-enabled ML is critical in developing middleware as a load balancer for managing and optimizing network resources in terms of allocation and scheduling. To handle this situation cost-efficiently, the collaborative approach of ANN with PSO is proposed through the platform of ORAN-B5G to optimize the load of requests in the form of load distribution by the size and priority of requests. It is because of the improvement in the code of load balance, such as $Bi\ (m)\ = \sum_{i=1}^{m} \sum_{j=1}^{m} ((\mathrm{mi} - \mathrm{mj}) + (\mathrm{mj} + \mathrm{r}))$, and $Bi\ (n)\ = \sum_{i=1}^{n} \sum_{j=1}^{n} ((ni - \mathrm{nj}) + \mathrm{r})$.

V. RESULTS AND DISCUSSION

In order to perform simulations of the proposed ORAN-B5G, we need to tune the system in such a way to deploy these extensibilities. The requirement of this installations is highlighted as follows:

- Network bandwidth: 1Mbps-1Gbps;
- Preservation (Static/Dynamic): 4 slots of 16-GB RAM and 4 slots of 2-TB SSD;
- Processing units: 3.0 MHz vPro processor, along with 8-GB integrated graphic card capabilities.

Initially, the proposed ORAN-B5G is tested on the designed Intelligent RAN Controller, where the relationship of network service management is simulated for evaluating network service requests with respect to time (s). In this test, we find the 521/units service requests rate in 263 second (s). The average network service requests handled by IRANC() and managed is 1.98 unit/s, as shown in Figure 6.

However, to optimize the requests of core network services, a designed Intelligent RAN Controller performs a vital role in scheduling down several requests and discarding redundant occurrences automatically. This is because the IRANC() is associated with the collaborative functionality of ANN-PSO for request optimization in real-time. Figure 7 illustrates an evaluation of request optimization of core network services via

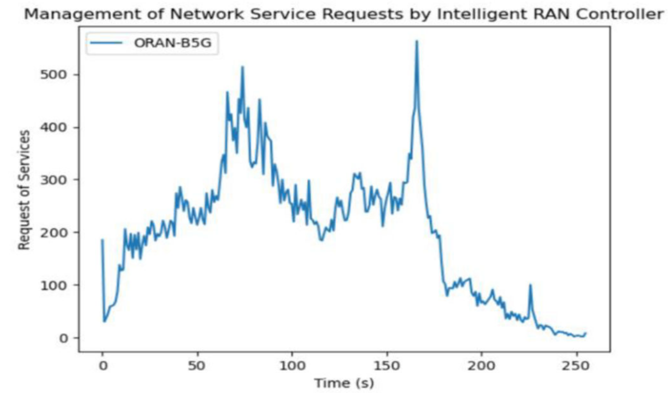

Fig. 6. Manages Network Service Requests via Intelligent RAN Controller.

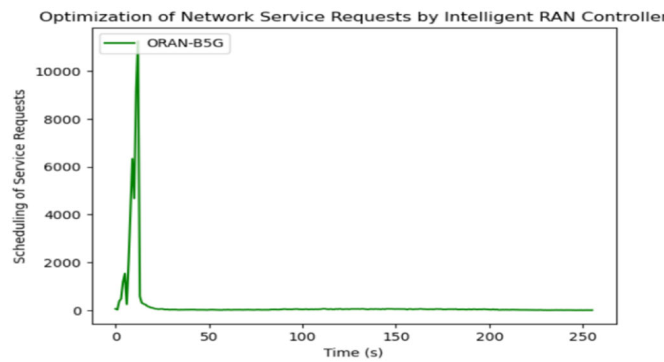

Fig. 7. Optimize Requests of Core Network Services via Intelligent RAN Controller.

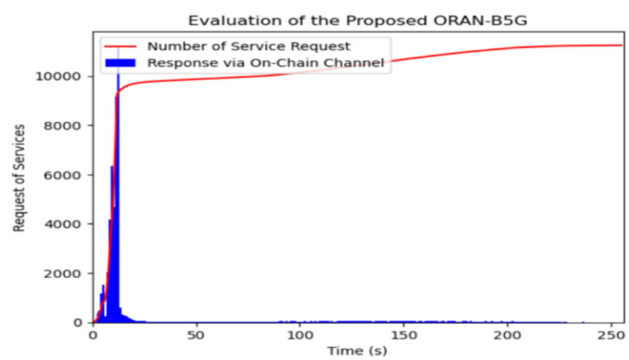

Fig. 8. A Number of Service Requests Responses via On-Chain Channel.

IRANC(), where the metrics of examination are the scheduling of service requests (10110 units) and time (267s). The average result of this simulation is 37.86 unit/s.

Figures 8 and 9 show the simulation results of the designed channels of ORAN-B5G, where the number of service request responses via an on-chain channel provides 543 units, an average of 247s, which can be approx. 2.19 units/s on average. The number of service requests responded to via an off-chain channel is 587 units, with an average of 266. The approximate result we achieved is 2.206 units/s on average.

On the other end, the simulation is performed to get the overall results of the proposed ORAN-B5G load balancer. In this design, we integrate ANN and PSO for managing

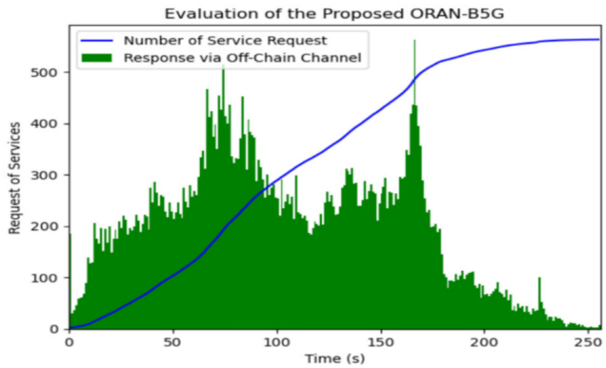

Fig. 9. A Number of Service Requests Responses via Off-Chain Channel.

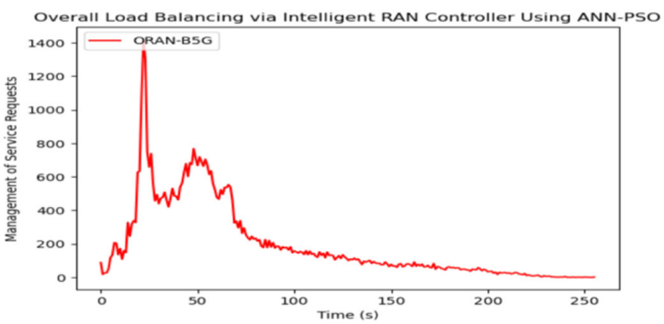

Fig. 10. Overall Results of Load Balancing (1).

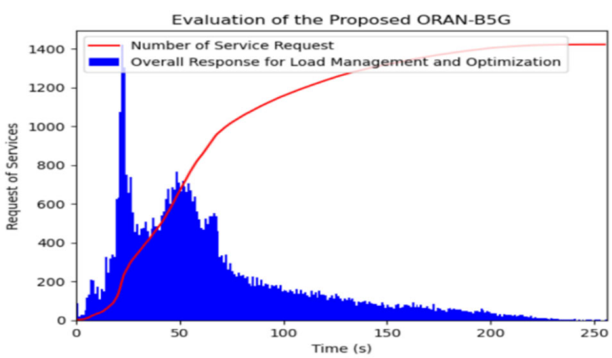

Fig. 11. Overall Results of Load Balancing (2).

IRANC() in terms of cost-efficient solutions compared to other state-of-the-art methods used for the functional implementation of core network services. The average cycle received by the load balancer's design is 1415 units in 274s, where the evaluated metrics are the number of managing requests and time, as shown in Figure 10.

Finally, Figure 11 illustrates the simulation results of the overall responses sent by the IRANC() in order to handle the load of service requests management and optimization, where the evaluation metrics are the number of core network service requests that occur (1409 units) and the response time (271s). At the same time, The average response management received by the ORAN-B5G is 5.19 units/s, which is considered a far better result than [32], [33], [34]. For this reason, we claim that the proposed ORAN-B5G is a good candidate for real-time O-RAN implementation for industry 5.0.

TABLE IV
COMPARE THE PROPOSED WORK WITH STATE-OF-THE-ART METHODS

References	Proposed Contributions	Technique(s)	Evaluation (%)
[31]	O-RAN resource management (network slicing)	The proposed Nrflex	1.611%
[32]	O-RAN resource optimization	Machine learning-enabled supervised techniques	1.63%
[33]	O-RAN resource allocation, scheduling, and optimization	Cloud-enabled UAV telecommunication technique (base station-based baseband units integration)	1.87%
[34]	O-RAN resource allocation	The customize TDM-PON, a proposed technique for network slicing and organization	2.54%
The proposed ORAN-B5G	O-RAN load balancer	Collaborative technique of ANN with PSO	3.19%

Through the simulations and results of the ORAN-B5G, we have claimed that this proposed architecture is one of the better solutions in the real-time implementation of O-RAN for industry 5.0 compared to [31], [32], [33], [34], as discussed in Table IV.

VI. Conclusion

This paper discusses the current lifecycle of 5G mobile communication with the connectivity of the cellular architecture of RAN, highlighting a few significant concerns that need to be addressed for technological maturity and future developments. In this paper, we first mention the importance of O-RAN and link this discussion to the need for technological transformation, as IT development is robust with people's involvement. Second, we adopt the problem that arises in managing load and balancing while designing the infrastructure of O-RAN from an industrial perspective. After analysis of such prospects, this paper presents a novel and secure architecture based on O-RAN technology with 5G cellular infrastructure for fifth industrial transactions, namely ORAN-B5G. In addition, the primary objective of this paper is to propose a standardized working hierarchy of the O-RAN adaptation and proper implementation in industrial 5.0. It is maintained with the association of 3GPP standard protocols. Substantially, in an industrial environment, there are several telecommunication transactional request schedules for manufacturing and production purposes; tackling each transaction execution is quite a complex task in the current architecture of O-RAN. In order to handle such types of loads, the proposed ORAN-B5G presents a lightweight load balancer that aims to distribute transactional load to different connected units (DU) and optimize using an AI-enabled ANN algorithm with PSO. This integration also helps to make an intelligent RAN Controller for compatible connectivity, reliability, and decision-making with robustness. However, the simulation results of the ORAN-B5G drive the advantages of adopting and deploying that make industrial units more protected and secure, including the physical layer-based dynamic controls access, testing applications on AI-based controller design capabilities, and deterministic latency with scalability. Through all these analyses, this ORAN-B5G is considered an excellent candidate to be implemented in the real-time industrial environment for future developments.

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