

SiGNALS*Flash!*

Dispatches from the frontier of wireless research



OPEN RAN/MAVENIR – TOO IMPORTANT TO FAIL?

RANDOM THOUGHTS FOLLOWING THE MAVENIR ANALYST EVENT 2024

EXECUTIVE SUMMARY

In mid-December, we attended the Mavenir Global Analyst event, held in Richardson, Texas. The event brought together industry analysts from North America, Europe, and Asia, for two days of discussions. In addition to analysts, there were customer testimonials – both live and in person – as well as a tremendous richness of information. Some companies tend to provide very little insight and quantitative information at their analyst or investor events. Mavenir takes things in the other direction by providing a wealth of information and frank dialog. As we mentioned after the last two events, Mavenir’s analyst events check all the boxes: access to senior executives and product managers from start to finish, the participation of key customers and partners, honest answers and frank assessments from product leaders that are technically savvy, not to mention great food and drink. This year, Mavenir couldn’t deliver on the warm Texas weather, but we won’t hold it against them.

In this *Signals Flash*, we discuss our takeaways from the event, with a primary focus on Open RAN and Mavenir’s ambitions, activities and outlook for the space. It also wouldn’t be a *Signals Flash*, report if we didn’t interject our own perspectives.

Key Highlights and Observations

- **Dazed and Confused.** Will the real Open RAN please stand up! There is way too much confusion regarding what is and isn’t Open RAN, or if it even matters. We think it can matter, and we discuss.
- **Too Important to Fail.** Much like the financial crisis of 2008, the Open RAN ecosystem is going through its own turmoil. The government ultimately bailed out the major banks and/or let failed banks get acquired by others without the acquirer incurring as much risk and uncertainty as normal. What, if anything, does this mean for Open RAN and Mavenir?
- **Current Challenges and Future Opportunities.** We discuss the many factors that have led to the slowdown in the Open RAN/Mavenir opportunity and what opportunities lie ahead.
- **Up Next - RedCap.** If you are a subscriber to our *Signals Ahead* research product then the next report will be a benchmark study of RedCap and how it compares with LTE Cat 4 as well as traditional 5G eMBB.

COMING SOON!

5G: The Greatest Show on Earth!



REDCAP BENCHMARK STUDY

PART OF "THE MOTHER OF ALL NETWORK BENCHMARK TESTS" SERIES OF REPORTS

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DAZED AND CONFUSED

In addition to being a 1993 comedy film starring Mathew McConaughey and Ben Affleck to name a few, Dazed and Confused refers to the bed the industry has made with Open RAN, O-RAN, Cloud RAN, Centralized RAN, C-RAN, Virtual RAN, vRAN, and the list goes on. It would be helpful if Cheech and Chong's comedy skit involving *Canis lupus familiaris* feculence held true and that something that looked like Open RAN and smelled like Open RAN, was, in fact, Open RAN. However, that train has already left the station, so we're stuck in this conundrum.

The original intent of Open RAN was to commoditize the radio access network by separating the hardware from the software components and to leverage open interfaces between network elements to allow for a multi-vendor network. Operators would select servers from one hardware vendor, and software from other vendors, throw it all together, and it would work like a charm, just like our first Hi-Fi stereo system, complete with turntable and cassette deck, that we assembled from the local Mid-City Stereo back in the day. Even better, the cloud/virtual aspect would somehow make it cheaper to deploy and maintain, while the network architecture would take the radio access network into the next G and beyond.

That scenario hasn't panned out to say the least. We have virtual RAN solutions that are single vendor solutions, and which aren't based on Open RAN. We have single vendor Open RAN solutions that we think will incorporate third party RRUs, suggesting at least one Open RAN interface exists, but there are no solid indications that it will ever incorporate third party DUs. DUs and RRUs with massive MIMO from different vendors also remain more futuristic while the challenges of maintaining DU/RRU product roadmaps that evolve in synch with each other cannot be ignored. We have fragmentation in the fronthaul interface, which now consists of four options, depending on the application (massive MIMO versus traditional, and ULPI, which moves certain equalizer functions from the DU to the RRU, thereby improving uplink performance. Vendors either need to support all options or hope their option(s) is what their operator customers want.

There are also lookaside and inline accelerator architectures, which many believe limit the operator's flexibility to mix and match hardware and software in the DU. Lastly, it is also unlikely that we'll ever see comingling of DUs and CUs from different vendors.

Takeaways. *Operators will need to make sure what they are being promised/sold is as advertised. If the network is Open RAN compatible, then it needs to be Open RAN compatible, and operators will need to understand the performance and logistical implications of introducing new vendors before and not after they've signed the contract on the dotted line. For vendors, there is a higher R&D cost associated with supporting the various fronthaul interfaces while the market opportunity for any option will be inherently reduced relative to a situation where there was only a single option available. We aren't suggesting there isn't value with having*



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VOL 46: UP!

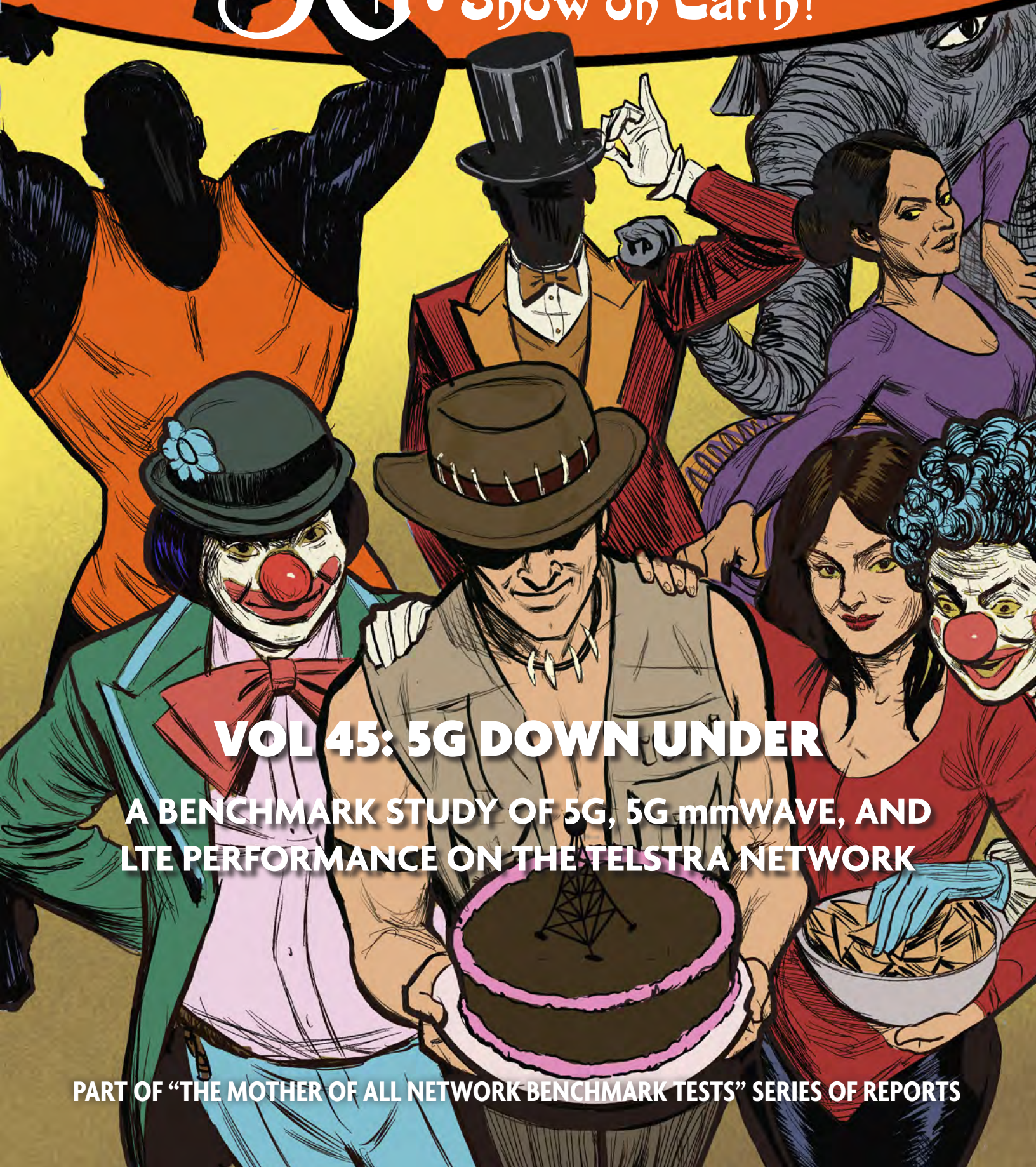
**A BENCHMARK STUDY OF 3Tx VERSUS 2Tx CPEs
(HAVING YOUR CAKE AND EATING IT TOO)**

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multiple options but there are tradeoffs. It also doesn't take a cynic to believe the inclusion of multiple options in some cases was intentional to limit the vendor playing field.

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VOL 45: 5G DOWN UNDER

**A BENCHMARK STUDY OF 5G, 5G mmWAVE, AND
LTE PERFORMANCE ON THE TELSTRA NETWORK**

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TOO IMPORTANT TO FAIL

During the US banking crisis of 2007-2008 that was caused by a real estate bubble and highly risky mortgages that became insolvent, the phrase “too big to fail” emerged with its implication being the US government wouldn’t let certain major banks fail since the impact would have dire consequences across the economy. Ultimately, Bear Stearns, Lehman Brothers, Washington Mutual, and a host of smaller regional banks went under or were acquired by competitors – generally, with friendly government terms that made it swallowable for the acquiring banks.

The phrase “Too Important to Fail” didn’t necessarily get mentioned verbatim at the analyst event, but to our ears it was at least alluded to – both with respect to Open RAN in general and Mavenir in particular. There is a somewhat warranted desire for the US to have homegrown 5G/6G suppliers, be they chipsets, smartphones or infrastructure. National security is probably the biggest reason since a foreign entity controlling critical infrastructure in the US isn’t desirable. It opens mobile networks up to hackers and eavesdroppers while DoD use cases, such as deployments on military bases or secure 5G networks in battlefield situations, almost inherently dictate the need for a US-based supplier, or at least a supplier from a very friendly country. Given the looming trade war with Canada, we aren’t even sure which country would qualify. Telecommunications networks are already susceptible to external hackers. If the hackers have the keys to the backdoor, then it makes it far more likely for a breach to occur.

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Ericsson’s potential move of its HQ from Kista to the US, we believe, is also influenced by the perception a US-based company is more likely to curry favor from the US government, especially for contracts that have tight security requirements, where US government funding is involved, or where the US government simply feels more comfortable with a US-based supplier. Our thought is that the location of a company’s HQ shouldn’t be the sole determinant of the company’s allegiance. We would also look to where the bulk of a company’s R&D efforts are taking place and where their primary investors are located. A company based in the US, but with large R&D facilities in India or manufacturing in China, or a US-based company with a large middle Eastern investor, isn’t quite the same as the local mom and pop shop where the owners are members of the local Chamber of Commerce, and the employees are your next door neighbors. The global nature of the telecommunications ecosystem makes it almost impossible to achieve a US-centric nirvana.

We don’t have the answers, but we can definitely ask the [rhetorical] questions. Do we really need Open RAN? Given the new definition(s) of Open RAN – see below – has Open RAN already come and gone? Can Open RAN exist without Mavenir? Will the US allow Open RAN/Mavenir to fail? What happens to Open RAN if Intel’s struggles become insurmountable? Can an entity from a foreign country that is quasi-friendly with the US invest in Mavenir while preserving Mavenir’s US roots?

Takeaways. *Our belief is that Open RAN’s success and future prospects hinge on the survival of Mavenir. However, this statement assumes the definition of Open RAN is more akin to the original definition than what AT&T is doing with its network. “Anyone” can build an RRU for some limited market opportunity and get it to work with a Nokia/Ericsson/Samsung/Huawei/ZTE DU. Whether or not it is a sustainable business model is another question altogether. However, if we want to adhere to the original definition of Open RAN then we at least need DUs from different vendors to interoperate with each other, not to mention RICs and their associated xApps and rApps. This scenario seems unlikely with the incumbent vendors. If Mavenir can’t*

IN CASE YOU MISSED IT: SIGNALS AHEAD BACK ISSUES

- **12/19/24 “5G: The Greatest Show on Earth! Vol 46: Up!: A Benchmark Study of 3Tx versus 2Tx CPEs (Having your Cake and Eating it Too)”** SRG just completed its 46th 5G benchmark study. For this endeavor we collaborated with Accuver Americas and Spirent Communications to conduct a benchmark study of 3Tx CPEs versus 2Tx CPEs and the impact that an extra transmit chain has on uplink performance in a 5G SA network. We used T-Mobile’s network in Irvine, CA where Ericsson is the infrastructure vendor.

Highlights of the Report include the following:

Our Thanks. We did this study with the support of Accuver Americas and Spirent Communications. Accuver provided us with its XCAL5 drive test software and XCAP post-processing software. We used its suite of tools for this study. We used the Umetrix Data platform from Spirent Communications to generate the uplink data traffic during our tests. Both companies have been trusted partners with us for nearly two decades. SRG is responsible for all analysis and commentary provided in this report.

The Scope. We did comparative stationary and drive tests using the 3Tx and 2Tx CPEs, as well as a Galaxy S23 smartphone that was limited to a single uplink transmit chain. We also looked at comparative results between UL-MIMO (n41) and UL-CA (n41 and n25) using the 2Tx CPE.

The Results. Perhaps we are stating the blinding obvious, but a 3Tx solution delivers higher uplink throughput than a 2Tx solution, thanks to the inclusion of an additional uplink layer. The differences between UL-MIMO and UL-CA hinged on the RSRP, although it is worth noting that we observed 2 layers on Band n41 to relatively low RSRP values.

More is Coming. There are more features coming to help improve uplink performance, including uplink transmit switching and UL-MIMO (with and without high power amplifiers) for FDD bands. TDD + TDD UL-MIMO is another uplink enhancement that we are hoping comes to market.

- **11/26/24 “5G: The Greatest Show on Earth! Vol 45: 5G Down Under: A Benchmark Study of 5G, 5G mmWave, and LTE Performance on the Telstra Network”** SRG just completed its 45th 5G benchmark study. For this endeavor we collaborated with Accuver Americas to conduct a benchmark study of Telstra’s network near Melbourne, Australia. We included an LTE versus 5G comparison as well as the industry’s first look at NR-DC (5G mmWave and FR1, plus an SA core network) in action. All tests leveraged the NETGEAR Nighthawk M7 Ultra router.

Highlights of the Report include the following:

Our Thanks. We did this study with the support of Accuver Americas, who provided us with its XCAL5 drive test software and XCAP post-processing software. We used its suite of tools for this study. Accuver has been a trusted partner with us for nearly two decades. SRG is responsible for all analysis and commentary provided in this report.

The Scope. We did comparative drive tests of 5G (Band n7) and LTE (Band 7), including full buffer downlink/uplink tests and limited bit rate downlink/uplink tests. These tests allowed us to compare the performance of the two networks with a particular focus on spectral efficiency. We also did NR-DC testing (FR1 +

FR2) in the Melbourne CBD, in which we looked at how/if FR1 provided a more consistent user experience above and beyond what 5G mmWave could deliver.

The LTE versus 5G Results. 5G provides significantly more capacity than LTE in the downlink direction. It was a much different story in the uplink direction for reasons that we discuss in this report.

The NR-DC Results. We challenged 5G mmWave performance by doing drive tests with the NETGEAR router placed in a non-ideal location within the vehicle. Without question, the combined use of FR1 and FR2/mmWave (NR-DC with SA) provided for a more consistent user experience (data rate) than 5G mmWave by itself or with LTE as an anchor cell (NSA) since LTE bandwidth is limited compared with mid-band 5G.

- **10/28/24 “5G: The Greatest Show on Earth! Vol 44: Apples to Apples The Benchmarking Game of Crazy Comparisons (Now with 2 New Players)”** SRG just completed its 44th 5G benchmark study. For this endeavor we collaborated with Rohde & Schwarz to conduct our third benchmark study of operators’ networks in the Dallas Metro Area. For this study we included Boost Infinite (DISH Wireless) and FirstNet (AT&T). R&S collected the data on our behalf and we used its suite of analytical tools, as well as its NPS (Network Performance Score) framework for the analysis of the data.

Highlights of the Report include the following:

Our Thanks. We did this study with the support of Rohde & Schwarz, who collected the data on our behalf and who provided its suite of post-processing tools to allow us to analyze the data. This study leverages the R&S NPS framework, which is consistent with the ETSI TR recommendations for benchmarking mobile networks. SRG is responsible for all analysis and commentary provided in this report.

The Scope. We tested 5 operators’ networks in the Dallas Metro area, incorporating ~1,340 voice calls (WhatsApp and VoLTE/VoNR) as well as a suite of user-experience data tests, including DL/UL file transfers, DL/UL capacity tests, web browsing, video, e-gaming/interactivity, and social media to evaluate the networks.

The Results. Using the NPS framework as a basis for scoring the results, FirstNet (AT&T) took overall top honors, followed by T-Mobile (tied for 1st in data), Verizon, AT&T, and Boost Infinite (DISH).

The Whys. Although the outcome is interesting, we believe it is far more interesting to understand “the whys” which resulted in the scores. Band/technology selection played a role, and we believe priority treatment of traffic and a dedicated core network did as well. Only one operator’s network used VoNR, which both helped and hurt it, while the lower score for Boost Infinite had very little to do with the radio access network (i.e., don’t blame Open RAN).

A Deeper Dive. It wouldn’t be a Signals Ahead report if we didn’t look at lower layer metrics and parameters, including signal quality and coverage (SINR/RSRP), MIMO usage by 5G band and in total, 5G carrier aggregation, total bandwidth utilization, and MCS, to name a few.

find success in the Open RAN market with its DUs then it is hard to imagine another company filling its shoes.

Mavenir may be able to ride out the storm without a new investment, but it would be tenuous. Further, a big operator is going to be less inclined to work with a vendor that is cash strapped and in a financially precarious situation. The CHIPS and Science Act was supposed to help the US semiconductor industry and strengthen the supply chain against competition [and potential threats] from China. Unfortunately, Intel never got the message, or so it would seem. A similar bailout, or more likely the awarding of favorable contracts, isn't an unlikely scenario. After all, the new (or is it old?) administration on January 20, 2025, was at one time considering a nationalized 5G network and they consider China to be a significant threat.

There is also the possibility of a rumored major investment from Aramco Digital, a Saudi-based company with a key executive that is very familiar with Open RAN. A billion dollars sounds like a lot of money, but considering Saudi Arabia has already invested \$2 billion USD to create a new professional golf league (LIV) with another chunk of change now targeting an investment in the PGA, it isn't outside the realm of reason. Now if we could just get them to pay our annual golf membership dues.

We don't know what the future holds. It could be a US bailout, a Saudi investment or an acquisition/investment by another big conglomerate with lots of cash (Amazon, Google, Meta, etc.), but something is going to happen. We also wouldn't rule out a strategic partnership with a company that benefits from the success of Open RAN and Mavenir (Nvidia, Qualcomm, Dell, HP, and AWS are on the list). We also wouldn't rule out SRG taking credit for predicting the future – we've thrown out enough possibilities in the last few sentences that hopefully something pans out.

CURRENT CHALLENGES AND FUTURE OPPORTUNITIES

Mavenir listed several factors that have limited the growth of Open RAN. As a side note, while we look at Mavenir purely from an Open RAN perspective with blinders on when considering its overall product portfolio, the reality is that Mavenir generates the bulk of its revenues from IMS, core network, and messaging platforms. Open RAN, however, remains a significant part of the overall story, both in terms of the company's investments as well as its revenue opportunities.

Operator reluctance to move to a 5G standalone network is the single biggest inhibitor of the Open RAN market opportunity, especially for a vendor that doesn't have a real presence in today's LTE networks. If an incumbent vendor has an operator's LTE network, then it becomes problematic to introduce a separate vendor providing the 5G network, especially since the interface between the two networks, let alone the X2 interface between the legacy LTE eNBs, aren't as open as they could/should be. There is a good reason why Mavenir has had so much success with DISH since the operator was deploying 5G as a greenfield network. There is also a good reason why Mavenir is a huge proponent of 5G SA since without 5G SA, it becomes very difficult to win 5G business from an operator with an LTE network. Rakuten made it work in Japan with Nokia supporting the translation hardware between the 4G network and the 5G Open RAN network, but we view this effort as a one-off opportunity that will struggle to get replicated in other markets.

Besides the need for 5G SA, there is the reality that operators award markets to a single vendor, so they have someone to blame when things go wrong. In a multi-vendor network, it can be difficult to accurately point the blame since it may not be evident where the fault lies. Imagine a network where every other cell site belongs to Vendor A with the remaining cell sites belonging to Vendor B. When handovers between sites fail or when layer management isn't working as planned, who do you blame? Who fixes the problem? This issue makes it difficult for a new entrant to come into a market and prove itself, at which point it wins more of the market. If the initial piece of the newly assigned market is clearly separated from the macro network – say an in-building deployment or stadium venue, then it is perhaps more doable to pull off. However, the market opportunity may be limited. We point out that operator shyness toward a multi-vendor network will also exist with a pure Open RAN network.

Lastly, if a new vendor wants to win a brownfield deployment, including both LTE and 5G, then its LTE solution needs to have feature parity with the incumbent vendor. Alternatively, the vendor gets relegated to some backwoods market where feature parity is less important. According to Mavenir, its LTE solution is currently 85% feature parity with its peers and that it will have full parity by the end of 2025. Mavenir claims it has full parity for 5G.

For these reasons, Mavenir's growth prospects with Open RAN will likely be tempered until 2026. In some markets, the 5G ship will have already sailed, thereby limiting the opportunity. In other markets, like Europe, 5G networks aren't as robust or there is a need to swap out an incumbent vendor who is no longer welcome. Mavenir highlighted several trials and/or commercial opportunities (under NDA) which could deliver the forecasted revenue. Interestingly, Mavenir is less interested in emerging markets where the margins are not good and where the contracts may not have the same collateral strength for new financing as more mature markets.

Deutsche Telecom (video), Boost Mobile (in person), ENet (in person – French Guyana), 1&1 (video), and TerreStar (in person) provided customer testimonials for Mavenir with some of them being more generalized and others more specific to Open RAN. In general, there are three Open

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RAN market opportunities: selling RRU hardware, selling DU software, and selling RRU hardware and DU software. The first opportunity is something that can be realized via the recent AT&T announcement, the second opportunity is what has happened with DISH, and the third opportunity is aligned with Paradise Mobile, as an example, although it is the long-term opportunity that is of most interest to Mavenir and where it sees itself having the most success. If AT&T is truly pursuing an Open RAN strategy, then it would also move in this direction.

Mavenir highlighted the benefits of artificial intelligence (AI) and how it can be used along with Open RAN to meaningfully increase spectral efficiency, thereby reducing the total cost of ownership with fewer radios/DUs, the need for less spectrum, and improved energy efficiency, while providing better performance/happier consumers. While we don't disagree with the analysis, we're not convinced the Open RAN vendors along with their silicon partners (who are heavily involved in AI) will deliver meaningful spectral efficiency gains over what a major vendor can achieve on its own. Integrating third party AI into a DU scheduler isn't trivial while we aren't convinced similar gains can be achieved via the RIC (RAN Intelligent Controller). The RIC was supposed to be the panacea for all that ails network performance, but we'd like to see real proof points before we're convinced it can support real-time applications that deliver performance gains. If the gains are as real and meaningful as suggested, then it should be relatively easy to prove for an organization that has familiarity in testing 5G networks. Just saying.

One interesting market opportunity is NTN (Non Terrestrial Networks). In addition to TerreStar, Mavenir has worked with Ligado Networks on NTN – starting with IoT-related applications and then eventually moving to voice/text and hopefully data with NR NTN. The opportunity, primarily for DU software, at least from an Open RAN perspective, is interesting for a couple of reasons. First, NTN is by and large a greenfield opportunity so there is no need to support LTE. This nuance makes the opportunity more real for an Open RAN provider. Mavenir can (and does) also provide core network solutions for NTN. Second, Mavenir claims that it is a technology/market leader in this space and that the traditional vendors aren't as interested in NTN. From our perspective, Ericsson and Nokia do seem interested and invested in NTN – Nokia was also the vendor that supported Loon – but it is quite possible the NTN market opportunity is one where Mavenir may have an advantage, or at least the playing field is level. The challenge is there are a lot of satellite providers chasing a business opportunity that is just emerging and one where consolidation/failures are almost inevitable.

NTN is an interesting market opportunity for Mavenir, plus it is a more level playing field.

Takeaways. *It isn't clear to us what it means to have feature parity with the major vendors because the major vendors don't have feature parity between themselves. From our testing, we know there are emerging 5G features that not all vendors support. For example, we know of 5G features that a mobile operator might promote as being available nationwide, but in reality, the new features are limited to a single vendor's markets. Likewise, operators frequently must wait to deploy a new feature because not all of their vendors support it. Mavenir has done a very good job of supporting new features and from our testing of the DISH network, we know the performance is quite good – limitations we've identified can sometimes be attributed to factors outside of Mavenir's control.*

We also agree that things would be much different if 5G NSA didn't exist as it has made it easy for the incumbents to maintain existing customers who need their LTE networks to provide the anchor for their 5G network. Swapping out an LTE vendor and their corresponding infrastructure for a new vendor who has a largely comparable 5G solution, but perhaps an inferior LTE solution (due to lack of feature parity), isn't an enticing proposition. Further, an operator

The market opportunity for Mavenir would be much different if 5G NSA didn't exist.

handing out some RRU hardware business is a doable entry point for some vendors, but it may not translate into a meaningful market opportunity with compelling margins.

Big US operators that are not named T-Mobile should be moving to 5G SA in the coming year. It is critical that Mavenir makes good inroads with AT&T, which is the most promising opportunity, although we know at least one other opportunity exists. Outside of the US and some developed markets in Asia, the timing for 5G SA is a bit more suspect. Continued demonstration of success with initial 5G SA networks will help accelerate the network transitions, as will new 5G features that operators want, but which require 5G SA networks as the starting point.

Until next time, be on the lookout for our next *Signals Ahead* (on RedCap)...

ON THE HORIZON: POTENTIAL SIGNALS AHEAD/SIGNALS FLASH! TOPICS

We have identified a list of pending research topics that we are currently considering or presently working on completing. The topics at the top of the list are definitive with many of them already in the works. The topics toward the bottom of the page are a bit more speculative. Obviously, this list is subject to change based on various factors and market trends. As always, we welcome suggestions from our readers.

Benchmark Studies

- *5G networks, smartphones, 5G modems, application processors and real-time gaming benchmark study*
- *RedCap*
- *5G mmWave SA benchmark study*
- *Open RAN network performance benchmark study 3 – Scheduling Efficiency*
- *SRS-based beamforming benchmark study*
- *Network Slicing*
- *Uplink transmit switching with UL-CA and UL-MIMO*

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