INDOOR WIRELESS TO 5G: FROM DAS TO SMALL CELLS

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1. EXECUTIVE OVERVIEW

As wireless systems continuously evolve to include new features, offer performance improvements, and enable new use cases, the Radio Access Network (RAN) must undergo changes in architecture and topology, as well as incorporate upgrades to new technologies, while remaining backward compatible with existing technologies. The RAN of the future must migrate to a very high throughput, ultra-dense, multi-technology Heterogeneous Network (HetNet).

To accomplish this without increasing Total Cost of Ownership (TCO), network architects are adopting techniques such as Network Functions Virtualization (NFV), Software-Defined Networking (SDN), Multi-Access Edge Computing (MEC), and changing system partitioning and modernizing fronthaul protocols to transport the very high throughput traffic levels anticipated in 5G systems.

While this holds true for outdoor mobile networks, it is in the indoor space where most mobile traffic originates that special additional consideration must be given to overcome the challenges specific to in-building wireless.

In this report, ABI Research examines the implications to the design of in-building systems, which are necessary to seamlessly handle this very high throughput, ultra-dense, multi-technology HetNet. ABI Research outlines existing 4G and Wi-Fi, and the upcoming 5G, OnGo, and MulteFire technologies that will impact in-building wireless systems soon.

ABI Research examines in-building system types, including repeaters, small cells, Distributed Antenna Systems (DASs), and Distributed Radio Systems (DRSs), and discusses these systems' architectures and topologies, spectrum and signal propagation, transport or fronthaul, and antenna configurations.

Leveraging virtualization, many DASs will evolve from the current Centralized RAN (CRAN) architecture to a DRS architecture. In parallel, many small cell architectures will also leverage virtualization to become DRSs. These trends will have the effect of reducing system costs so that DASs can be economically deployed in buildings with smaller floor areas than before. Similarly, small cell systems can become viable for larger floor area deployments than is currently the case for many systems.

These architecture changes come with a set of challenges that many vendors and system integrators must tackle. Virtualization increases throughput and latency demand on the connection between the radio unit and the virtualized or centralized digital unit. This fronthaul connection is the subject of many specification initiatives and is currently at risk of fragmentation, which may limit uptake. The increasing adoption of DRS, the emergence of multiple technologies, and the proposal of multiple fronthaul specifications are the main updates in this report from ABI Research's previous report on the topic in March 2017.

ABI Research also found that the advent of 5G in mid-band and high-band will drive more investment in in-building wireless systems, as these signals do not easily penetrate indoors from outside and a high Signal-to-Interference-Plus-Noise Ratio (SINR) is required whether for the current Long-Term Evolution (LTE) RAN or the 5G RAN to meet high throughput goals. However, for millimeter wave 5G, a short-range Line of Sight (LOS) link is best, and reliance on multipath effects and signal processing may be challenging.

As throughput rates increase from the convergence of these new technologies, the in-building system's transport network must evolve to handle these data rates. This means that there will be an increasing penetration of fiber in the building as the transport network evolves to meet these demands and legacy passive DAS systems are no longer compatible with the modern and evolving RAN.

The increasing adoption of high order Multiple Input, Multiple Output (MIMO) antennas will place limitations on the in-building RAN because each antenna requires its own Radio Frequency (RF) chain and transport. In-building DASs will likely be limited to 4X4 MIMO arrangements for sub-6 Gigahertz (GHz) propagation. The advent of massive MIMO in the 5G RAN will only be possible for millimeter wave bands inside buildings and this dictates that real-time beam management be done in the radio unit, potentially undoing any TCO benefits resulting from virtualization.

2. INTRODUCTION

Next-gen 5G RAN will shift basestation functionality to a COTS server in a data center with a small footprint, lowering energy consumption, and facilitating and simplifying network management and operation

The imminent rollout of 5G transforms mobile networks to next-generation, virtualized, multi-technology, and future-proof ultra-dense HetNets underpinned by state-of-the-art fronthaul. The advent of RAN Virtualization (VRAN) will have a fundamental role to play as the distinction between small cells and DAS blurs. In-building systems in the 5G era will offer virtualization hosted in a telecommunications data center connected over fronthaul to Access Points (APs) or radio units many kilometers distant from the data center. This next-generation 5G RAN will shift basestation functionality to a Commercial-off-the-Shelf (COTS) server in a data center that occupies a small footprint, lowers energy consumption, and facilitates and simplifies network management and operation. Using the concepts of NFV and SDN, simplified and virtualized mobile networks will also lead to new innovative use cases and business models.

In-building wireless systems are ideally suited to leverage virtualization for RF distribution indoors because these locations represent a relatively constrained environment where many factors can be controlled by the system integrator/designer. Impacts to RF propagation present in the outdoor environment, such as signal attenuation due to weather or foliage, do not exist. RF signal blocking present outdoors due to changing signal propagation paths, such as moving traffic, also do not exist. These factors mean that the indoor environment is relatively static, resulting in decreased RF signal degradation and improved system performance.

As 5G heads to new mid-band sub-6 GHz and high-band millimeter wave spectrum, new in-building wireless challenges will arise. The signal propagation characteristics at these frequencies will demand innovative antenna and signal processing to ensure the throughput demand is matched to the capability of the fronthaul. Next-generation fronthaul transport protocols, coupled with baseband decomposition into real-time and non-real-time functions, will underpin the evolution to the 5G RAN. Network topology, fronthaul transport, spectrum and signal propagation, and antenna design are all among the challenges that will be tackled as in-building wireless moves into the 5G era.

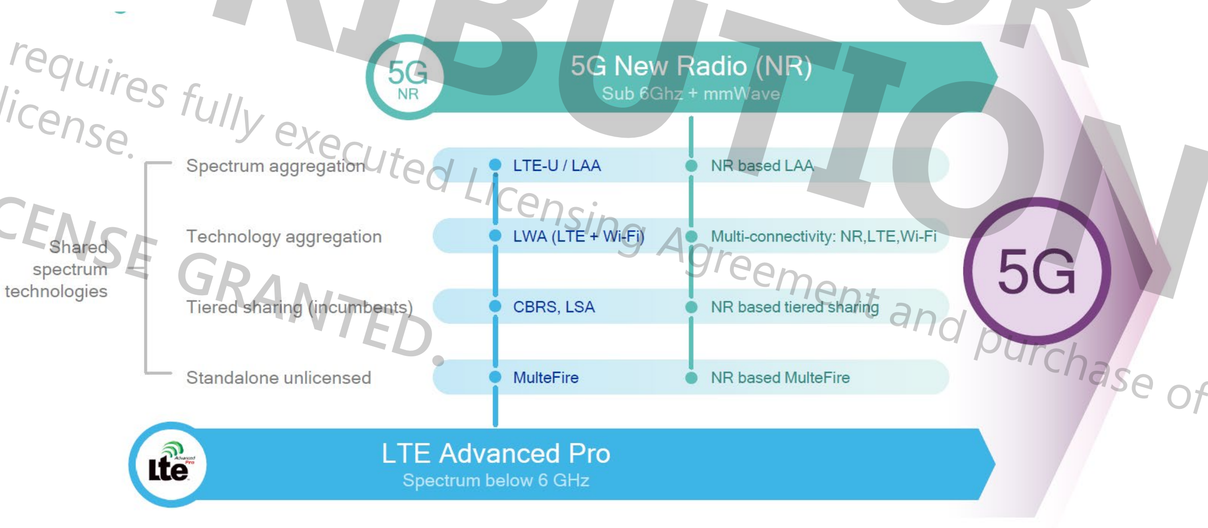
3. THE INDOOR WIRELESS RAN

The 3GPP is continuing work on defining 5G NR in Releases 16 and 17 and will add more features

The 3GPP has defined 5G New Radio (NR) in Release 15 for both Non-Stand-Alone (NSA) and Stand-Alone (SA) architectures, and work continues for Releases 16 and 17, which will see the additional of more features. It is important to note that 5G builds on previous 3GPP releases and that LTE serves a critical role in supporting 5G. 5G NR is designed to be compatible across a wide range of licensed, unlicensed, and shared spectrum technologies from low bands below 1 GHz, to mid bands from 1 GHz to 6 GHz, to the high band millimeter wave and centimeter wave bands. In Figure 1 below, Qualcomm has illustrated its vision of the 5G RAN.

Figure 1: 5G HetNet Concept

(Source: Qualcomm)



3.1. 4G

The most recent iteration of LTE is LTE-Advanced Pro embodied in 3GPP Releases 13/14, which incorporates carrier aggregation, with up to 42 different carrier combinations, higher order modulation and MIMO antenna techniques. These techniques will become an increasingly important part of Mobile Network Operators' (MNOs) options in the evolution to 5G. Under continuous pressure to boost data throughput, MNOs will first upgrade to 256 Quadrature Amplitude Modulation (QAM). MIMO will be