Crossing the 5G and IoT Connectivity Chasm with SDR and SDN

When the Radio Can Be Part of the Cloud

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The 5G promise is broad and ambitious, but business leaders need to recognize that we are at the very beginning of this journey, and emerging technologies under the 5G umbrella are creating new opportunities for new entrants to fill the gaps as the world moves toward the promise of 5G such as 5G-enabled IoT, new shared spectrum resources, hybrid multi-cloud services brokering, network slicing on demand within mobile computing nano-data centers at the carrier edge.

Now The Radio Can Be A Part Of The Cloud

By 2025, 5G applications are generally expected to emerge that will be consumed by an exploding range of connected things from mobile devices, laptops and newer IoT devices to large servers, routers and storage arrays in the data center. These 5G applications will drive the need for new mobile and fixed connectivity architectures that enable quality delivery of experience and efficient deployment across the Cloud Continuum and the carrier edge.[1]

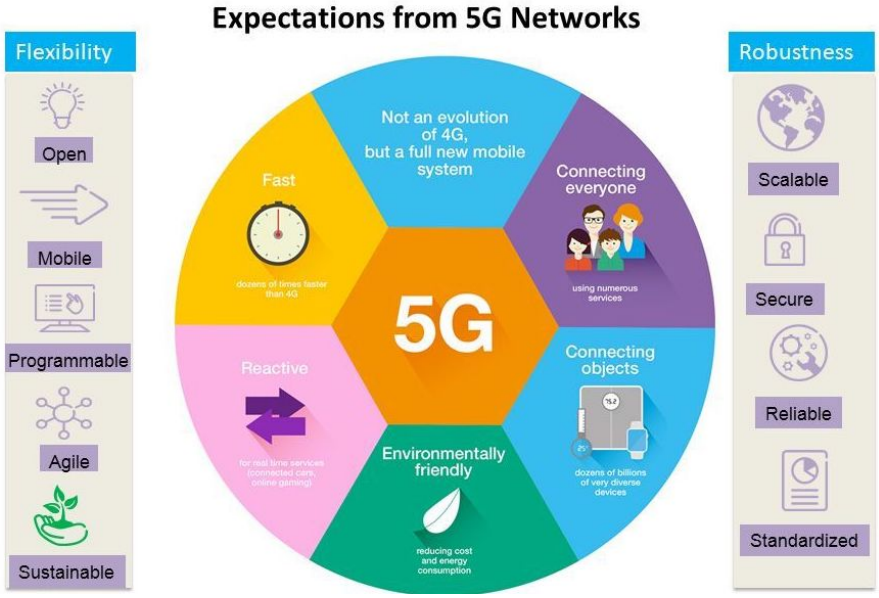

Figure 1: Source: ITU

Though 3GPP has made significant strides in 2018 to baseline standards for 5G, fragmentation in the emerging 5G/IoT connectivity landscape is going to be an ongoing challenge for operators, enterprises and consumers. New thinking in radio systems will be needed to drive 5G application innovation and investment in 5G infrastructure as the shake out of a wide range of connectivity protocols, technology standards and interoperability issues occurs through the early phases of 5G /IoT evolution across the globe. The ITU suggests that the newer thinking

[1] C.Gonzalez, L.Lee, C. Begue, A. Sharma & M. Kienzle. (2018, March 8). *The Future of Cloud: The Cloud Continuum.* IBM & *neXt Curve*.

needs to achieve programmability, flexibility and adaptability of mobile wireless assets including the radio.

Virtualizing The Radio Will Change The Game

5G carrier-edge nano-data centers housed in cell tower locations and central offices of the past will need new, innovative radio designs. Legacy approaches included a 2-pronged approach of radio resources in cell towers and small cell deployments. With Software-Defined Radio (SDR) and programmable electronics a third approach has occurred that presents new possibilities in radio equipment flexibility and adaptability.

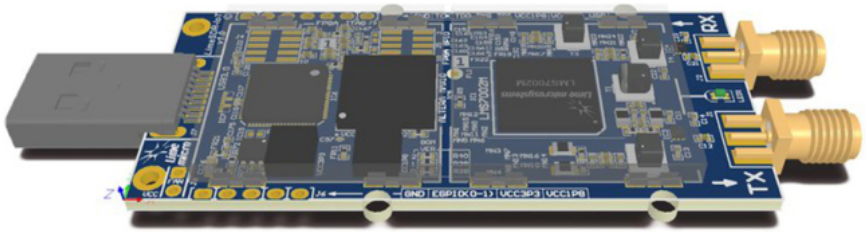

Figure 2: LimeSDR Mini SDR Transceiver

Software-defined networking (SDN) technology is an approach in networking leveraging cloud computing concepts that facilitates network management and enables programmable networks. Software-defined radio technology leverages these same software-defined concepts and applies them to the radio interfaces, which are typically “hard-wired” to communicate in specific frequencies with pre-defined protocols. Now, radio interfaces can be “programmable”.

Software-Defined Radios Plus Cognitive Computing And Dynamic Algorithms

A software-defined radio can be flexible enough to leverage different spectrum bands on-the-fly making new designs of IoT devices, base stations, and small cells possible with the following benefits:

- Allows several transmitters to transmit in the same place on the same frequency with very little interference creating full duplex-communications as Kumo Networks is doing, thereby doubling capacity,
- Able to adaptively "lock onto" a directional signal so that receivers can better reject interference from other directions allowing it to detect fainter transmissions by leveraging adaptive beam-forming techniques for improved communications,
- Improve the efficiency of spectrum utilization by leveraging Cognitive Radio techniques,
- Improve QoE (Quality of Experience) for resource-intensive applications such as Ultra HD video by applying SDx resources end-to-end with Software-Defined Radio and software-defined data center resources (CPU/GPU/CDN) along with SD-WAN networks for backhaul.

Software-Defined Radio Needs Adaptable Hardware

Today, many SDR units are shipped with a range of chip types including general purpose processors (GPP), digital signal processors (DSP) and field programmable gate arrays (FPGA), with the latter being widely adopted for its user configurability that can foster hardware reusability and repurposing. FPGAs are also great for device hackers who want to build and configure their own software-defined radio transceivers for their private networks.

According to the IoT Lab at Santa Clara University's Dept. of Computer Engineering in their report entitled: "Software-defined Radios: Architecture, State-of-the-Art, and Challenges" the tradeoffs between various chip types are as follows:[2]

COMPARISON OF SDR DESIGN APPROACHES

	GPP	DSP	FPGA
Computation	Fixed Arithmetic Engines	Fixed Arithmetic Engines	User Configurable Logic
Execution	Sequential	Partially Parallel	Highly Parallel
Throughput	Low	Medium	High
Data Rate	Low	Medium	High
Data Width	Limited by Bus Width	Limited by Bus Width	High
Programmability	Easy	Easy	Moderate
Complex Algorithms	Easy	Easy	Moderate
I/O	Dedicated Ports	Dedicated Ports	User Configurable Ports
Cost	Moderate	Low	Moderate
Power Efficiency	Low	Moderate	High
Form Factor	Large	Medium	Small

Figure 3: Source: IoT Lab at Santa Clara University, "Software-Defined Radios: Architecture, State-of-the-Art, and Challenges"

FPGAs present a compelling value proposition for operators looking to modernize their RANs with Smart Antennas, which are considered ”intelligent” or ”smart” due to their ability to select a frequency band and adapt with mobile tracking (adaptive beam forming to self-align) as well as interference cancellation in real-time and on demand. The advent of secure over-the-air (OTA) silicon updates will enable mobile network operators to remotely update their mobile radio devices and repurpose or re-platform them to support new software-define radio functions as needed and as connectivity requirements and technologies change.

[2] Rami Akeela & Behnam Dezfouli. (2018, April). *Software-defined Radios: Architecture, State-of-the-art, and Challenges.* Santa Clara University.

Implications for Business and Technology Leaders

5G will bring about a new mobile network that not only is spectrum-efficient but is resource-efficient with lower bill of materials, more resilient, cost-effective to manage and modernize going forward as the 5G technology landscape and market rationalize themselves from their scattered, fragmented current state. Improved spectrum usage and sharing will make more capacity available and foster new revenue opportunities and models for network operators.

CIOs and CTOs of communications service providers embarking on 5G should explore SDR-based technologies as they re-vector their base stations and deploy new adaptable small cell sites to provide 5G connectivity that will enable a growing and diverse range of IoT applications, new media and content distribution platforms and low-latency applications that are yet to be imagined. The benefits of SDR and user configurable logic such as FPGAs can ally some of the first-mover jitters and concerns that mobile network operators may have regarding investing in early-phase technologies and assets for their 5G mobile networks.

The Research Team

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References

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