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INTELLIGENCE ON ALL THINGS WIRELESS

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The move to CI/CD requires the move to CT: *CONTINUOUS TESTING*

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Introduction

Vital network functions are moving from hardware to virtualized software instances, and those software instances are increasingly being deployed in cloud environments. The goal is to give operators access to the scale, economics and innovative potential associated with the cloud. But, in a new paradigm where services can be spun up, down and tweaked dynamically, traditional testing processes also need to evolve. As operators become more IT-centric and leverage continuous integration/continuous and deliver/deployment (CI/CD) practices, they also need to be mindful of the need for continuous testing (CT).

What is CI/CD?

CI/CD — is a software development principle or method in which automation is introduced into the entire lifecycle of software or application development, from testing to deployment. The automatic and continuous nature of CI/CD allows organizations to get software more quickly, efficiently and reliably into production and then out into the market.

More specifically, continuous integration means merging all validated working code into a shared mainline code several times a day, while continuous delivery refers to the practice of producing reliable software in short cycles that can be released — or delivered — at any time.

The other "D" (deployment) comes into play here, because once the software is delivered, it can then be deployed. CD results in more predictable and on-demand software deployments.

Why operators need it: CI/CD is key for automation

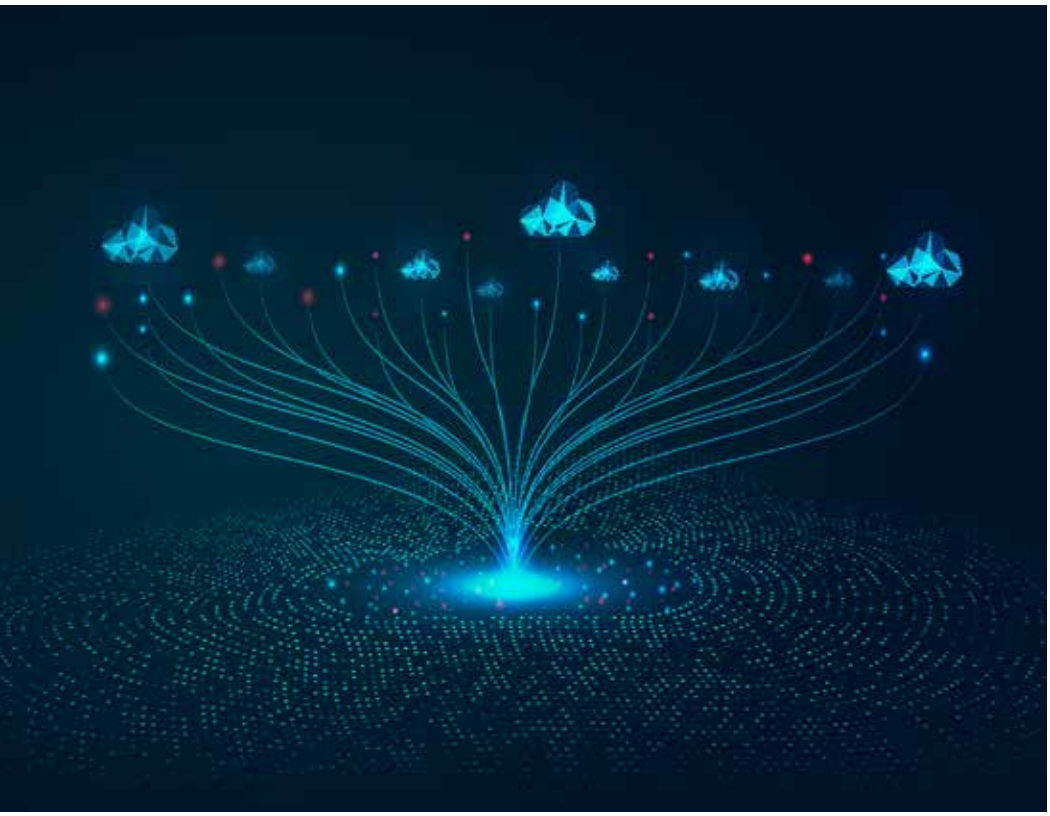
CI/CD has historically been used for IT and enterprise applications; however, as critical network functions continue to move from hardware to virtualized software instances in cloud environments, telecom operators have started to consider automated development, delivery and deployment of software as a vital undertaking.

"Cloud-native technology gives us the granularity of software. 5G architecture provides granular network tenancy, and CI/CD gives us granularity of change."

Gareth Price, Ericsson Consulting Leadership Team, Ericsson

"Telecoms CI/CD is about the automation of the telecom software lifecycle," explained Gareth Price, a member of Ericsson Consulting's leadership team, in a blog post. "We can add network capabilities much more often without making the engineering or operational support more complicated with automation. We can choose how much of the network to change, allowing us to gradually migrate to new software while reducing the risk of change."

He added that CI/CD is "critical" to 5G because it delivers the "granularity of change" necessary for next-generation networks. "Smaller, frequent changes get more value to customers more quickly without the non-linear risk. However, the higher granularity of network software composition, higher frequency of update, and higher customization of network services increases the total test burden – that's where CI/CD is critical to 5G's success. The delivery of more customer value more quickly with fewer risks demands automation," he said.



How do you do continuous testing?

The move towards CI/CD and CT is part of the telecom industry's larger push for full automation. According to Ericsson, service providers will all begin this journey at different stages, but most will find "some low hanging fruits to start with."

"A typical CI/CD entry point is the automation of all validation and verification activities. Additional quick wins include software download-related tasks and selected low-level tasks in software preparation and deployment," the vendor wrote in a blog post. "All these individual automated steps can then be orchestrated into larger sections, and finally

"In an always-on cloud-native world, always-on testing becomes as important as basic connectivity."

Doug Roberts, General Manager of Lifecycle Service Assurance, Spirent Communication

into a complete CI/CD flow with less manual intervention."

When bringing continuous testing to live networks, it's important to build and design for this framework from day one, rather than waiting to consider testing towards the end of the life cycle.

"In an always-on cloud-native world, always-on testing becomes as important as basic connectivity," stated Doug Roberts, general manager of lifecycle service assurance at Spirent Communications. "Continuous testing capabilities should therefore be embedded into the infrastructure, by default, from day one. If they're not? You might find yourself adding months to deployment timelines trying to implement testing after the fact."

Roberts suggested embracing the shift from deterministic lab environments to unknown production environments because with 5G, the network becomes much more dynamic and unpredictable when compared to previous network environments. "A network element deployed today might initially support 3,000 users and two application types, but a year from now, it might need to support 100,000 users accessing a dozen different application types," he explained. "If network behavior is no longer deterministic, testing can't be either. Instead, certification labs should focus more on verifying that new elements are scalable and flexible enough to change with the network as it evolves."

CI/CD in a disaggregated telecom network: A series of triggers

Historically, whenever a change is made to the source code, CI/CD triggers the build of new artifacts. In the case of classic CT, this build then triggers testing, and if the test passes, the build is pushed through to production; if it fails, it's rejected.

In the network and telecom space, though, explained Tibor Fabry-Asztalos, SVP product develop engineering, Dell Technologies Telecom Systems Business, the process is slightly different: "When it comes to the network and telecom, [CI/CD] is more a combination of DevOps and GitHub [a hosting service for software development] because the cycle is triggered by the injection of new software from a vendor. And It's not just changing a file in the source code, but actually bringing in a new component."

The move to Open RAN, which disaggregates Radio Access Network (RAN) functionality from specialized hardware to vendor-neutral hardware and software-defined technology, promises a new level of flexibility and innovation for operators. However, more vendors in the mix means integration

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Eugina Jordan, CMO, Telecom Infra Project

challenges, as well as more software upgrades to keep on top of. Looked at another way: Network disaggregation means more software changes, which means more triggers, or as Fabry-Asztalos put it: "triggers, kicked off by other triggers."

A CI/CD environment that is developed specifically for Open RAN across many hardware and software vendors will address this challenge by ensuring the speedy and automatic delivery of RAN software upgrades. With CI/CD, any and every single change made to the RAN software is delivered to a joint staging environment — a replica of a production environment for software testing — using automation and the feedback loop. This means that at any time, RAN software in the CD environment is ready to be tested and deployed with the push of a button. And this speed, of course, is critical because, as Fabry-Asztalos pointed out, the ability to "absorb" innovation faster is one of the biggest reasons to adopt Open RAN principles in the first place.

Eugina Jordan, CMO for the Telecom Infra Project, says that the cloud-native aspect of this is an important caveat. "You cannot put monolithic architectures through CI/CD—it's just not built this way," she said. "You can only do it with a containerized, microservices architecture. Only organizations that are moving or have moved to cloud native will be able to implement this."

Why do continuous testing? Enabling true cloud native operations

The combination of 5G and Open RAN has the upside of giving operators lots of hardware and software vendors to pick from. The downside of the combination is 5G and Open RAN is that interoperability between more vendors in a disaggregated and/or cloud-native network adds complexity that has to be managed. Dish is just one of many global operators, both greenfield and brownfield, that are working to leverage Open RAN concepts and technologies, specifically the RAN Intelligent Controller, to cut operational costs through automation.

ACentury's VP of International Sales and Distribution David Woodcock, the various possible network configurations and component suppliers, as well varying latency requirements for services, all have testing implications. "If you have a customer that wants a network slice with an application that needs low latency and they need it today, you don't have two weeks to test it. You've got to test it and get it out quickly," he provided.

"Right now, everything happens manually," pointed out TIP's Jordan, which doesn't allow operators to introduce new services and generate new revenue fast enough. "If your test cycle is six months, every six months you can bring something new," she adds. Meanwhile,"operators that have already migrated to a new model, like Rakuten … they can bring metaverse services, like tomorrow, because they can build them on the framework of CI/CD." In remarks at last year's Mobile World Congress Las Vegas, Zia Syed, president of Rakuten Symphony's Symworld platform, said that it can take as long as nine months for an operator to onboard a new application; Rakuten, he said, has built CI/CD into its cloud-native platform as part of its efforts to speed up and automate the deployment of network software.

The sheer number of devices on our networks will also put additional testing demands on service providers. "When every lightbulb and doorknob can be a client on your network, with a chipset you've never heard of, with RF characteristics that you 've never seen – how are you going to let all those

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Said Berrahil, Vice President of 5G Technology, Dish Network

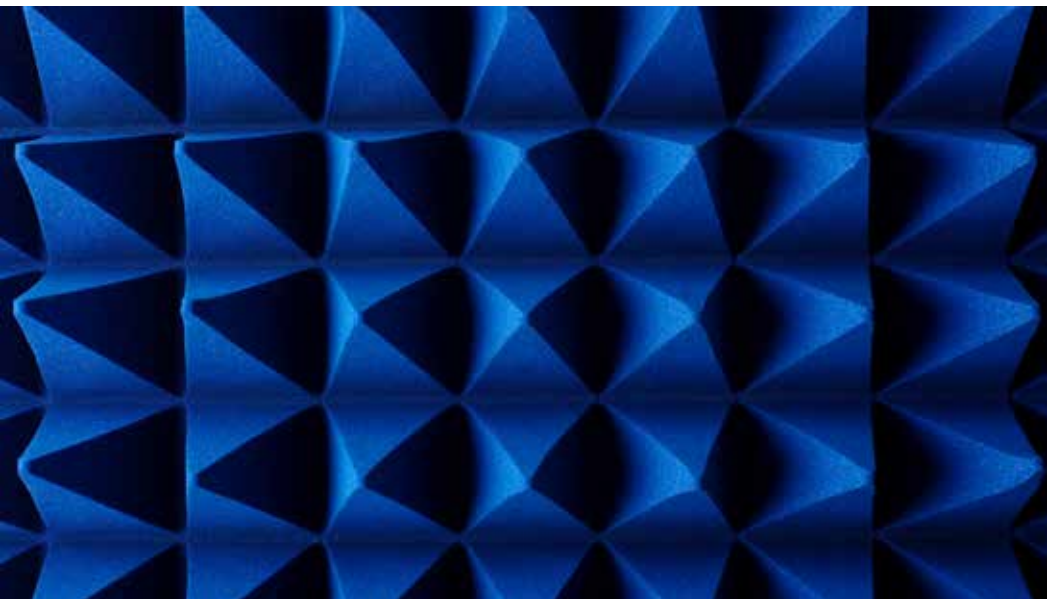
things on your network?" Woodcock said. He added that providers need new tools to test and validate the explosive activity that our networks will continue to experience.

U.S. operator Dish Wireless is in the process of building out a cloud-native 5G network that adheres to Open RAN principles and specifications, and according to the company's Vice President of 5G Technology Said Berrahil, testing is foundational to the company's goal of network automation.

"They're capable of correlating [active and passive testing] to do some predictive analysis and monitor their network…We want to bring this all to telco," he said during the Open RAN Global Forum virtual event. "But then, there is a next step and this is what brings us to Dish, is that we don't test only to validate. We don't test only to monitor, but we test to learn. The number one reason for me for testing is to provide enough data for our data products, our AI machinery, to exist. There is no data science without data — bit of a simplistic view but I need to have enough data for me to be automated and to have AI and to be predictive. And this is why we have testing-as-a-service."

Berrahil said his goal is to run 10 million test cases per day — right now, he said, he's off by a few zeroes but making progress. And the need arises because the level of network complexity means ongoing operations and, as a function of that, testing, has to be a machine-led activity. "We are looking for behaviors and we are injecting noise in the network, provoking the network, pushing the network to its limit in order to learn from it. And this is done in an autonomous manner."

Data is fed into an orchestration layer where decisions are made. "I would like to stress," Berrahil said, "…this network cannot be managed by humans."



Is RF the limiting factor on continuous network testing?

CI/CD is a tool of the IT world, of hyperscalers. Mobile network operators have worked for years to remake themselves in that image, to become software-centric in order to achieve the same scale and agility. But MNOs are MNOs precisely because they have something that no one else does: A Radio Access Network. And for all that it is invisible to the eye, RF is ultimately a physical interface.

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"The cloud-scale companies like AWS, Azure, and Google Cloud, they live this world," said Woodcock of ACentury. "They're used to frequent, small changes, multiple times a day. And the mobile network operators are going to need to be able to get to that as well, to take advantage of the agility and the capability of cloud-native networking. But they're handcuffed to the fact that they've got this giant physical asset of a wireless network that is going to need to be able to be tested at the same kind of speed.

"CI/CD is all about automating all the test suites – which is really easy when what you're testing is virtual," he continued. "But the radio layer is very much physical." That often means manual test set-up in a lab that mirrors, as much as possible, the production network. "You can't really do continuous integration and continuous deployment, with continuous testing in the middle, if you have to stop doing what you're doing and re-align your lab to do the next test," Woodcock said. "RF is different. I've seen it many times in my career where people from the wired IT industry assume that the radio link part of any network is just like an Ethernet cable, and it's not. So you need to incorporate that layer into your end-to-end test – and right now, it's the limiting factor for how fast you can test."

He explained: "When [carriers are] doing new feature testing or regression testing, when Apple releases a new iOS update, or there's new Android firmware, or Network Vendor A releases a quarterly patch to their infrastructure, they have hundreds or thousands of test cases they need to run in their labs to make sure all that stuff works, still. And that involves doing 100s of mobile originated phone calls and file downloads and video calls all while simulating roaming between all their different site designs and vendor combinations and to do one of those tests it sometimes takes them hours or days to set up the RF environment in their lab to do a test that takes 20 minutes."

Because there is so much to test, he continued, he has seen firsthand that there can be time-to-market delays in, say, being able to sell a flagship device because the lab isn't available. "It's an ongoing challenge. It's going to get worse, too," Woodcock said. Not only does every "G" add new spectrum bands and increase the complexity of the RF environment (and add to test time), the emergence of Open RAN and the pushing of disaggregation into the RAN adds yet another layer that needs to be integrated. "The number of vendors involved is an order of magnitude higher, and who knows what their cadence is going to be for when they release their driver updates?" He foresees that operators will manage that complexity by limiting the number of vendor combinations they allow in their networks and demanding that those vendors work together ahead of time on integration. But, he said, "They're going to need to build a testing infrastructure that allows them to play with those combinations and try to find ways that they break, and prevent that. And [do it] fast." Because otherwise they lose the very speed and agility that they have been working to achieve by implementing software so deeply and broadly across the network.

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David Woodcock,Vice President of International Sales and Distribution, ACentury

Carriers, Woodcock said, "honestly have had their hands full with the transition to cloud-native and virtualized networks. … They were fairly comfortable with how they handled the RF part of their worlds. But … more and more now, they're starting to think, this is now the limiting case in how we accelerate. So they need to rethink about how to speed up the RF portion of the end to end test."

Three drivers of the telco shift to CI/CD: From a waterfall to a pipeline

What is the changing paradigm for communications service providers in terms of integration and deployment? It comes down to three aspects.

More network software deployed from to edge and RAN

Kalyan Sundhar, vice president and general manager for Keysight Technologies' wireless network access business, said that across the board, lines are blurring in terms of software concepts and their role in the network, particularly in the context of Open RAN. While greenfield market entrants like Dish are pushing the concept of CI/CD more aggressively across their networks, all telecom operators have been pursuing implementations of more software-centric networks for years now—they virtualized their network functions, implemented cloud RAN,and have partnered with various cloud providers to handle network workloads and develop edge-clouds.

Speed is key

Telcos want to move faster than they have been able to in the past, and putting software-based networks into place has set the stage for new agility. The cadence of feature releases from major vendors were typically ingested once or twice a year and required arduous and extensive testing because of the scope of the releases. "Customers … don't want to wait for this big waterfall model where you're going to get an [update] and then wait for six more months before you get the next feature—and sometimes it's longer," said Sundhar. "The pipeline for getting something is really shortened by doing CI/CD, because you're continuously integrating newly developed features into the mainstream." Now, Sundhar said, he has heard of CSPs' software release cadences stepping up to anything from once a month to once to a week—which is a huge leap in speed. A blog post from DevOps platform company Copado touts Telecom Argentina achieving "CI/CD maturity" and moving from being able to handle one major software release per year to "constant deployment" and "often releasing more than a dozen deployments each day without any negative impact on the final customer."

The ability to more rapidly benefit from innovation

When software updates aren't a huge monolith, the ability to integrate small changes on a weekly or biweekly basis can result in rapid realization

"The pipeline for getting something is really shortened by doing CI/CD, because you're continuously integrating newly developed features into the mainstream."

Kalyan Sundhar, Vice President and General Manager, Wireless Network Access Business, Keysight Technologies

of benefits. The flip side of that, Sundhar said, is that you also have the option to more easily back out of changes. "That's the other advantage. You also have the option of quickly reverting back if something doesn't [work out]," he adds. "You could trial something [and say] okay, this is not quite ready. You can back off and go to the previous build."

It's important that such changes be small, incremental ones that don't require top-to-bottom, end-to-end validation of the entire network system, though. "You cannot do what you did in 12 months in a one-month cycle," Sundhar explained. "The reason it took 12 months, or six months, or nine months, was because … changes are coming from everything, and you're trying to make sure that it's validated end-to-end." In a CI/CD model, if you isolate the change—to a specific interface, perhaps—then testing can become a bit less cumbersome, he says: Spot checks rather than exhaustive testing. Where it gets tricky, he continued, is when an operator wants to promote multiple things at the same time: Upgrading an infrastructure version from multiple vendors at the same time, for instance, multiples the possible risk of something going wrong. "The sweet spot is … that you want to contain [changes] as much as possible, then it's easier to do the upgrade," he said.

The flip side of that, Sundhar said, is that you also have the option to more easily back out of changes. "That's the other advantage. You also have the option of quickly reverting back if something doesn't [work out]," he added. "You could trial something [and say] okay, this is not quite ready. You can back off and go to the previous build."

"Customers want to go to the disaggregated world, because they want to absorb innovation faster. They want to be able to monetize innovation faster," said Dell's Fabry-Asztalos, SVP of product development engineering. That could mean the ability to adopt new content, features or security updates and push them into production more rapidly—an attractive proposition when it comes to agility. But that's not to say there's no tension among speed, potential innovation and risk. "If you talk to CTO side … they want it really frequently," observed Fabry-Asztalos. "If you talk to the operations, obviously they're more cautious, because they have to deal with the risk coming in. … There's always a balance between how frequently you want to innovate or take advantage of capabilities coming, versus how much risk you are taking on the operations side."

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Tibor Fabry-Asztalos, Senior Vice President, Telecom Systems and Product Engineering, Dell Technologies

There are a couple of fundamental aspects to achieving continuous testing as part of CI/CD: One of them, Fabry-Asztalossaid, is the ability to test huge numbers of variations and be able to absorb test cases from many sources into repositories and apply them agnostically. It naturally follows, then, that you have to be able to do that with automation for speed and efficiency, because how long it takes to test and validate is really the limiting factor on how fast new features can be adopted. "If [testing] doesn't scale, it's not economical," he said. It was one thing for CSPs to absorb innovation that was largely pre-packaged. Now, they are seeking innovation that is perhaps a bit more raw, closer to its source material. "You still have to put it together. You still need to make sure that it actually works, and when it comes to production, it needs to be stable," said Fabry-Asztalos.

CSPs also have to come to terms with the fact that while agility and new partners offer exciting possibilities, something does get lost along the way. They can opt out of getting a "black box" solution from a major NEM—but that also means that someone else now has to be responsible for the increased amount of system integration work. Operators still want one hand to shake—or grasp when they need to troubleshoot. "Who provides this full integration and this workflow? Because [operators] are not set up for it, it's not [their] expertise," said Fabry-Asztalos. He goes on to say that he is seeing an increasing realization on the part of CSPs that they need to work with a systems integrator to help navigate the new landscape. For some time, he said, they assumed that the necessary ecosystem would just spontaneously form on its own, vendors would come together, and CSPs would be able to get the same kind of "clean package" that they were used to getting. "It doesn't really work that way," Fabry-Asztalos observed. "So you need to make sure that somebody arbitrates, and that's where the SI comes in. And of course, it has to ultimately be in partnership with the CSP customers."

CI/CD/CT are all part of a larger continuum of network transformation

The mega-trends driving the adoption of CI/CD and CT relate to operator's need to simultaneously build an adaptable, differentiated network while reducing secular operating costs. To do this, software and cloud computing are essential. And because software and cloud computing are essential, so too are the management and testing processes established in the world of IT. Without implementing CI/CD and CT, operators are not making the highest and best use of their investments in increasingly advanced 5G networks.

Verizon, for instance, is rapidly scaling out its virtualized RAN which is built to be compliant with O-RAN Alliance specifications. Simultaneously the operator is also leveraging its private Verizon Cloud Platform (VCP) to host and manage virtualized and container-based network functions.

"We're already beginning to see significant benefits from this network transformation and our Verizon Cloud Platform," Bill Stone, vice president of technology development and planning, said during the Open RAN Global Forum. "To name a few, the network functions, given they're implemented on a common platform, that commonality enables us to bring in the automation and orchestration tooling."

He continued to say that automation and orchestration tooling deployed on a common platforms lets Verizon "apply it broadly across all of the network functions that are implemented on the VCP platform rather than tooling in the past that might be used for a specific vendor a specific network function, so you would end up with multiple types of tooling."

Back to the idea of a continuum or network transformation, Verizon is also building out owned fiber to its cell sites. And the operator is in process of scaling its next generation packet core to scale from 400G to 880G and 115 Tbps to 230 Tbps.

Tying it all together, Stone said, "We're already realizing cost efficiencies. It's reasonable and expected that we're going to be able to continue to remove costs from the business as we move forward with this highly innovative network that we've put in place. To bring it back to what's most important, which is our customers, we're already leveraging our best-in-class fiber/spectrum assets to provide a keenly differentiated experience for our 5G Ultra Wideband customers. And finally, the combination of our assets and aggressive deployment of new technology, it's just going to continue to pave the way for additional growth and new services in the future."

Conclusion

To refocus on the foundational role of CT in the broad network transformations happening throughout the 5G upgrade cycle, we return to Roberts of Spirent who spelled out the challenge, the goal and the reality: "Operators still have work ahead to translate all lab functions to the live network—much less implement autonomous CI/CD pipelines across the infrastructure. But the steps they're taking now lay the foundation for true cloud-native operations. Service providers may not be able to control every part of the network as they have in the past. But with continuous testing, they can worry less about how constant change might impact the network, and focus on harnessing that dynamism to fuel innovation." ((•))

Editor's note: *RCR Wireless News* Executive Editor Kelly Hill, Managing Editor Catherine Sbeglia Nin and Editor in Chief Sean Kinney contributed to this report.

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