Air interface design for 5G: a METIS-II perspective

Milos Tesanovic[1], Venkatkumar Venkatasubramanian[2], Malte Schellmann[3], Jamal Bazzi[4], Miltiades C. Filippou[5], Daniel Calabuig[6], Osman Aydin[7], and Caner Kilinc[8]
[1]Samsung Electronics; [2]Nokia Networks; [3]Huawei Technologies ERC; [4]DoCoMo Euro-Labs; [5]Intel Germany GmbH; [6]Universidad Politécnica de Valencia; [7]Nokia Bell Labs; [8]Ericsson

***Abstract*— This paper describes the approach adopted by EU H2020 / 5G-PPP project "METIS-II" for a harmonized 5G air interface (AI) design, based on a suitability assessment framework for 5G AI candidates. The assessment focuses on "harmonization KPIs" and how to measure them (qualitatively / quantitatively). The paper proposes that evaluation of 5G AI candidates should, in addition to performance, include the "extent of harmonization", which is defined in this paper.**

Keywords—5G air interface, User Plane design, RAN architecture, multi-connectivity, 3GPP, METIS-II, 5G-PPP

I. INTRODUCTION

The METIS-II project [1] envisions that a new radio is needed to fulfil all the 5G performance requirements of the envisioned new use cases including some extreme low latency use cases, ultra-reliable transmission and xMBB requiring additional capacity that is only available in very high frequencies, as well as mMTC with extremely densely distributed sensors and very long battery life requirements. Designing an adaptable and flexible 5G Air Interface (AI), which will tackle these use cases while offering native multi-service support, is one of the key challenges in designing a 5G RAN, with far-reaching impact on overall system design. This paper will highlight the challenges of designing an AI to operate in a wide range of spectrum bands and cell sizes, capable of addressing the diverse services with often diverging requirements, and elaborate the concept of harmonization and its proposed role in the assessment framework for 5G AI candidates.

II. 5G AIR INTERFACE: KEY REQUIREMENTS AND DESIGN CHALLENGES

A key question related to the 5G system is how the different AI candidate technologies, including LTE-A evolution, can be integrated into one overall 5G AI, such that this design supports the wide landscape of bands, cell types etc., and such that both the complexity of the standard and that of the implementation are minimized, while the performance of individual technologies is not sacrificed. An adaptable and flexible 5G AI design is therefore required to address these issues while efficiently multiplexing multiple services. An illustration of the required configurability is given in Fig. 1, where it is shown how sub-carrier spacing and TTI length can be varied to suit different data services, spectrum bands, network deployment scenarios and user mobility. METIS-II envisions that the overall 5G AI should ideally be characterized by a large extent of protocol harmonization across the technologies used for different bands, services and cell types. In general, benefits of harmonization include better utilization of available resources due to the flexibility even in short time scales, reduced complexity in the access nodes and the end devices, lower delay in case of switching between AI variants, less standardization and implementation effort and simpler upgrading of an existing system by implementing additional AI variants.

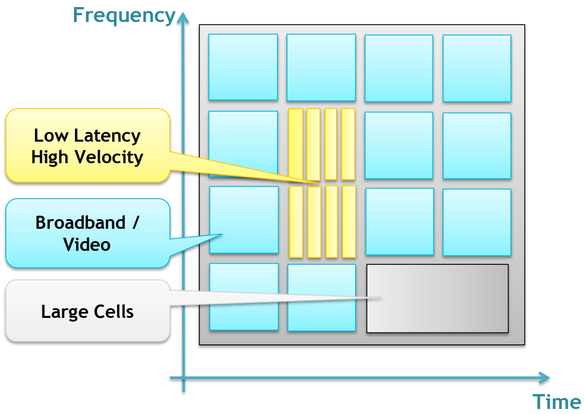

Fig. 1. Example of enhanced AI configurability for multi-service support.

Note that, while a large extent of lower-layer harmonization among novel 5G AI candidates may already be considered in their design phase, the lower-layer harmonization of novel protocols with evolved legacy technology (LTE and beyond) may be challenging or not even desirable; here, the benefits of harmonization have to be weighed against the potential legacy constraints imposed towards the novel 5G AI technology.

The 3GPP activities on AI design are quite comprehensive and well-aligned with ITU timelines. However, the initial 3GPP studies are understandably limited to 3GPP-prescribed use cases and prioritise OFDM-based waveforms. Additionally, they are constrained by the requirement of tight interworking between the new RAT and LTE from the outset, whereas there exists consensus in METIS-II that the newly designed 5G AI should not be constrained to be backwards compatible with LTE-A. METIS-II also additionally envisions that future proofness needs to be guaranteed. Therefore, it should be clear that the METIS-II 5G AI framework takes into account and expands the current considerations in 3GPP; while current 3GPP study and work items focus on specific aspects such as numerology details, in METIS-II we explore a comprehensive integrated system. Additionally, assessment methodologies put forward in this paper are of broader scope than those developed within standardization activities, such as the ones in 3GPP. In what follows, the key METIS-II concept of a harmonized AI design is explained in further detail.

III. METIS-II CONCEPT OF AI HARMONIZATION

Key METIS-II AI design principles have been outlined elsewhere [2]. In addition, different specific proposals for the overall 5G AI design are being developed within METIS-II [2], but also within other 5G Infrastructure Public Private Partnership (5G-PPP) projects, standardization bodies, and elsewhere. These different proposals contain different levels of harmonization. Some alternatives rely on the harmonization of the lower layers, while other solutions rely on the harmonization of the higher layer protocols (with a higher differentiation at lower layers). Each METIS-II proposal currently under study is a single framework comprised of multiple AI components selected to fulfill the performance of the different use cases and scenarios as depicted in Fig. 2. Such harmonization alternatives could each have several (potentially different) benefits. In order to evaluate the degree of these benefits contained in different proposals, harmonization KPIs have been defined so that not only performance but other equally important aspects (e.g., cost and complexity as well as switching delay) are taken into account in when assessing the relative suitability of different proposals as 5G AI candidates. These harmonization KPIs are:

- Ability to dynamically utilize radio resources: This KPI assesses in which time scale the proposed AI can utilize the frequency bands in a given location.
- Support of User Plane (UP) aggregation: This KPI assesses the degree of ability to aggregate multiple AI components on different layers of the protocol stack to support UP aggregation.
- Ability to reuse SW and HW components among components of new AI: This KPI assesses the ability to reuse SW and HW components by the different AI components / instantiations, for both the UE and the network equipment.
- Standardization effort and product development of AI proposals (time to market): This KPI assesses the amount of work needed to standardize and develop the different AI proposals.
- Ability to integrate new AI proposals with LTE-A: This KPI assesses the ability a proposal has to integrate with LTE-A, using the KPIs explained above. Within METIS-II there is a consensus that LTE and 5G radio would likely be integrated on PDCP/RRC level.
- Forward compatibility: This KPI assesses the ability of efficiently introducing new features and services in the future without the need for re-designing the AI.

Beyond harmonization, METIS-II will also investigate to which extent UP instances related to different bands can be logically aggregated on certain layers, and beyond which layer there would be a single Control Plane (CP) instance. Different AI design proposals may offer different support of CP features, which needs to be considered.

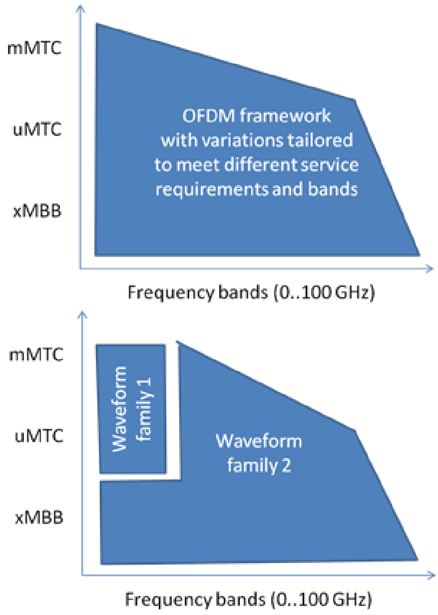

Fig. 2. Examples of potential overall 5G AI landscapes.

IV. CONCLUSIONS AND FUTURE WORK

This paper discussed the topical issue of 5G AI design and how the METIS-II project approaches this pivotal component of overall 5G RAN design. Key focus was on the extent of harmonization across underpinning components in overall AI considerations, which was defined in this paper as a combination of features such as utilization of radio resources, implementation complexity, standardization effort, forward compatibility, and interaction with legacy systems. Additional criteria include UP-related design principles, and requirements posed from CP considerations. Initial thoughts and concepts presented in this paper will now be further studied and elaborated with a view to shaping the technical and economic trade-offs to be taken into account when assessing new AI technologies.

Acknowledgment

This work has been performed in the framework of the H2020 project METIS-II co-funded by the EU. This information reflects the consortium’s view, but the consortium is not liable for any use that may be made of any of the information contained therein.

References

[1] METIS-II Project (“Mobile and wireless communications Enablers for the Twenty-twenty Information Society II”), https://metis-ii.5g-ppp.eu/

[2] M. Tesanovic, M. Schellmann, P. Weitkemper, D. Calabuig, O. Aydin, C. Kilinc, V. Venkatasubramanian, “Towards a flexible harmonized 5G air interface with multi-service, multi-connectivity support”, Proc. ETSI workshop on Future Radio Technologies – Air Interfaces, Sophia-Antipolis, January 2016.