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TURNING 5G VISIONS INTO REALITY

2019 is shaping up to be a huge year for 5G, potentially the tipping point for all of the standardization work, technology development, spectrum auctions and refining of use cases that has come before. The transition from field trials to initial commercial deployments is happening and 5G mmW networks are turned on.

That started to become clear in late 2018, as Verizon rolled out a 5G fixed wireless service and AT&T activated its 5G network coverage in 12 markets.

More recently, the Federal Communications Commission's millimeter-wave spectrum auction ramped up, drawing more than $700 million in bids by mid-January. The next steps will play out in the coming months, as all the major U.S. carriers and many others abroad likely will be making bigger announcements about their timing for broader 5G availability.

"It's absolutely a critical year for 5G," said Joe Madden, principal analyst at Mobile Experts.

"There is going to be a lot of marketing confusion at the beginning that will start to get sorted out, and from a technical point of view, a lot of carriers are completing field trials and sorting out the technical issues that will allow them to deploy thousands of base stations."

In crossing the frontier that lies between 5G visions and reality, the industry passes an evolutionary milestone. The potential of 5G is tremendously exciting—much higher capacity networks enabling applications like fast, high-quality movie downloads; much lower latency to support a new range of real-time business applications and fuel a Cloud-Based Internet of Things (IoT) revolution; comprehensive, reliable network coverage outdoors and indoors; and network slicing to create dedicated paths for premium and mission-critical services.

Many of those capabilities are now upon us, but that does not mean the technical, economic and operational challenges of testing, deploying and rolling out 5G network coverage are history. To realize 5G's potential, operators need a much denser network with more directive signal capabilities than current networks. Many of them will use high-frequency millimeter-wave spectrum bands to build out active antenna array systems that support these needs, but higher frequencies pose challenges related to signal strength, power dissipation and thermal management. Fortunately, these challenges can be overcome, and the key to solving them lies deep with 5G architectures at the integrated circuit level.

"Companies like ours that provide the active antenna integrated circuits do not sell directly to the service providers," said David Corman, Chief Systems Architect at Anokiwave, "but we have a pronounced effect on helping service providers resolve the technical issues and manage the capital expenses and the operating expenses to make 5G happen,"

NEW RADIO, NEW ARCHITECTURE, NEW SPECTRUM

With each new generation of wireless technology the industry develops, we come face to face with one of the sector's most limiting factors: Spectrum is a finite resource. The 3GPP's 5G New Radio standard, approved last year, sets the stage for network operators to use a new air interface that leverages existing 4G radio access network gear to

begin building out 5G coverage at new frequencies.

For 5G, much of what's left for use in a crowded spectrum universe is below 600 Mhz or at much higher frequencies that lie above what have been used for 4G. These higher millimeter-wave spectrum bands are generally defined as being above 30 GHz, though in the U.S. the bands in play for 5G are at 24 GHz, 28 GHz, 37 GHz, 39 GHz and 47 GHz. In 2018, the FCC began auctioning off the first two, and the other three will be auctioned off in the second half of this year.

"Especially in cities, operators will need capacity growth of 5G to keep up with demand," Madden said. "But, there is a lack of available spectrum real estate to do so. Allocating the millimeter-wave is a very important step for the future of 5G."

The resulting networks will use active antenna array systems and will be able to leverage MIMO-based beamforming and beamtracking capabilities to enable more directive transmissions and more efficient use and re-use of available spectrum through spatial diversity.

"Today, the wide sectorized antennas in use don't allow you to be directive," Corman said. "With millimeter-wave antenna arrays that provide highly directive beams you can address areas of dense coverage and provide higher capacity through spatial diversity thus increasing performance and enabling new applications."

However, Madden added that building networks to operate in the millimeter-wave band is no easy trick. "At these frequencies signals don't travel all that well, so you are looking at shorter distances and larger numbers of cell sites, so more expensive deployments," he said. "You may need more power for the signal to be stronger and travel better, but you don't want to burn so much heat by doing that."

TURNING LIMITATIONS INTO STRENGTHS

The millimeter wave band presents network operators with uncongested contiguous bandwidth to explore and fulfill their 5G visions without some of the radio interference issues that plague some lower frequency bands. Yet, those higher frequencies also present the limitations Madden mentioned.

WHITE BOX NETWORKING IS COMING TO 5G

The overall technology picture at millimeter wave frequencies is evolving quickly. As the first 5G networks are being tested and launched, the industry already is eyeing another technology evolution – the migration to white box hardware and network virtualization.

Anokiwave's 28 GHz AWA-0134 Active Antenna

To that end, at Mobile World Congress 2019 in Barcelona Anokiwave's 28 GHz AWA-0134 Active Antenna, along with Keysight's open RAN test platform proof-of-concept, supported by Keysight's 5G Signal Studio and the company's 5G signal analysis hardware and software (N9040B UXA), will be part of the industry's first O-RAN 5G mmWave radio unit (O-RU) white box demonstration of an operating open radio access network 5G radio unit (RU) with fellow O-RAN alliance members.

The live O-RAN 5G radio unit (RU) white box demonstration will showcase a fully programmable multi-channel RU with a flexible fronthaul interface operating in the 28GHz mmWave spectrum, which combines the essential building blocks to create a blueprint for the next generation RAN.

"We're excited to work with Anokiwave and to play a prominent role in developing the standards to create a robust interoperability framework that addresses new 5G market opportunities," said Giampaolo Tardioli, Vice President of Keysight's Network Access group. "Keysight's end-to-end visibility, validation, and performance test capability across RF and protocol measurement domains enables the industry to accelerate development and integration of open RAN systems."

"Some of it is fundamental physics," Corman said. "The higher in frequency you go, the more path loss you're going to incur as you transmit from Point A to Point B."

The temptation may be to ramp up power to increase signal strength but doing so increases power dissipation and generated heat, which also increases network and energy costs. "One of the things you can do to overcome that is turn a weakness into a strength," Corman said "The fact that the wavelengths are short means that you can use flat panel antennas that are physically small but very directive, so you can concentrate energy to your target, and overcome the higher path loss."

Anokiwave brings additional advantages into this scenario with its kinetic green functionality, which allows DC power into the antenna array to be dynamically managed to reduce average power dissipation and extra heat that otherwise would be generated.

"If you're talking to a user that's far away you may need to energize the entire antenna, but if you're talking to a near user there's no reason to have all that power dissipation," Corman said. "Thermal management is a big deal because these antenna arrays don't have fans."

The long-term benefits of effectively managing power output on energy efficiency and expense is stunning. "Say you had 500,000 base stations and 5 million small cells deployed," Corman said. "If you look at the power consumption for the beam steering alone it's 2.6 terawatt-hours of energy, which equals about 63% of the annual energy output of the Hoover Dam—and that's a number that's just going up and up over time."

He added, "If through better management methods we can conserve even just one-third of that power, that would be enough to power 82,000 U.S. homes for one year."

Still, managing power conservation throughout a dense urban market, one with macrocells, small

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—David Corman, chief systems architect at Anokiwave

cells light pole-mounted antennas and antennas on customer premise equipment, can prove a massive undertaking. Anokiwave makes this easier is through its use of telemetry in its integrated circuits, allowing the antennas to issue reports on current power output and thermal conditions so operators can better understand changes and service needs. Effective thermal management means smaller and less expensive boxes, which means small cells can fit into more environments.

The technical architectures used for 5G also can leverage other strengths as they are deployed in the dense urban environments where the millimeter-wave spectrum will prove most useful. For example, tall buildings present line of sight obstacles for some wireless technologies, but the agile beam management capabilities in the 5G standard can leverage reflections off buildings to maintain strong, reliable network performance. Also, using MIMO to get separate, physically diverse beams to different users and destinations means spectrum can be reused, allowing more powerful data streams to more users.

Such capabilities will be very important in 5G environments that will contain more network users—not just individuals, but also connected cars and automated devices joining the fast-growing IoT. Supporting all of that depends on the ability to resolve the signal/power/heat issues inherent at millimeter wave frequencies.

THE DAWN OF A NEW AGE

5G networks do not come pre-assembled with set-it-and-forget-it options. As these networks are deployed at high-frequency millimeter wave bands, managing the technical and economic challenges of building such complex and densely-configured networks requires attention to the finer details. Many challenges already are solvable at the integrated circuit level, so network operators and their vendor partners can focus on testing their gear and commercializing their networks.

In the testing phase, Anokiwave offers another advantage in the form of its zero-calibration technology, which eliminates a costly testing process during active antenna manufacturing. "Traditionally, in order to form a high-quality beam in the far field you need to have equal amplitude and phase from every channel within the active antenna," Corman said. The zero-calibration technique eliminates the need for that expensive and time-consuming set-up, allowing operators and their partners to roll our 5G architectures more quickly with the confidence they will have higher-quality beams to when they turn up service.

As more 5G networks and services go live and expand, we will start to see real benefits. For consumers, that means ultra-fast data and video performance, and consistent and reliable coverage for using richer applications. For enterprises and vertical industries, the very low latency of 5G means support for mission-critical data and video applications requiring real-time response. This 5G reality will set the foundation for the next evolution — a more automated world driven by artificial intelligence and leveraging densely-connected IoT environments to support smart homes, smart buildings and factories and smart cities. The wide-open millimeter-wave spectrum is where much of this innovation is set to occur.

"Over the long term, 5G increasingly will use millimeter wave bands especially in the U.S. market," Madden said. "Having the ability to resolve technical and economic issues now is important."