Enhancing O-RAN xApp Intelligence with Cross-Domain RAN-Core Data Integration

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***Abstract*—The Open Radio Access Network (O-RAN) architecture introduces openness and intelligence through the RAN Intelligent Controller (RIC) and its xApps. Despite these advantages, existing xApps operate solely based on RAN-side measurements, with real-time core network (CN) information remaining unavailable. This separation restricts their ability to perceive end-to-end network conditions and limits the accuracy of prediction-driven control. In this study, we explore the impact of augmenting xApp intelligence with CN-awareness. Using the ns-3 platform, we generate RAN-level features such as eNB traffic load and CN-level attributes represented by session types. Based on these datasets, we develop two traffic estimation models: one relying exclusively on RAN data and another leveraging both RAN and CN features. Our evaluation shows that incorporating CN context yields a substantial improvement in estimation accuracy compared to the RAN-only baseline. We further illustrate practical scenarios—including congestion-aware scheduling, anticipatory handover management, and fine-grained policy adaptation—to demonstrate how enhanced predictive capability can translate into more effective RAN control. The results underline the importance of cross-domain visibility and provide motivation for enabling xApps with joint RAN–CN insights in future O-RAN systems.**

***Index Terms*—O-RAN, RIC, xApp, Core Network, Cross-domain Intelligence, Traffic Estimation**

I. Introduction

The Open Radio Access Network (O-RAN) architecture has gained significant momentum as a key enabler of openness, programmability, and intelligence in modern mobile systems [1]. Central to O-RAN is the RAN Intelligent Controller (RIC), which provides a platform for deploying third-party applications—commonly referred to as xApps—that utilize data-driven analytics and AI techniques. These applications aim to enhance the behavior of the radio access network (RAN) by improving performance, automating control decisions, and reducing operational complexity. By offering standardized interfaces and fostering interoperability, O-RAN encourages rapid innovation and facilitates the seamless integration of new xApps into commercial networks.

However, the current design of O-RAN exposes a critical constraint: xApps are predominantly limited to information obtained from the RAN domain, while instantaneous insights from the core network (CN) are not directly available [2]. Although RAN-level metrics—such as signal conditions, traffic load, and interference—capture vital elements of radio performance, the overall user experience is jointly influenced by CN characteristics, including session attributes, congestion patterns, and policy control mechanisms [3]. The lack of access to CN-side information restricts the ability of xApps to accurately model network-wide behavior, thereby reducing the potential effectiveness of their optimization and prediction capabilities.

Motivated by this challenge, the present work examines how integrating CN information can improve the intelligence and performance of xApps. Using the ns-3 simulation framework, we construct a traffic estimation problem in which RAN features are represented by eNB traffic measurements and CN features are characterized by session types. Two learning models are developed: one utilizing only RAN-side inputs and the other incorporating both RAN and CN data. Experimental results reveal that the integrated model consistently yields superior estimation accuracy compared with the RAN-only counterpart. Beyond this specific problem formulation, the results indicate that predictive models across various network management tasks can benefit substantially from joint RAN–CN visibility.

We also investigate how enhanced predictive accuracy can be operationalized within the O-RAN ecosystem. Through use cases such as congestion-sensitive scheduling, anticipatory handover optimization, and fine-grained policy adaptation, we demonstrate that access to CN context enables more informed and effective decision making. These examples illustrate the practical advantages of equipping xApps with multi-domain awareness and point toward the broader potential of cross-layer intelligence in future O-RAN deployments.

The key contributions of this study are outlined below:

- We highlight a structural constraint in existing O-RAN deployments, namely that xApps operate without direct access to real-time core network (CN) context.
- We develop and compare traffic estimation models, demonstrating that incorporating both RAN and CN features yields markedly higher prediction accuracy than relying solely on RAN-derived inputs.
- We illustrate practical use cases where cross-domain predictive models can enhance RAN decision-making processes, enabling more efficient and context-aware operational strategies.

The rest of the paper is organized as follows. The motivation and methodology, including ns-3-based data generation and the design of traffic estimation models, are presented in Section III. Representative use cases and operational implications enabled by cross-domain prediction are discussed in Section IV. Finally, concluding remarks are provided in Section V.

II. Related Work

The O-RAN initiative has emerged as a key framework for achieving openness, programmability, and intelligence in future mobile networks. At the core of this architecture lies the RAN Intelligent Controller (RIC), which provides an environment in which third-party xApps can leverage AI-based analytics to optimize RAN behavior [1]. A substantial body of research has focused on utilizing RAN-specific indicators—such as traffic demand, interference patterns, and user mobility metrics—to improve scheduling, radio resource management, and handover procedures [4], [5]. While these studies highlight the adaptability and automation enabled by O-RAN, their dependence on RAN-only information restricts their capability to represent the full spectrum of end-to-end service behavior.

On the core network (CN) side, 3GPP has increasingly acknowledged the relevance of AI/ML in Release 19. Technical Report 23.700-84, in particular, emphasizes the importance of CN attributes—including session type, congestion conditions, and policy control parameters—for more informed and intelligent decision-making [3]. However, although these efforts recognize the value of exposing CN-level information, they do not provide concrete mechanisms or design strategies for integrating such data into O-RAN xApps.

Overall, prior work has laid a foundation for intelligent RAN control within the O-RAN ecosystem and has recognized the potential benefits of cross-domain learning. Nevertheless, the explicit fusion of CN-driven features into xApp intelligence remains largely unaddressed. This paper distinguishes itself by demonstrating, using ns-3 simulations, that CN session information can significantly enhance traffic estimation accuracy and support more effective operational decision-making in O-RAN. By bridging insights from both RAN and CN domains, our work contributes toward realizing practical cross-domain intelligence for future xApp deployments.

III. Motivation and Methodology

In the current O-RAN framework, xApps are granted visibility into RAN-side metrics such as traffic load and radio measurement reports. However, they lack a standardized mechanism for accessing real-time core network (CN) information—including session attributes, congestion conditions, and policy control states. This separation between RAN and CN data domains prevents xApps from developing comprehensive models that reflect the full end-to-end behavior of the network. Consequently, existing prediction and inference methods operate with incomplete information, which can reduce their accuracy and limit the impact of corresponding optimization decisions.

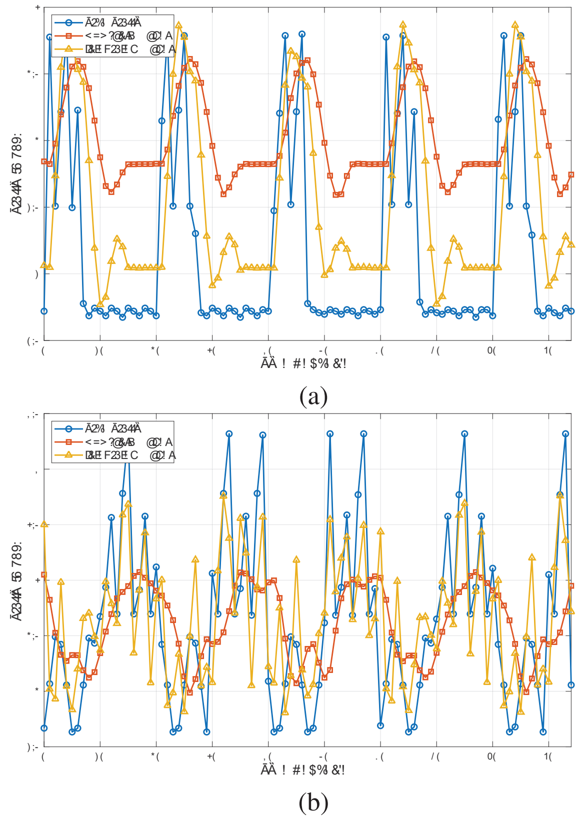

Fig. 1. Traffic estimation accuracy of the RAN-only and integrated models. (a) Scenario 1. (b) Scenario 2.

To explore the value of incorporating CN context, we develop a traffic estimation model using the ns-3 simulation environment. Within this setup, two categories of features are generated. The RAN-side dataset consists of traffic volume measured at the evolved NodeB (eNB), representing radio-layer load characteristics. Meanwhile, the CN-side dataset captures session type information, which reflects user service profiles that influence both transport and core network behavior.

Based on these data sources, we design and compare two distinct models: (i) a RAN-only model trained exclusively on eNB traffic measurements, and (ii) an integrated model that jointly utilizes RAN features and CN session types. The evaluation results indicate a clear improvement in estimation performance when CN features are included. This demonstrates that CN-level information provides complementary insights that enhance predictive capability beyond what can be inferred from RAN data alone. As shown in Figure 1, the integrated model consistently surpasses the RAN-only model across all evaluated scenarios, reinforcing the practicality and significance of cross-domain feature integration.

More generally, our results indicate that numerous predictive and inference-driven tasks stand to gain from the fusion of RAN and CN information. Leveraging features from both domains allows learning models to enhance their accuracy and resilience, ultimately supporting more capable and context-aware xApp intelligence within O-RAN systems.

IV. Use Cases and Operational Implications

The enhanced predictive performance obtained through the joint use of RAN and CN information has significant consequences for operational decision-making in O-RAN systems. This section highlights several illustrative use cases that demonstrate how cross-domain prediction models can bolster network intelligence and support more effective optimization through xApps.

A. Congestion-Aware Scheduling

Accurate traffic forecasting allows the system to anticipate congestion events before they materialize. When RAN-level traffic indicators are combined with CN session attributes, xApps gain the ability to differentiate between elastic traffic (e.g., video streaming) and delay-intolerant traffic (e.g., voice or real-time applications). With this knowledge, scheduling algorithms can be dynamically adjusted—for example, by prioritizing latency-sensitive sessions or shifting flexible traffic to periods of lower demand. Such congestion-aware scheduling enhances fairness, reduces packet loss, and improves overall quality of service (QoS).

B. Proactive Handover Decisions

Mobility management remains a core challenge for RAN operations. Traditional handover algorithms depend primarily on radio metrics such as RSRP or SINR, which fail to reflect the service requirements of user sessions. By incorporating CN-level details—such as whether the active flow corresponds to interactive video or large file transfer—xApps can tailor handover decisions to the needs of each session. Latency-critical services, for instance, can be transferred early to neighboring cells with more stable loads. This proactive approach lowers the likelihood of call drops, strengthens service continuity, and improves user-perceived experience during mobility.

C. Fine-Grained Policy Enforcement

Cross-domain prediction further enables more precise enforcement of network policies. When the system can anticipate the demand associated with each session category, it becomes possible to implement operator-defined policy rules more effectively. Examples include enforcing priority for emergency communication traffic or selectively throttling background applications. Considering both radio load conditions and session-level CN context ensures that policies align with real-time demand, thus supporting compliance with service-level agreements (SLAs) while improving resource utilization.

D. Additional Opportunities

Beyond these representative scenarios, the integration of RAN and CN information unlocks numerous additional possibilities. Anomaly detection, for example, can be significantly improved by identifying irregular patterns that may be invisible from radio metrics alone. QoE-oriented optimization for multimedia applications can also benefit from correlating session types with radio and user context. Moreover, accurate forecasting of future load conditions enables energy-saving mechanisms such as dynamic cell switching or adaptive resource activation, allowing the network to reduce power consumption without degrading service performance.

E. Summary of Implications

Taken together, these use cases demonstrate that fusing RAN and CN insights contributes not only to more accurate predictions but also to the development of a new class of intelligent control strategies. Empowering xApps with cross-domain visibility improves network adaptability, resource efficiency, and service quality across practical deployments. Furthermore, the operational gains extend beyond conventional RAN optimization, enabling broader objectives such as SLA adherence, improved user experience, and sustainable energy use.

V. Conclusion

This paper highlighted a key limitation of current O-RAN systems, where xApps operate with RAN-only visibility and cannot leverage real-time CN information. Using an ns-3–based traffic estimation framework, we showed that models combining RAN and CN features achieve significantly higher accuracy than those relying solely on RAN data, demonstrating the clear benefits of cross-domain awareness. We also presented representative use cases—such as congestion-aware scheduling, proactive handover, and fine-grained policy adaptation—that illustrate how improved prediction accuracy can translate into more effective operational strategies in O-RAN. Future work will extend this framework with additional ML models, richer CN features, and evaluations on real O-RAN testbeds. We expect that these insights will support emerging standardization efforts aimed at enabling tighter integration between RAN and CN, ultimately advancing intelligent cross-domain xApps for next-generation networks.

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