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Iacovos Ioannou*, Christophoros Christophorou*, Vasos Vassiliou*, Loizos Christofi*, John S Vardakas*, Erin E Seder*, Carla Fabiana Chiasserini*, Marius Iordache*, Chaouki Ben Issaid*, Ioannis Markopoulos*, Giulio Franzese*, Tanel Järvet*, Christos Verikoukis*

* ADROIT6G

***Abstract*—ADROIT6G targets establishing a revolutionary 6G wireless system architecture designed to meet emerging applications' performance demands. The current 5G design is redesigned and enhanced by implementing a comprehensive distributed and dynamic framework, wherein compute nodes are dispersed across the far-edge, edge, and cloud domains. Additionally, this architecture incorporates 6G terrestrial and non-terrestrial communications to establish a resilient network. Distributed computing nodes located at the far-edge, edge, and cloud domains facilitate deploying virtual functions of software-defined disaggregated RAN and core networks, virtual applications, and AI agents. These nodes are dynamically orchestrated as part of the overall network control and management strategies. The architecture of ADROIT6G comprises three primary frameworks that operate on a programmable inter-computing and inter-network infrastructure. These frameworks include the AI-driven Management and Orchestration Framework, the Fully distributed and secure AI/ML Framework for CrowdSourcing AI Framework, and the BDI-, AI-driven Unified, and Open Control Operations Framework. Additionally, implementing a closed-loop functions component is established and specifically engineered to enhance the efficiency of network and service operations over infrastructure resources. These components collaborate harmoniously to establish a complex and adaptable 6G network infrastructure capable of attaining the ambitious objectives and key performance indicators established for 6G, guaranteeing a future-oriented 6G network environment.**

***Index Terms*—6G Architecture, DAI Framework, BDIx agents, Crowdsourcing AI, AI/ML, NTN, UE-VBS**

I. Introduction

ADROIT6G seeks to establish the groundwork for long-term research on technological improvements in low Technology Readiness Level (TRL) to define a revolutionary 6G wireless system architecture. The proposed architecture meets future applications' performance needs and associated technological trends. It seamlessly incorporates 6G terrestrial and non-terrestrial communications into a robust network, aiming to provide ultra-low latency support for a massive number of devices. The ADROIT6G network's architecture represents an advancement over the current 5G architecture. It adopts a fully distributed and dynamic paradigm, with distributed computing nodes (functional elements) across the far-edge, edge, and cloud domains. The distributed computing nodes, each of them with their own characteristics and capabilities, are used to deploy on demand in cloud-native environments across far-edge, edge, and cloud domains operated by different stakeholders, virtual functions of software-defined disaggregated RAN and core network, virtual applications, as well as AI agents, which are orchestrated dynamically as part of the overall network control and management strategies. The ADROIT6G architecture consists of three main frameworks operating on top of a programmable inter-computing and inter-network infrastructure.

- The **AI-driven Management and Orchestration Framework**, which is essential for the management of the distributed applications and services across the various infrastructures, extending from traditional cloud environments to the heterogeneous edge and the far-edge/device layer.
- The **Fully distributed and secure AI/ML Framework for CrowdSourcing AI**, which represents a novel approach targeting to enhance network operations, network management, and service delivery through the use of Artificial Intelligence (AI).
- The **BDI- & AI-driven Unified & Open Control Operations Framework**, which targets the forming of D2D communication under the gNodeB and also harnesses storage, computational, and networking resources of the ubiquitous smart Mobile Devices (i.e., Smartphones, Tablets, etc.), for augmenting the network's cellular, storage, and computational capabilities with the use of Distributed Artificial Intelligence (DAI).

In addition, a **Closed-Loop Functions component** is defined, which is designed to address the complexities inherent in managing 6G networks by leveraging automation to optimize network and service operations while efficiently utilizing infrastructure resources.

This paper builds on the work done in [1] and aims to extend further the description of the ADROIT6G conceptual architecture provided previously by the authors.

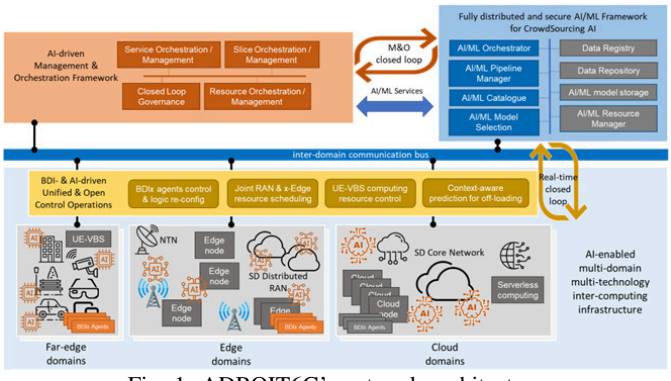

Fig. 1: ADROIT6G's network architecture.

This work has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 739578, the ADROIT6G project of the SNS-JU under Grant Agreement No. 101095363, and the Government of the Republic of Cyprus through the Deputy Ministry of Research, Innovation and Digital Policy.

II. The ADROIT6G Architecture

The three main frameworks of the ADROIT6G network architecture and the Closed-Loop Functions approach depicted in Fig. 1 are not just a collection of tools but a groundbreaking approach to network design. These work in synergy to create a sophisticated and dynamic 6G network ecosystem capable of achieving the ambitious goals and KPIs set for 6G, ensuring the realization of a future-ready 6G network landscape.

The **AI-driven Management and Orchestration Framework** is pivotal for managing distributed applications and services across various infrastructures, extending from traditional cloud environments to the heterogeneous edge and the fa-edge/device layer. It is designed to handle the complexities of advanced End-to-End (E2E) communication services that involve multiple stakeholders, including network operators, cloud service providers, and other service entities. It provides for the efficient and effective deployment, management, and orchestration of network services and resources. The aim is to streamline the composition, deployment, and management of network slices, services, applications and resources, facilitating seamless interoperability across diverse network segments and ensuring optimal network performance, reliability, and scalability.

The **Fully distributed and secure AI/ML Framework for CrowdSourcing AI** represents a novel and forward-thinking approach to enhancing network operations, management, and service delivery through the use of Artificial Intelligence (AI) and Machine Learning (ML). This framework is built on the premise of collaborative intelligence, where network and computing nodes across the system share resources, data, and AI/ML models to optimize tasks such as decision-making, prediction, and network management. This collaborative effort aims to conserve resources at a systemic level, leveraging the work done by others to improve efficiency and effectiveness across the board.

The **BDI-** & **AI-driven Unified** & **Open Control Operations Framework**, responsible for the network automation's real-time and near-real-time close loops. It coordinates the dynamic and inter-domain resource allocation in the short term based on the current network condition and context-aware predictions. It targets the control of the user equipment (UE) to form D2D communication networks under the gNodeB. Additionally, it controls and leverages User Equipment as Virtual Base Station (UE-VBS) Computing infrastructures, resulting from D2D-Relays, created for harnessing the storage, computational, and networking resources of the ubiquitous smart Mobile Devices for augmenting the network's cellular, storage, and computational capabilities. Controlled by Belief-Desire-Intention eXtended (BDIx) agents under a Distributed Artificial Intelligence (DAI) Framework, this kind of infrastructure is robustly equipped to take autonomous decisions in a decentralized manner across the network and leverage the UE-VBS Computing infrastructures resources for re-organizing, in real-time, the cellular, Non-Terrestrial Network (NTN) and edge computing infrastructure to meet the demanding Key Performance Indicators (KPIs) set for 6G and tackle the extreme performance requirements of 6G use cases. In addition, this framework is responsible for the joint scheduling of RAN & x-Edge resources that are related to the decisions on the association of the end-user devices and to the radio access points and the edge hosts, as well as for the context-aware prediction to provide support to the orchestration strategies by off-loading tasks from UEs to the network edge.

The **Closed-Loop Functions component** in ADROIT6G architecture addresses the complexities inherent in managing 6G networks by leveraging automation to optimize network and service operations while efficiently utilizing infrastructure resources. These functions are essential for adapting to the dynamic and variable nature of network traffic, devices, and applications in real time, utilizing a zero-touch automation approach that relies on a data-driven methodology. This approach ensures continuous optimization of infrastructure, services, and applications based on monitored data. Note that UE-VBS and BDIx agents are special cases of closed-loop functions.

From the **technological domains** point of view, the ADROIT6G network architecture is expanded to the far-edge, edge, and cloud domains.

- At the **far-edge** domain, located at the device level, we have an essential layer handling data processing and control directly within user equipment. This domain in ADROIT6G enhances network efficiency through reduced latency and increased data throughput, enabled by technologies like BDIx agents and UE-VBS Computing. It transforms traditional cellular frameworks into dynamic and intelligent systems, ensuring the network meets the high demands of 6G technologies with improved connectivity, lower costs, and a flexible structure.
- The **edge** domain in ADROIT6G consists of local data centers catering to specific facilities with the necessary server and network infrastructure to host applications, including 5/6G User Plain Function (UPF) units for ultra-reliable low-latency communications. It also integrates satellite networks to extend coverage and provide additional connectivity for resilience, coverage expansion, and computing placement.
- At the **cloud** domain, ADROIT6G offers dynamic resource allocation and automated network operations essential for supporting varied network service requirements, from consumer applications to industrial IoT. It facilitates efficient data routing and management, optimizing performance and reducing costs.

III. Conclusion

The ADROIT6G project represents a groundbreaking endeavor to create a sustainable, artificial intelligence-driven, cloud-native architecture for 6G.

References

[1] C. Christophorou, I. Ioannou, V. Vassiliou, L. Christofi, J. S. Vardakas, E. E. Seder, C. F. Chiasserini, M. Iordache, C. B. Issaid, I. Markopoulos, G. Franzese, T. Järvet, and C. Verikoukis, "Adroit6g dai-driven open and programmable architecture for 6g networks," 2024.