W-band point to multipoint system for small cells backhaul

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***Abstract*— The backhaul of high density small cell networks is one of the main applications of the wireless system under development in the frame of the Horizon 2020 TWEETHER project. The challenge is to provide multigigabit backhaul with an affordable and flexible network to avoid the high deployment cost of the fiber. The 3-GHz bandwidth available at W-band (92 – 95 GHz) is suitable for the purpose while being light licensing for Point to Multipoint communications. The high atmospheric attenuation at this frequency band is overcome by using a high power Traveling Wave Tube purposely fabricated to be integrated in the transmission hub.**

Keywords—TWEETHER, W-band, point to multipoint, traveling wave tube, 5G, access, backhaul

I. INTRODUCTION

The 4G architecture now and the 5G architecture tomorrow have to be built by deploying large number of small cells in the sub-6 GHz band to provide the high data rate required by the growing end-user demand for more bandwidth-intensive mobile services [1]. To meet this demand, it is predicted to use a wide range of cell radius of about 50 – 300 meters with a capacity of up to 300 Mbps. The proliferation of small cells has to be supported by a capillary backhaul network. Further, the backhaul network should be flexible to accommodate eventual reconfigured distribution of small cells. These features pose a challenge on the backhaul implementation to cost-effectively provide capacity at multigigabit level. The fiber, where available, is the best solution. However, the time and cost of deployment of the fiber infrastructure could be not compatible with the fast growing small cell network scenario. Wireless backhaul is, in principle, the most affordable and flexible solution for the new high density small cell architectures. To be effective, these architectures has to satisfy the following constraints:

- Wide frequency band to support multigigabit transmission
- Distribution in point to multipoint (PmP) to permit an arbitrary and flexible allocation of the small cells in the covered area
- Low footprint of the transmission hub for easy installation and low-cost site leasing
- Easy pointing for a fast and reliable installation.

The region of the spectrum from 50 GHz to 250 GHz, includes a number of wide frequency bands suitable for wireless communications [2, 3]. Most of the frequencies below 100 GHz are already regulated and some of them, as in case of the E-band (70 – 84 GHz), are available only for Point to Point (PtP).

The W-band (92 – 95 GHz) is still unexploited and represents a very promising band for PmP distribution. Among the advantages of operating in this region, it is the short wavelength that requires small antennas and consequently permits to achieve an overall small footprint of the transmission hub and the terminal, and thus simplifying the installation.

While PtP wireless systems are already available, most at V-band and E-band [4], the high atmospheric attenuation is still

an insurmountable barrier for a PmP distribution (Fig. 1). The available power amplifiers at millimeter waves do not provide the power level to feed a low gain, wide aperture antenna required to cover a wide area.

The Horizon 2020 TWEETHER "Traveling wave tube based W-band wireless network with high data rate, distribution, spectrum and energy efficiency" [5] project aims to foster a new concept in millimeter wave wireless networks enabling Point to multipoint (PmP) distribution at W-band with power level comparable to the microwave range by integrating a high power Traveling Wave Tube (TWT) in the transmission hub.

A Consortium of nine European partners, Lancaster University in UK, Thales Electron Device, Bowen, OMMIC and Telecom ParisTech in France, HFSE and Goethe University of Frankfurt in Germany, Universitat Politecnica de Valencia and Fibernova in Spain, comprises the wide breadth of expertise to succeed in the realization of the first PmP system at W-band.

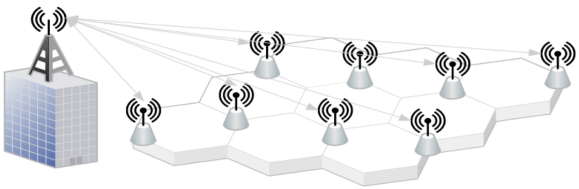

Fig. 1. Small cell wireless backhaul

II. SMALL CELLS BACKHAUL

The TWEETHER W-band system is considered part of a three tier architecture: fiber, capacity distribution, users. In particular, the TWEETHER system addresses the connecting tier between the fiber infrastructure and the user tier, whose capacity can be tailored according to several parameters such as the density of users, the area to cover, the range for a given availability, and the raining zone.

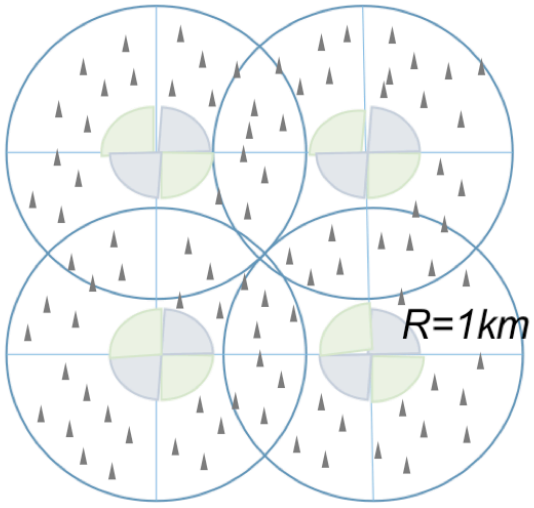

Fig. 2 Four sector architecture for dense small cell coverage

The TWEETHER target is to provide a capacity of up to 10 Gigabits/km^2 with full flexibility in terms of cell distribution in the coverage area. Each transmission hub (TH) can cover different sectors with different apertures, making the system modular and flexible. As an example, Fig.2 shows the case of a coverage area of 10 km^2 with sixteen sectors. For each TH, four TWTs are used, one for each sector.

The first year of activity of the project was devoted to study a wide range of deployment scenarios to define the potentiality and verify the full exploitation of the TWEETHER system from the point of view of the operator. The design and fabrication of the numerous components is in progress.

The first prototype of the Traveling Wave Tube has been designed. A number of samples of the metal interaction structure at W-band have been fabricated and measured. The low power circuits, based on chips on GaAs technology, have been designed, fabricated, measured and re-designed to achieve the system specifications.

A specific study on the breadboard assembly and the housing of the system is in progress.

III. CONCLUSIONS

The TWEETHER project is bringing a breakthrough in the backhaul field enabling wireless high capacity backhaul at millimeter wave frequencies. The high technological challenge and the need of an affordable system, are tackled by a consortium with the widest range of expertise in the numerous aspects of the project.

IV. ACKNOWLEDGMENT

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REFERENCES

[1] R. Vilar, J. Martí and F. Magne, "Point to multipoint wireless backhaul systems for cost-effective small cell deployment," *European Microwave Conference (EuMC) 2015*, Paris, 2015, pp. 1092-1095.

[2] J. Takeuchi, et. al. "10-Gbit/s Bi-directional wireless data transmission system using 120-GHz-band ortho-mode transducers," in *2012 IEEE Radio and Wireless Symposium*, 2012, pp. 63–66.A.

[3] I. Kallfass, et al. "All Active MMIC-Based Wireless Communication at 220 GHz," *IEEE Transactions on Terahertz Science and Technology*, vol. 1, no. 2, pp. 477–487, Nov. 2011.

[4] C. Colombo; M. Cirigliano "Next-generation access network: A wireless network using E-band Radio frequency (71–86 Ghz) to provide wideband connectivity," in *Bell Labs Technical Journal*, vol.16, no.1, pp.187-205, June 2011

[5] TWEETHER website [Online]. Available: http://www.tweether.eu

[6] C. Paoloni, R. Letizia, F. Andre, S. Kohler, F. Magne, M. Rocchi, M. Marilier, R. Zimmerman, V. Krozer, G. Ulisse, A. Ramirez, R. Vilar " W-band TWTs for New Generation High Capacity Wireless Networks," Proc. IEEE International Vacuum Electronic Conference 2016, April 2016, Montery USA