Maximizing 5G's Potential with Scalable, Intelligent, and Heterogeneous Computing

Harpinder Matharu, Sr Director Technical Marketing, Wired and Wireless Group at Xilinx

As 5G commercialization continues to take hold, anticipation is building for what 5G could mean for our increasingly connected world. Indeed, over the next decade we expect to see consumers, businesses, and the economy transformed by 5G's capabilities as the technology is deployed more widely. Despite the transformative potential, issues such as performance, power, coverage and cost present roadblocks that could hinder deployment and application of the 5G network.

Addressing the Challenges

When looking at performance, the sub 6GHz massive MIMO radio (32T32R and 64T64R) in the mid bands is the dominant form factor being deployed for the beam centric 5G NR across the globe. While field results have shown promising improvements, particularly for downlink throughput, performance has been below expectations. Additionally, power, coverage and cost are other issues that need to be resolved. Plus, uplink performance has been poor for UEs residing in the cell edge.

Operators and the system OEMs have learnt valuable lessons from the first wave of 5G NR deployments and are making several improvements in next generation 5G NR system design to overcome these issues. The cross-layer co-optimization between the scheduler (MAC layer) and beamforming (Low PHY), improved functional partitioning for more optimal beamforming management and applications of machine learning (ML) algorithms are some of the leading areas of study and implementation. Adoption of more efficient GaN power amplifiers, improvements in the power amplifier linearization algorithms and integration of digital and ADC/DAC functions are the leading development vectors to reduce power and lower cost of the 5G NR massive MIMO antenna panels.

It is important to remember that we are still in the early phase of 5G NR commercial rollout. Enhanced mobile broadband is the leading use case to address the rapidly growing bandwidth demand in the mobile networks. The disruptive service based 5G core architecture is non-existent in the current deployments. As 5G deployments move from non-Standalone mode (anchoring on LTE for control signaling) to Standalone mode, we will see the emergence of a service based 5G core network. The shift to a 5G core network would accelerate the emergence of new applications and use cases. This shift in turn would put further requirements on 5G NR base stations in terms of latency, throughput and reliability. The ability of the installed base of the 5G NR base stations to adapt to the emerging requirements over the next 3-5 years would be crucial to deploy new services.

Changing Needs of Operators

Certainly, next generation 5G equipment requirements have evolved with more operators planning deployments. The occupied bandwidth is doubling from a typical system bandwidth of 100MHz to 200MHz. The number of carriers and carrier combinations are also going up. And, digital front end is targeting much higher bandwidth for sub 6GHz radios.

Typical bandwidth requirements in the next generation 5G systems for mid bands or C band is 400MHz instantaneous bandwidth with occupied bandwidth of 200MHz. This is to enable multi operator equipment sharing as well as to reduce system SKUs to address customer requirements across different countries. New PA technologies are being considered for wide bandwidth radios, particularly GaN PAs to boost power efficiency by another 5-10%. Linearizing or digital predistortion of these systems is much more complex and compute intensive. While all these changes are being implemented, it is mandatory to keep the power footprint same per MHz of the spectrum.

Maximizing 5G Network Potential

For operators who are building 5G networks, the sub 6GHz mid band beam centric 5G NR massive MIMO systems deliver much higher cell capacity along with the unique ability to direct capacity where it is needed. The macro radios in the low band have high coverage characteristics. Mobile network comprising of well-coordinated high capacity sub 6GHz massive MIMO systems and low band macro radios with large coverage area would be an ideal combination to offer scale, performance and cost-effective service rollout.

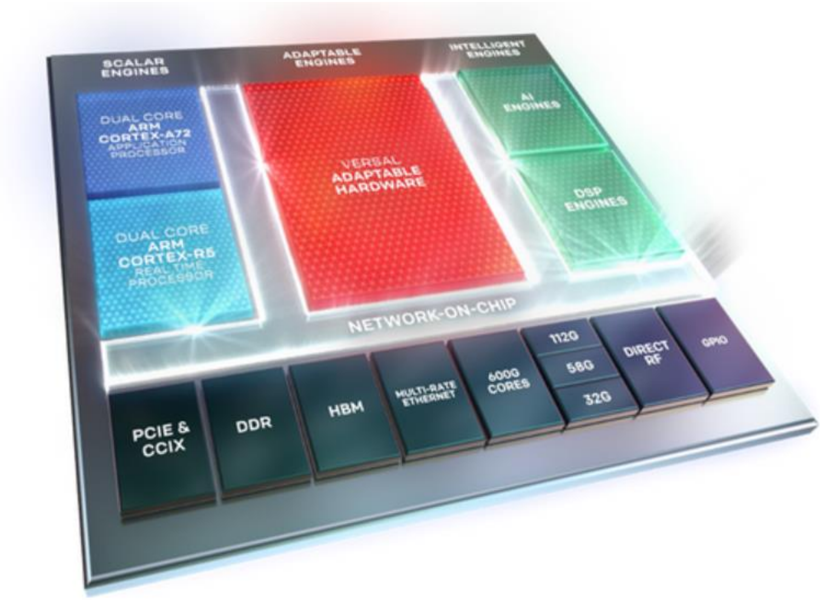
To maximize network potential, 5G baseband systems need to be intelligent, with AI/ML algorithms, to make radios work in a well-coordinated way and to maximize performance per each radio node while efficiently load balancing traffic across these nodes. In addition, 5G mmWave radios could be deployed in addition to the sub 6GHz network at locations where high capacity is needed, and the radio environment is well suited for mmWave propagation. The 5G mmWave radios are in early trials and deployment in some parts of the world. This technology is expected to improve within the next few years to offer the lowest cost of data capacity at several sites within mobile networks. Importantly, as the 5G core network is yet to be deployed, many new services and associated requirements will surface in coming years. It is crucial to have adaptable radios and baseband systems to accommodate these future requirements in the field to preserve and maximize returns on the CAPEX spent, while not missing on revenue streams on future 5G services.

Advancing Next Generation 5G Networks

As the industry sets its sights on the next-gen 5G networks, flexible, standards-based solution that combines software programmability, real-time processing, hardware optimization and any-to-any connectivity with the security and safety are needed. This will enable wireless system vendors to rapidly design, innovate and differentiate their solutions, with ease of field upgrades and significant TTM advantages.

Need for Adaptive Computing

With 5G infrastructure requirements and industry specifications still evolving, there is a strong need for the adaptive computing. The Xilinx 7nm Versal™ Adaptive Compute Acceleration Platform (ACAP), a new category of heterogeneous compute devices, is designed to address the requirements of next generation 5G equipment. The highly-integrated, multicore, heterogeneous compute platform operates at the heart of 5G to perform the complex, real-time signal processing, including the sophisticated beamforming techniques used to increase network capacity.



5G requires beamforming and this entails significant compute density and advanced high-speed connectivity – on-chip and off-chip – to meet 5G's low-latency requirements. Adding to this, different system functional partition requirements and algorithm implementations lead to a wide range of processing performance and compute precision. It is extremely challenging for traditional FPGAs to optimally address this requirement while meeting thermal and system footprint constraints. Versal ACAPs offer exceptional compute density at low power consumption to perform the real-time, low-latency signal processing demanded by beamforming algorithms. The AI Engines, which are part of the Versal AI Core series, are ideal for implementing the required mathematical functions and offer high compute density, advanced connectivity, as well as the ability to be reprogrammed and reconfigured even after deployment.

Future 5G Networks

Looking forward, 5G networks need to be more scalable, intelligent, and heterogeneous. Technologies such as distributed small cells, massive-MIMO with hundreds of antennas, and centralized base-band processing via CloudRAN, will dramatically increase coverage and data throughput. Networks will need to connect securely through backhaul and optical fronthaul for processing. And, to ensure 5G can meet its true potential, operators and wireless infrastructure manufacturers need to leverage technology that can solve capacity, connectivity, and performance challenges, while also offering flexibility to support multiple standards, multiple bands and multiple sub-networks that enable diverse use cases and applications of 5G.