Point to Multipoint at Millimetre Waves Above 90 GHz

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***Abstract*—The Point to multipoint wireless distribution is the most effective and affordable modality to deliver data to a high number of terminals distributed randomly in a wide area. The use of high density small cells, mandatory to increase the throughput per users, maintaining terminals at sub-6 GHz frequency, needs capillary backhaul networks that fibers cannot effectively provide. The TWEETHER project for point to multipoint at W-band is opening the route to a new generation of millimeter wave wireless networks for an affordable and easy to deploy backhaul and access with high capacity. The perspectives offered by the full millimeter wave spectrum provide a solution to the increasing data rate request.**

Keywords—millimeter waves; access; TWEETHER; TWT; point to multipoint.

I. INTRODUCTION

Point to multipoint (PmP) is the most effective wireless distribution modality for serving a high number of terminals [1, 2]. It is commonly used at microwave frequencies from base stations to mobile handsets. At microwave frequencies, the low atmosphere attenuation, high diffraction, high penetration through walls and many other obstacles, no Line of Sight (No LOS) propagation and high power available at the transmission hub, are the features that allowed to build and deploy affordable and wide radius cells.

The limited spectrum available, unfortunately, does not permit to support the extraordinary increase of traffic with adequate Quality of Service, that already needs capacity density at multigigabit level per kilometer square. The only option to overcome the narrow microwave bands is the densification of cells, reducing their radius to serve less users with more capacity per user. For the purpose, the sub-6 GHz technology is suitable, very low cost and the MIMO could provide further spectral efficiency to the architecture [3 – 5].

The unsolved question for the implementation of high density cell architectures is the backhaul. Backhaul is very critical in urban environment where the constraints to deploy cables and fiber pose high costs and long time of execution. It is also critical in low density area, where the fiber is too expensive to be deployed. It has been already extensively demonstrated that millimeter wave frequencies, including the 28 GHz band will offer the most effective and affordable solutions to the small cell backhaul. The Point to point (PtP) systems are already available (V-band, E-band and D-band in testing phase) [6 - 8]. PmP systems have been recently introduced at Q-band [2].

The H2020 TWEETHER is the first project to bring the PmP above the 90 GHz [9, 10]. The 3-GHz bandwidth available in the range 92 – 95 GHz permits to achieve a capacity density of about 10 Gbps/km^2. The technology developed in TWEETHER project will open the exploitation of the W-band with a new backhaul paradigm and the foster the future electronics for the wide bands available up to the 300 GHz range [11].

II. CHALLENGES AND OPPORTUNITIES

A. Attenuation

The atmosphere is the main obstacle to the Point to multipoint distribution. In principle, with clear and dry sky the attenuation per kilometer is not so different from microwave range. The increase of attenuation of 20-30 dB in rain condition strongly affects the availability. ACM can mitigate this lowering the modulation order in rain condition, but the required transmission power is still too high for the available technology. The TWEETHER project addresses the quest by adopting a high power traveling wave tube (TWT). TWTs are the only devices, so far, capable to produce power at ten of Watt level at millimeter waves [12].

Presently, no technological option is available to enable PmP at frequency higher than the W-band.

On the other side, the attenuation has the relevant advantage to permit an effective frequency reuse that will substantially improve the spectrum usage.

B. Bandwidth

The wide frequency range, 90 - 370 GHz, not yet exploited, includes several sub-bands centered at 140 GHz, 240 GHz and 300 GHz with tens of GHz available for PmP and PtP. While experiments in PtP were already performed demonstrating high data rate up to 40 Gbps above 100 GHz, the very short range achieved, makes the PtP not yet usable for long outdoors links.

The range limitation is much more severe for PmP. The vacuum electronics is so far the only technology to enable PtP and PmP above 90 GHz. However, the exploitation of the full

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millimeter wave portion of the spectrum would permit to satisfy the capacity needs for most of the future scenarios.

III. Architecture

A three Tier architecture is the most effective and simple for the new generation networks. The Tier 1 is the fiber infrastructure, the Tier 3 is the LTE layer. The Tier 2 is the backhaul tier. The TWEETHER system is the first response to a multigigabit per second PmP to build a Tier 2 to effectively

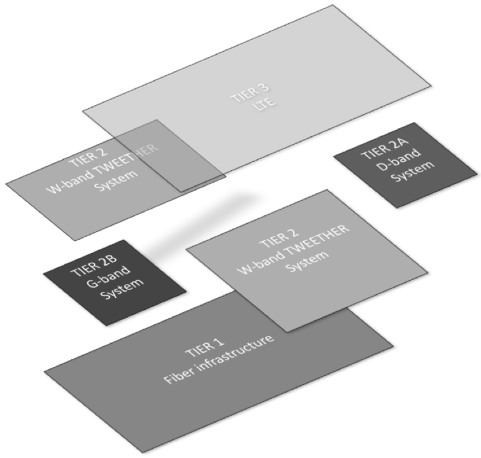

Fig. 1. Three Tiers architecture.

transfer tens of gigabit per kilometer square from Tier 1 to Tier 2. The technology for the Transmission Hub and the NTE Terminal is in the final phase of development in the W-band (92 – 95 GHz). The operational target of the system is to cover circular sector with radius longer than 1 km, and aperture up to 90º, to feed tens of Point of Presence per sector, with 99.99% availability in ITU zone up to K.

The advancements of the millimeter wave technology of TWEETHER will demonstrate that with a proper equipment higher frequency bands can be considered for Tier2, complementary to the W-band, both for PtP and PmP. This will permit to create sub tiers to provide extremely high capacity where needed, with flexible and affordable systems (Fig. 1). A substantial technology development is needed. The feasibility and potential costs will be the key parameters for the future exploitation of the millimeter wave bands.

IV. Conclusions

The substantial advancement in the technology for W-band in PmP and the availability of the first systems at D band pose a solid pillar in the evolution of millimeter wave networks for access and backhaul. The challenges are to improve the technology and make it accessible to the market of operators for a wide deployment.

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