Scaling performance testing for next-generation networks

A conversation with
Erik Org,
Director of Product Management,
Lab Systems, and
Vivek Vadakkuppattu,
Director of Test Plan Solutions
Azimuth Systems

SENZA FILI CONSULTING

By Frank Rayal

Frank Rayal. Hello, and welcome to this conversation with Erik Org and Vivek Vadakkuppattu from **Azimuth Systems**. I am Frank Rayal.

This conversation is part of a Senza Fili report on heterogeneous networks and the latest solutions from the wireless ecosystem that will make HetNets a reality.

Today we are speaking with Erik Org, Director of Product Management, Lab Systems, and Vivek Vadakkuppattu, Director of Test Plan Solutions, both with Azimuth Systems. Azimuth is a leader in mobile-performance test solutions for network operators, device OEMs, chipset vendors and infrastructure providers.

I'd like to start with you, Erik, by asking you to give us a brief overview of Azimuth Systems.

Erik Org. Azimuth Systems focuses on real-world test solutions. One of the biggest challenges operators, and device and infrastructure vendors have is testing their products in a way that reflects how the end users actually experience them. What Azimuth offers is a suite of products, platforms and solutions that help our customers replicate real-world performance in the lab.

It all starts with our core platforms, like the ACE channel emulator, which can recreate the propagation conditions that exist between any particular piece of infrastructure and a handset. To that, we add automation and test plans, developed by my colleague Vivek's team, in order to provide end-to-end solutions that can provide our customers the data and the measurements that matter to them – that is, end user experience. Maybe, Vivek, I could ask you to add about test plans and how that fits into Azimuth's mission.

Vivek Vadakkuppattu. My team takes the products and platforms built by Engineering and creates a test plan. The way to look at it is almost like Lego blocks. You have all these products, which are like individual blocks. And you can combine them to build a building.

What we do is we sit down with an operator, or anyone in the ecosystem, for that matter. We try to figure out what problem they are trying to solve. Someone might say, "I want to roll out VoLTE." Once we know what problem they are trying to solve, we develop test scenarios and automate a solution that helps them roll out this technology in an efficient, timely manner.

Frank Rayal. When we are talking about new technologies and new architectures, HetNets are now a major focus for the industry, and there are a lot of benefits that come along with HetNets, mainly capacity. But there are also challenges. What do you see as the main challenges to HetNet deployments from your perspective, being on the testing side of wireless networks?

Erik Org. I would immediately point at the fact that features and technologies like HetNet are multilink

technologies. They are technologies that require multiple simultaneous links between infrastructure and terminals in order to deliver the best overall average performance to all the users of the network. To technologies like HetNet, I would also add carrier aggregation or multi-user MIMO.

The fundamental challenge is simply that you need a hardware platform that can support multiple links at one time. From my perspective in terms of lab products, what I'm focused on delivering for Azimuth are test beds that can support these multiple links.

In the example of HetNet, the smallest test bed you might want to consider might have two to three femto cells, and two to three macro cells, because if you thought about a typical deployment, there might a home NodeB adjacent to a second home NodeB, so when you are trying to look at the performance of a UE that is within the coverage area of a femto cell, that UE is always in conflict to figure out where it should attach to. Do I attach to the femto cell in my home? Do I attach to the macro cell under which the femto cell is deployed? Or, if I go near a window in my house and I start to pick up an adjacent femto cell or a farther macro cell, what is the best piece of infrastructure for my terminal to connect to? This is all part of the decision making that the service provider has to offer in order to ensure the best average performance for all the users, not just that one particular user in the house, but all the users that are attached to the macro cell, and other users that are attached to adjacent femto cells.

I think that certainly presents challenges for test plans, so as I mentioned, my team would provide this fundamental platform, and then I look to Vivek's team to offer a test plan that could enable that. And in fact, one of the things I know Vivek is working on is test plans for small cells.

Vivek Vadakkuppattu. More and more operators are embracing the concept of small cells. The industry term for this is network densification. With this come two challenges. The first are technological challenges. Take a common scenario, for example: when you are outdoors and you go inside your apartment. What happens is your device goes from the macro network to the femto network. In some instances, the device could ping-pong between the macro cell and the femto cell. That leads to very destructive behavior, and the user experience is not very good. So, you have inherent technical challenges.

Apart from the technical challenges, the second challenge is complexity. Earlier, if I just looked at homogeneous networks, all your handovers were just between 3G to 2G, and it was all macro cell to macro cell. With HetNets, you take what was a one-dimensional problem, and you make it two- or three-dimensional. There is cellular to Wi-Fi handover. There is macro-cell to femto-cell handovers. The number of permutations and combinations increases exponentially.

This, combined with the fact that technology by itself is becoming more complex, makes it very difficult for anyone in the ecosystem – whether they are deploying a HetNet, or developing a device or infrastructure equipment that is going to sit in the heterogeneous network – to cover all the corner cases in testing.

That is why the focus of the test plans that my team develops is to make sure that we cover all the typical corner cases.

There are two reasons why we are able to do this. First, because of automation. If we have 40 different scenarios to cover, it is no longer scalable to do it manually, as the industry used to do it ten years back, when you just had two combinations. Automation is a big piece of what we do.

Second, as testing increases, as the number of permutations and combinations increases, it becomes imperative that we choose tests that help to pick out issues, so whatever tests we run help to catch an issue we won't be catching otherwise. We do this through our real-world testing expertise.

Frank Rayal. How do you actually take the complexity of the network and bring it into the lab? How do you achieve that with your solutions and with your approach?

Erik Org. We have a couple tools that are designed to help do that, because as the test beds get more complex, it is easy for our customers to get caught up in just the mechanics of building the test bed. Building a test bed doesn't solve problems for them. They need to actually use the test bed and collect data and have it presented in a way that is easy for them to analyze and assess.

To help them do that, most recently we are working on a tool called the Multilink Scenario Application. The name is self-explanatory. It is a tool designed to help our customers build scenarios that reflect multiple links, where multiple eNodeBs are connected to one or more UEs.

In particular, we are looking at scenarios for both carrier aggregation and HetNet. Essentially, we'll give customers visual cues to let them choose between coverage situations with one or more eNodeBs. On top of that, we'll overlay mobility paths. Customers will be able to create mobility scenarios for testing everything from handovers to, in the case of carrier aggregation, secondary-cell attach and release events.

By presenting this in a very easy-to-use fashion, we let customers create scenarios that can be immediately replayed on the ACE channel emulator. We do that through another tool, called Field-to-Lab. Field-to-Lab enables playback of both scenarios created with the Multilink Scenario Application as well as files created from drive tests, which were recorded using a diagnostic monitor such as QxDM or through a hardware scanner like the JDSU scanner in the field.

We take either of these inputs, and we can then directly replay these field conditions on the channel emulator such that our customers can recreate real-world scenarios in their lab. They can do it in a way that reflects multiple links for HetNet or carrier aggregation, or an individual link, if that's their test goal.

Frank Rayal. When it comes to your solution set, you had to make some decisions and choices on what to build and the approach you take. What differentiates your approach from other solutions for testing that are available on the market?

Vivek Vadakkuppattu. There are two things that differentiate us, and I touched on this earlier. The first thing is that our goal is in performance testing. If you look at the industry as such, testing is broadly broken into performance testing and conformance testing.

The products that we have are conformance-ready right from day one, but we spend a lot of time in developing solutions for performance testing, because at the end of the day, what the customer remembers is the exception and outliers – for example, "With a particular device, I've got really good performance." It is not the bare minimum performance that people look at. So it is that focus on performance testing that differentiates us. It manifests itself in the form of real-world testing. Our focus is on real-world testing using real-world conditions with real-world applications.

Figure 1 Azimuth Field-to-Lab solution emulates real-world characteristics in the lab. Source: Azimuth Systems

The second thing is automation, because as I mentioned, the number of test cases that people need to run has been increasing over the years. What differentiates our solution is the focus on end-to-end automation. When I say end-to-end automation, I mean automating from the base station all the way down to the handset, so you have a way to automate the entire system.

Frank Rayal. If we look at the LTE roadmap, most of the networks deployed today are based on Release 8 or 9, and a few networks now have started to implement some Release 10 features. Where do you see the testing environment right now in relationship to the LTE roadmap?

Erik Org. The deployment of new technologies follows a pretty common cycle. The focus is initially on compliance and functionality, because how can you worry about performance unless you demonstrate basic functionality?

So today, when we think about HetNets, small cells and carrier aggregation, most of the testing done by the early adopters and by the first operators deploying these technologies is focused on compliance and functionality.

I would say performance in the early going is certainly important and relevant, but because only a small number of customers are using those features, performance is not yet a bottleneck.

But as people start to take advantage of the benefits of a heterogeneous network, of a network with many small cells, or a network with carrier aggregation – well, those network elements are going to start becoming more congested. As that happens, operators and equipment vendors are going to become more and more concerned about whether they are going to be able to deliver the performance that subscribers expect.

We've seen this with the advent of LTE, where the focus was initially on compliance testing and the use of standard channel models to verify that the links were set up and functioned properly. But as more and more people began to use those technologies and the number of subscribers on each of the networks went up, operators have become more focused on performance testing. We expect it to develop in the same way with HetNet and with carrier aggregation.

In fact, that is what we've seen so far. The first people deploying HetNets and carrier aggregation are focused on compliance and functionality. They are only now, six months after launching those features, starting to think more and more about performance testing.

Frank Rayal. Some of these features that you mentioned in terms of test plans are equally applicable to the macro-cell and the small-cell layers. Do you see the focus now being more on getting these features right for the macro-cell layer and maybe doing the small-cell layer later? Or are both the macro cell and the small cell being moved in unison?

Vivek Vadakkuppattu. One of the interesting things we are seeing in the industry is that small cells are gaining a lot more significance as opposed to what we saw with 3G. So while the focus is still on macro cells to a great extent, people have started looking at small cells at a very early stage. Now, when we work with operators, we work with an operator to define our test plan, to do interoperability testing. Typically, if this had happened three years back, the focus would have been entirely on macro-cell networks.

Right now, right on day one, the operators said, "I want to start with the macro-cell network, but I want to keep in mind that in the future I want to start testing with small cells." So what we see is a new trend in the industry, where small cells are beginning to gain significance not only during deployment, but right from an early planning stage.

Frank Rayal. I would like to ask you about what you touched upon earlier – the automation of the test plans because of the growing number of devices and small cells. Can you go into more detail to give us a flavor of the type of work that you do to address this issue? It is a fairly complex issue now, with multiple frequencies being available, multiple systems: 3G, Wi-Fi, LTE and different types of devices. How can operators deal with all this mix of systems in their networks?

Vivek Vadakkuppattu. I think that is a great question. If you look at the challenges you mentioned, technology has gotten more complex, whether it is additional frequency bands, new technologies and a number of devices – the need for automation becomes very imminent.

Then when asked the question, "What do I need?" or "What does the industry offer?" That is where you find that there are very few solutions in the industry that can work across technologies or that can work across applications. It seems very fundamental, but many times you would find one automation tool that works for voice, one that works for data, and one that works for subscriber experience.

When we come up with test plans and automation, our goal is to make sure that we have a solution that not only works across technologies, but also works across different operating systems. Our customers shouldn't have to worry about the OS of the device since their focus is on getting devices out into the market and not in the intricacies of the automation support for different mobile OS platforms.

So the automation we create is a consistent platform that works across technologies, operating systems, and different frequencies. That allows us to abstract all this complexity from the end users. If an operator wants to roll out four new frequency bands and twenty devices with five different operating systems, the testing is going to be the same regardless of the device type and technology, because all the details of the operating system and the chipset are abstracted through the automated tools that we offer.

Frank Rayal. Are there some quantifiable benefits to the automation? Are there some metrics that you have in mind in terms of improvements, or something tangible that helps the operators, that you can share with us?

Vivek Vadakkuppattu. I can actually give you a very specific example. We worked with one of our customers in rolling out a new test plan. This customer used to do the same testing earlier, manually; it used to take eight hours to do ten tests. Using automation, they are able to run the same ten tests in just one hour. So right off the bat, you are able to cut down the test time from an entire day to an hour.

Now, the beauty of automation is it allows you to do testing 24/7. So what that means is that I go from being able to run ten tests a day to being able to run 240 tests a day. That is at least a 20 times improvement over what you were doing manually.

Another area where we see this level of benefit is Field-to-Lab, so maybe Erik, you can talk about the improvement customers have seen using Field-to-Lab.

Erik Org. With Field-to-Lab, we are able to capture field conditions and then replay them on our channel emulator – which means that you don't have to go back to the field over and over again if you want to test incremental changes in software or hardware. We have been able to capture some empirical results from our customers, and from that we've determined that many customers experience a 30% or greater reduction in total drive testing when they use Field-to-Lab.

Field-to-Lab doesn't replace drive testing, because you still have to get out there in order to see what the real-world conditions are. But once you've captured them, now you can recreate them on a repeatable basis in the lab using Field-to-Lab and our ACE channel emulators. Another way to look at it is that, for most devices, there are fairly extensive lists of tests that need to get accomplished in the field, and those tests have a cost: a cost in terms of time for the drive test team and equipment to get out there. The cost of doing a full set of acceptance tests in the field could range from $30,000 to $50,000 per device. By moving tests to the lab, not only can I save total test time, but I can save absolute dollars that can be reallocated within my drive test budget.

Frank Rayal. Erik, how does Field-to-Lab actually work? In the field, you have basically a very complex environment. How do you bring that into the lab? What exactly are you doing to bring it to the lab?

Erik Org. We've designed our Field-to-Lab product to work pretty seamlessly with a wide range of drive test tools. Drive test tools range from software-based diagnostic monitors, such as QxDM, provided by Qualcomm, to a bunch of hardware scanners that might be provided by JDS Uniphase, PCTEL or other vendors. Each one of these drive test tools creates a log file. It is with that log file that we begin.

The log files contain everything from RSRP to signal-to-noise to CQI – basically, all the measurements of RF performance and of the RF propagation environment that the terminal or the drive test tool were able to capture over the course of a drive test. We take that log file as the input to our system. We do a couple of things with it. First, we can apply algorithms to filter and smooth the data, because not every drive test is perfect. Sometimes there are gaps in the data, sometimes there are outliers, and so first we fix that.

But then we provide a means to visualize and assess the drive test; these visualization tools vary, and by way of example, include histograms reflecting distributions of RSRP or of signal-to-noise, and also a map interface where we can show you where the drive test occurred. The nice thing about this is that, as events happen during the drive test, you can quickly pinpoint them using our tools and you can see the RF conditions that existed both before and after the event occurred. That is the first part.

The second part, and probably more significant piece, is that during the drive test, you saw one, two, or maybe ten sectors. But the lab test bed that you have to recreate it on might only have two. Field-to-Lab must select from the 10 sectors observed during the drive test and map the data to the lab test bed in a meaningful way. We have both algorithms as well as custom controls for the users to go and determine which of the sectors they would like to map to the test bed and replay.

Once we have done that, we have the output of AzMapper, which we call a player file. The player file can be streamed in real time to the ACE channel emulator in order to recreate those specific field conditions.

So in short, with Field-to-Lab: start in the field, create a log file, then map the log file to the lab test bed using AzMapper. And while you are doing that, you can both visualize and assess the field conditions that existed during the drive test. Then replay the drive test on the test bed in your lab.

Frank Rayal. Thanks to Vivek and Erik for this candid conversation. I would also like to thank the viewers for watching this conversation with Erik Org, Director of Product Management, Lab Systems, and Vivek Vadakkuppattu, Director of Test Plan Solutions, both from Azimuth Systems.

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Acronyms

2G	Second generation
3G	Third generation
ACE	Azimuth channel emulator
CQI	Channel quality index
eNodeB	Evolved NodeB
GPS	Global positioning system
L2	Layer 2
L3	Layer 3
LTE	Long term evolution
MIMO	Multiple input, multiple output
OEM	Original equipment manufacturer
QxDM	Qualcomm eXtensible Diagnostic Monitor
RF	Radio frequency
RSRP	Reference signal receive power
RSSI	Received signal strength indicator
UE	User equipment
VoLTE	Voice over LTE

About Senza Fili

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About the author

Frank Rayal is founding partner at Xona Partners, a boutique management and technology advisory firm specializing in telecom, media, and technology. He is a telecom industry professional with more than 20 years of experience working with network operators and system vendors to develop and deploy innovative wireless solutions. Frank co-founded small-cell backhaul pioneer BLiNQ Networks. He held senior product management, marketing and business development positions at Ericsson, Redline, and Metawave. He holds a BS in electrical engineering from Case Western Reserve University, Cleveland, Ohio, and an MASc in electrical engineering and an MBA from the University of Toronto, Canada. He is a senior member of IEEE, and a member of Professional Engineers Ontario.