Holographic Beam Forming

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Beamsteering arrays are a key piece of FR2 5G infrastructure. In mmW links, beamforming assures RF link quality by providing additional antenna gain to compensate for elevated propagation loss (1/r2 loss). It also enables spectrum reuse, as the regions outside the beam can also transmit and receive in that same spectrum with minimal interference from the signals inside the beam.

Holographic Beam Forming and Phased Array

Pivotal Commware manufactures Holographic Beamforming® (HBF) antennas for its Echo 5G™ and Pivot 5G™ mmW repeater products. HBF describes a passive array antenna that can steer RF beams over a wide area. HBF is a far simpler architecture than a conventional active analog phased array because it requires only a simple switching component at each element. This contrasts with a phased array requiring power amplifier, low noise amplifier and phase shifter (as well as Transmit/Receive switching) at every element in the array. The HBF architecture also divorces the array sizing from the choice of amplifiers used to drive the array. Antenna parameters such as beamwidth, gain and scan can be independently optimized from the amplifier chains efficiency and output power.

This is a critical distinction. Distributed, specialized phased array chips remove design flexibility. Radiated power and array size are intimately coupled in a phased array chip approach. In the case where narrow beams are required (but only moderate radiated power), a large array is required. The phased array chips are often poorly scaled for such a system and the amplifier class-A operation (which cannot be simply backed off) leads to unacceptable DC power consumption. Even in cases where the phased array chips are ideally scaled, distributed amplification cannot be linearized with digital predistortion techniques, so will be fundamentally higher power draw than a linearized HBF-based approach.

Power Consumption

Semiconductor advances are also an important piece of the 5G mmW picture. Power efficiency in wireless devices is a key design consideration on both the handset and infrastructure side. Once a desired small cell location has been identified, small differences in power consumption can make the difference between viability and impossibility. On the handset side, battery life is one of the most noticeable factors for user experience. Unfortunately, for semiconductors the costs scale with performance. This leads to one of the key debates in the phased array space: What type of semiconductor should be used?

Overwhelmingly, low-efficiency but reasonably priced Si based phased array chips have flooded the market. HBF, with its singular amplifier, prefers GaAs-based power amplifiers for higher output power and improved efficiency. Thus far, the cost of a singular GaAs PAs has been better than distributed phased array chips for the array sizes Pivotal has designed.

Metrology

Metrology for beamforming arrays is quite crucial for predicting their field performance. One of the most challenging is validation of over-the-air (OTA) performance. Ideally, each beam from a pre-defined set of beams is characterized for realized system gain as a function of frequency and angle (azimuth and elevation). Two critical loops dictate the time and expense that must be spent on antenna array characterization. The first is primarily mediated electronically: the rate at which a beam can be set up on the array, measured at a single angle, and then cycled to the next beam so that all beams are characterized at the single angle. The second is more mechanical -- how fast can the antenna measurement be moved to other angles? Both factors can multiply out to some serious test time required. Test equipment vendors have long sought to minimize test time needed for OTA but must be careful about how they size the 'quiet zone' as this sets the maximum size of antenna their equipment can measure. Such measurements usually require the full system (radomes, packaged electronics, thermal housing, etc.) to be measured to gain sufficient accuracy. The test challenge is about the same at this level for both HBF and phased arrays. Both are more driven by the test equipment capabilities rather than anything intrinsic to the two approaches.

The test challenge is multiplied significantly if in-situ gain and temperature calibration is needed as part of the test. HBF with its singular power amplifiers are intrinsically easier to characterize in this sense than the distributed, element level amps in phased arrays. In both cases, a temperature compensation table is needed for systems that will see wide temperature ranges and have sufficiently tight requirements on performance.

Smart Repeaters

5G mmW systems continue to advance rapidly on all fronts. The key challenge being how to most cost effectively deploy mmW for both the Fixed Wireless Access and Mobility scenarios. One of the crucial elements in mmW is the availability of devices that are somewhere between a UE and gNB in terms of cost and capabilities. In many urban and suburban scenarios, a full gNB based deployment is prohibitively expensive. The use of mmW 'smart' repeaters (repeaters that beamform with configurable coverage patterns) will be crucial for equalizing coverage between mmW and sub-6 systems. As challenges are met by new, easily deployed network elements, we expect mmW utilization to take off as the bandwidth advantage offered at mmW is extremely significant.

The Ecosystem

Pivotal's mmWave-optimized ecosystem of products delivers on the promise of 5G by leveraging mmWave's capacity and directivity. Network operators can match costs with revenues by deploying 5G mmWave precisely with subscriber demand instead of broad geographies while greatly reducing TCO and time-to-revenue for their mmWave networks.

Pivotal 5G mmWave Ecosystem

WAVESCAPE™

NETWORK MODELING

- Identifies optimal network node placement for repeaters and gNBs using ultra high resolution geodata imagery, and optimizes for specific business cases, e.g., mobility and FWA
- Confidently qualifies service to buildings, even windows

PIVOT 5G

NETWORK REPEATER

- Extends gNB coverage by 50%; one Pivot doubles service reach of a gNB at an order of magnitude less cost than adding gNBs alone
- Requires no fiber connection, consumes 28W of power, weighs eight pounds, site approves easily and deploys three times faster than gNBs
- Installs easily, self-aligns and commissions remotely

PIVOTAL 5G ECHO

SUBSCRIBER REPEATER

- Low-profile, glass-attached repeater installed by subscriber for in-building mmWave penetration
- Ubiquitous Gbps coverage indoors at 95+% of area
- Ideal for FWA, mobility indoors, enterprise solutions

IBMS

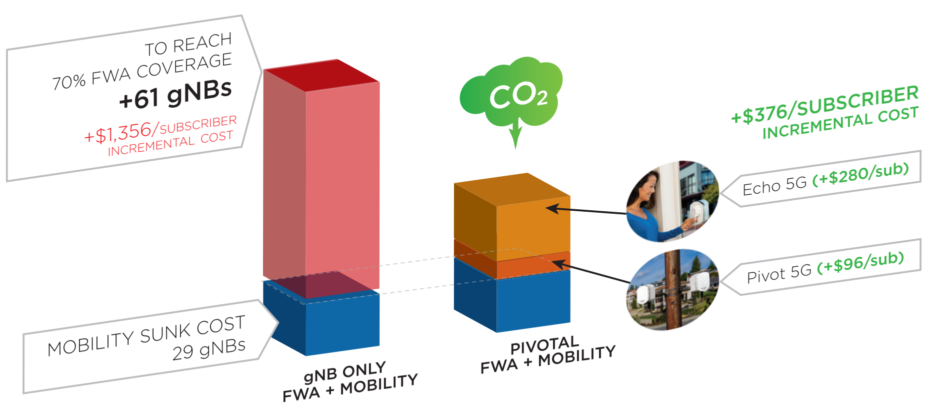
INTELLIGENT BEAM MANAGEMENT SERVICE

- Real-time Configuration, Performance and Fault Management
- Supports self-healing and network load balancing
- Integrated with WaveScape for real-time coverage view

Crack the code for mmWave Total Cost of Ownership (TCO)

WaveScape shows that a 29-gNB mobility network requires 61 more gNBs at an incremental cost per subscriber of $1,356 to achieve 70% FWA coverage for the 2,924 subscribers not already served. By contrast, deploying 2,744 Echos and 56 Pivots instead of 61 more gNBs generates an incremental FWA cost per subscriber of $376. Fewer gNBs translates into 2.4M fewer tons of CO2/year, equivalent to eliminating emissions from approximately 500,000 vehicles for one year.*

Four Square Kilometers: 70% FWA Coverage



* Based on energy savings associated with the analysis above replicated across the average area of the 300 most populated cities in the U.S.