Interference Management for 5G
A METIS-II Perspective

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***Abstract*—This paper provides highlights on the envisioned interference management framework for 5G RAN, which is pursued by 5G PPP METIS-II project. In this framework, factors like the expected high density of access nodes reusing the same spectrum, the diverse sources of interference from heterogeneous access technologies and the consideration of multiple 5G services with different KPIs can have strong impact on the user's performance. To this end, three key interference management drivers are discussed, which aim improving users' performance in terms of cell-edge throughput, provide energy-efficiency aware resource management and minimize the signalling overhead using BS clustering and context-awareness.**

Keywords—5G; Interference Management; Energy Efficiency; METIS-II

I. Introduction

In fifth generation (5G) radio access networks (RANs), new challenges in terms of interference will arise mainly due to the employment of ultra-dense networks (UDNs). Furthermore, numerous other factors will strongly affect the way interference management is handled, e.g. the wide usage of beam-forming, the uplink/downlink (UL/DL) cross-interference in case of dynamic time-division duplex (TDD), novel modes of communication (e.g., self-backhauling, and cellular assisted device-to-device, D2D), and more diverse and stringent application requirements, e.g., latency-critical applications. It is, thus, required to develop an interference management functionality block that natively supports the new communication variants and effectively satisfies very different and demanding performance requirements.

Interference management in current cellular networks has been extensively studied in literature [1]. Various power control techniques have also been developed to provide enhanced performance within the network. In Long-Term Evolution-Advanced (LTE-Advanced) networks, such mechanisms were mainly studied and standardized from an UL perspective with a particular focus on keeping the receiver dynamic range below a pre-determined level [1] [2]. Nevertheless, in the case of ultra-dense deployments of access nodes in 5G networks, interference management schemes are gaining even more relevance and shall be tailored for the dynamic operation envisioned in such networks [3].

In addition, 5G RAN is expected to operate on various bands (below and above 6 GHz) and support various 5G services with wide range of requirements. Further, RAN moderation will imply dynamic radio topologies [4], e.g., activation/deactivation of nomadic access nodes (NNs) to attain on-demand network densification for coverage and capacity enhancement [5]. To this end, special focus of interference management will be on reducing the overhead and signaling required (e.g., with context aware mechanisms), while keeping energy efficiency high (e.g. by dynamically switching off small cells).

II. Envisioned Interference management framework

A. Overview of technologies

As mentioned above, there are many challenges for a future 5G RAN with respect to interference avoidance and management and the coordination of multiple transmit and receive points. For example, new traffic types for machine-type communications (MTC) will generate short to very short bursts of data and will require novel concepts and mechanisms for the interference management. In addition, towards the dynamic small cell deployment, moving relays are assumed considering the possibility of implementing full-duplex operation using different frequency bands for the backhaul link and access link, for relaxing the scheduling burden for certain delay-sensitive services.

In 5G RAN, one key RAN functionality framework, which is aimed to construct the agile resource management (RM) framework [3], is the Interference Management functional block. The agile RM framework aims at the efficient and effective mapping of resources to diverse services and applications in the complex 5G landscape, which includes different deployments, use cases and novel communication modes, e.g., various D2D communication modes. The highlights of the envisioned agile RM framework will also be discussed in the EuCNC presentation.

Interference Management in this paper can be grouped in three different classes, given the different objectives they aim to solve. That is,

- **Enhancing cell-edge throughput** by either using cooperative nomadic nodes in hotspot areas or by creating "interference-free" zones to enhance cell edge performance.
- **Enhancing energy efficiency** by dynamically switching on/off small cells, while providing coordinated multi-

point transmission and reception (CoMP) mechanisms to deal with the potential user's performance degradation and the load increase at the surrounding cells.

- **Reducing overhead** by clustering small cells and performing intra and inter-cluster CoMP mechanisms.

Figure 1 illustrates an overview of the proposed interference management technologies in a realistic Madrid grid, which can be seen as a toolbox of solutions that can adhere by the requirements of different use cases and deployments.

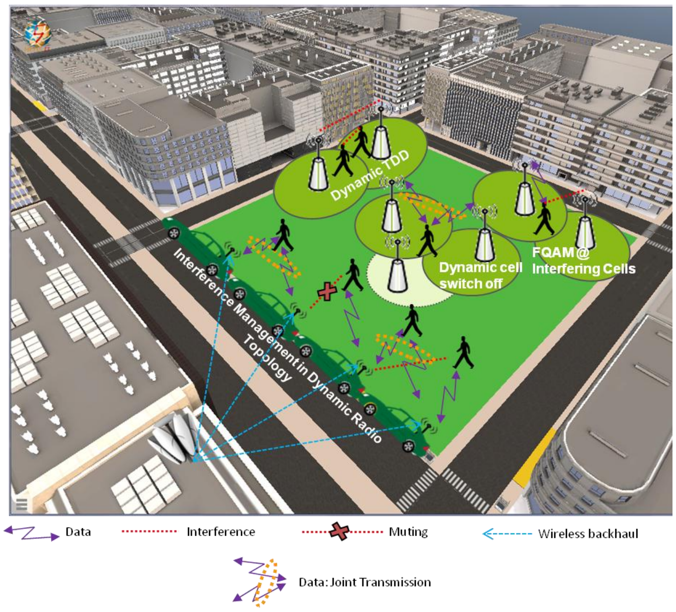

Figure 1 Interference management technologies for 5G

B. Measurements and Context Infomation

In addition, the measurement aspects are of key importance, since the context information required from multiple sources (e.g., user equipment, UE) needs to be identified for the above interference management solutions. Also, the challenges pertaining to 5G RAN deployments shall be rigorously captured and mechanisms reducing the overall overhead should be developed to cope with the expected high access node density and heterogeneity.

ITU-R WP5D, Revision 2 to Document 5D/TEMP/469-E, Chapter 5.3.8 defines context awareness as delivering context information in real-time on the network, devices, applications, the user and his environment to application and network layers in the context of IMT-2020. This context could be classified as device level (e.g., battery state and, processing load), user level (e.g., quality of experience preferences, activities, location, and mobility status), environment level (e.g., devices in neighborhood, topology, background activities, and weather) and network level (e.g., load, throughputs, reliability, supported radio technologies, interference and spectrum availability) context. The context data are gathered by UE and base station (BS), and then they are sent to specific databases in the network and exploited by extended and new radio management algorithms. New fast radio management for the efficient control of spectrum resources anticipated in 5G air interfaces (AI) will have notable impact on UE and BS measurements.

Fast resource and interference management including power control and incorporating context awareness has been explored and standardized for cellular networks. However, in heterogeneous 5G networks deploying dense and widespread small cells, there are still many challenges, especially in the exploitation of user data for radio resource allocation. The amount of data to be gathered and the complexity of resource management algorithms need to be tracked carefully between the network performance enhancements they make available and the load they impose on both the BS and the UE in terms of data gathering, signaling, processing and storage. For example, since multiple use cases possibly with contradicting key performance indicators (KPIs) are identified in 5G, different air interface variants (AIVs) may be used in different use cases. Besides, the carrier aggregation among the same AIV and across different AIV also makes the context data management a very challenging task for UE because of the stringent requirements on battery life and latency.

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