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PRESENTATION

Lilian Veras

Welcome, everyone, to the Intel Network Builders webinar program. Thank you for taking the time to join us today for our presentation titled: “Virtualized Networks at Terabit Speeds? Yes!”

Before we get started, I want to point out some of the features of the BrightTALK tool that may improve your experience. There's a questions tab below your viewer. I encourage our live audience to please ask questions at any time. Our presenters will hold answering them until the end of the presentation.

Below your viewing screen, you will also find an Attachments tab with additional documentation and reference materials, including a number of websites and documents mentioned in this presentation.

Finally, at the end of the presentation, please take the time to provide feedback using the Rating tab. We value your thoughts and we'll use the information to improve our future webinars.

Intel Network Builders webinar series takes place live twice a month, so check the channel to see what's upcoming, and access our growing library of recorded content. In addition to the resources you see here from our partners, we also offer a comprehensive NFV and SDN training program through Intel Network Builders University. You can find the link to this program in the Attachments tab, as well as a link to the Intel Network Builders newsletter.

Intel Network Builders partners have been working to accelerate network innovation by optimizing their solutions on Intel technologies. These industry leaders are recognized in our Winners’ Circle program, and Benu Networks is a Titanium Partner. Learn more about our INB Winners’ Circle program by clicking on the link in the Attachments tab.

Today we're pleased to welcome Mike McFarland from Benu Networks, and Paul Mannion from Intel.

Mr. McFarland is responsible for Product Management and Marketing at Benu Networks. He has over 20 years of networking and telecom experience and has taken startups to global market-share leadership and led billion-dollar product lines. Previously, he was VP of Product and Marketing for Airvana’s 3G and 4G small cell businesses, achieving an IPO in 2007 and subsequently acquired by CommScope. Mr. McFarland also led product management at Cisco Systems for several multi-billion-dollar product lines. Mr. McFarland holds an MBA from the Kellogg School of Management at Northwestern University, and a BSME, also from Northwestern University.

Paul Mannion is Wireline and Converged Access Segment Business Director at Intel, focused on the application of Cloud Technologies to the Broadband Access Network.

Welcome Paul and Mike, and thank you again for joining us today. I will hand over to Paul to start off-- to Mike to start off, I'm sorry. Thank you.

Mike McFarland

Thanks, Lilian. And thanks, everyone, for joining. We're excited to have you here. We have a big crowd, and so I appreciate everyone's interest. What we wanted to do today was dispel some myths. Perhaps they weren't myths in the past, but a lot has happened over the years with virtualized technology, and particularly for virtualized networking functions, and we are going to be going over some of the great improvements that have been achieved on virtualized network systems and the speed at which they can now perform.

So let's jump into the agenda. I'm going to start off by just giving everyone a brief overview of Benu Networks, and then we'll spend some time talking about some of the market drivers of the broadband market, and the resulting architecture implications of that. We'll then touch on the Benu and Intel collaboration, which has been very deep for many years, and followed by the performance test results, and how we scale a BNG system to 100 terabits, which is, of course, a very large amount of traffic and millions of subscribers in one BNG system. And then finally, we'll wrap it up with some additional value that can be unlocked beyond just performance from such a system.

So just quickly about Benu Networks. We were established back in 2010. We sell globally, but we're headquartered in Boston. We are an industry leader in Software-Defined Edge solutions. So selling exclusively to service providers into their carrier networks, and focused primarily at the Edge and sometimes the core of the network. And a heavily engineering-led organization, so over 80% of our employees are in engineering, and this allows us to not only, of course, stay at the cutting edge, but also have a very broad breadth of feature sets that we can provide for our customers.

And if you are not as familiar with us, we are deployed at some very large carriers worldwide, and we carry a lot of traffic every day, about seven petabytes of traffic per day. That's more than all the wireless traffic in North America. So it's a significant amount of traffic that we're taking. About 25 million connected homes and businesses. And while this is a sampling of our customers, we also have a sampling of our partners here as shown. We work with a lot of companies that are supportive of our efforts, and Intel, of course, is one of them, and we're very pleased to be part of the Intel Network Builders program.

So just a little bit about our product line, and where we're going to be focusing on today. So we're going to be focusing on primarily our SD-Edge platform, and that platform here in the middle is basically sitting between the access network, typically, and the rest of the core network or internet enterprise and 5G cores. And the primary network functions that it supports, and I'll just go from the bottom up, is the CGNAT function for Carrier-Grade Network Address Translation. We also support our Wi-Fi Access Gateway, and the Trusted Wi-Fi Access Gateway, or (T)WAG. This is for service provider Wi-Fi services, or you might know them as hotspot services. It also can be used for mobile offload.

The product we'll be talking about today primarily is the BNG, or Broadband Network Gateway, and a Provider Edge Router function is integrated with that, and that's for home and business broadband subscribers, as well as for MPLS VPNs for enterprises. Now, this product will evolve into a 5G Access Gateway function and UPF, which is basically enabling wireless and wireline convergence for 5G, and it really takes fixed-mobile convergence to the next level.

And then the last function is our SASE Gateway, or Secure Access Service Edge Gateway, and this basically is a function that enables security in the network for enterprise and small business customers. It can even be leveraged for residential subscribers to provide security for them. And this can be either run separately or as an integrated capability with the other network functions below, such as the BNG, which is a nice value-add in that you can integrate that as a base part of the broadband service that you offer. It can be a very strong differentiator. All of this can be managed then with our Benu advanced services cloud sits in either a cloud service or can be installed on-premise.

So let's just quick-- a little bit about our Broadband Network Gateway. One of the things that we're really focusing on is making sure that it's open, and so a couple of examples of that is, first of all, Vodafone announced that they're testing Benu, along with a couple of other vendors, in a multi-vendor test of a broadband standard called Control and User Plane Separation, and it's one of the standards

defined by the Broadband Forum, and it allows for a control plane to speak to a user plane from another vendor, and vice versa. And so, this is the world's first and I think that this is an example of how we're trying to make sure that our system is open.

Similarly, we're participating heavily in the Telecom Infrastructure Project. You may be familiar with this, also known as TIP, and they have a project around OpenBNG, and we've been shortlisted as one of the top software vendors for that. And again, that's a further demonstration of our commitment to having an open system.

The other thing that we've really focused on is making sure that we have flexible deployment models because different customers have different preferences for what they want to deploy. So we support our software as a bare-metal software running on an appliance, where it looks just like a networking appliance like you've been familiar with probably for decades, but we can also package it as a Virtual Machine running as a VNF, and we support OpenStack and the VMware platform. We also support cloud-native containers with Kubernetes management, and so we've been certified for OpenShift, from Red Hat, as well as the VMware Tanzu, or also known as the Telco Cloud Platform, and we've also actually run our system on cloud solutions like the Amazon EKS, and also bare metal Kubernetes.

So we have a lot of different options, and we find that customers do have strong preferences in terms of where they are at, in terms of some of them are more familiar with virtualized systems, and some are not, and so we have a solution for all of them. And one of the things we wanted to do was get a little feedback from all of you as to where you are in your path to virtualized or cloud-native architectures. So we have a quick poll question that I'm going to put up.

And I'm going to start with this. So hopefully, you can see the poll question. It should say, “When does your company plan to use virtualization technology in your fixed network?”

I'm not quite sure how to close the poll. Lilian, maybe you can help me? I'm not sure.

Lilian Veras

Sure. Let's get some answers in and then we can close it.

Mike McFarland

Okay, all right.

Lilian Veras

Just a few more seconds.

Mike McFarland

Okay, looks like we're still getting a few entries. People are really thinking hard about this one. All right, I think if you-- last chance to answer. All right, end that, and... Can we see the results?

Lilian Veras

We have 54% of people who answered already using it.

Mike McFarland

Okay, that’s great, and now it looks like another 38% are going to use it in the next one to two years. Okay, fantastic. Well, so regardless of where you're at in that evolution, we do have software-based solutions that look just like a network appliance, but we do run-- In this case, we're talking about our solution that runs on an x86-based system using Intel chipsets. So let's keep going.

A few things about the market, and what's going on in the market. So one of the things-- You know, someone said this once where this-- The future is easy to predict, but very difficult to get correct. So I thought that was very appropriate in the sense that a lot of these

things on this sheet you probably would not have predicted 10 years ago. All of the various applications like Alexa and Slack, even the rise of VR and AR, which just started back in 2012, but is going to be a $73 billion market in just a few years. I certainly didn't expect video streaming to grow as fast as it did. It's been around for a while, but boy, has it taken off, and things like telemedicine with the COVID pandemic really took off, cloud gaming recently started and it's become a huge market, all the multiplayer games as well as then games that are completely hosted in the cloud. And then video analytics, if you think about—there are some controversial technologies like facial recognition, but just all the video analytics that are going to be occurring in terms of identifying objects, identifying crimes, identifying unsafe environments in a work environment, or whatnot, there's just going to be a numerous number of examples here. And this, of course, drives a lot of upstream bandwidth and requires relatively low latency, like some of these other applications like for cloud gaming, the VR and AR. So numerous things that have to be considered.

I would say that these applications are extremely impactful on the network, and as a result, they cause the network to need to be able to adapt and evolve. So if-- And if you look at all the existing things like Secure Access Service Edge, all the people working remotely, the IoT and connected devices, the huge reliance on cloud, cloud gaming taking off, and as we mentioned, the VR and the OTT, all of these things have become significantly large markets, and with either billions of devices or billions of users, or billions of market size. So, very significant changes occurring in the network and relatively unpredictable. If you're making product decisions now, a lot of times you want them to last for 10 years. And so, how do you-- in the next 10 years-- prepare your network for this unpredictable future? How do you prepare it for rapid application innovation, connected device growth, low latency applications? Because we know they're coming, so how are you going to address that in your architecture and networking decisions today. Increased competition. Carriers are continuously under more pressure. And convergence of the network. So, how do you manage all these risks?

So, really, you need to take a new approach with your broadband network. The unpredictable future requires a BNG that is adaptable. The fact that there's rapid application innovation really requires more agility. Connected device growth requires you to scale up. Low latency applications really bring the need for a distributed Edge. So, pushing the BNG out towards the Edge of the network so that packets don’t have to travel as far. Increased competition, which results in needing a lower TCO, a lower total cost of ownership, and new service capabilities to differentiate. And finally, Wireless-Wireline Convergence is coming. And so, the investments you make today, you want to make sure can evolve to 5G access gateway function, UPF, and hybrid access gateway, because this will allow you to converge your wireless and wireline networks.

So, what we want to talk about today is legacy BNG versus Benu Networks BNG. So, a legacy BNG is chassis-based, typically, optimized to move bits. It’s architecturally static and constrained. You really have limited flexibility as to how you can modify this over time and a different approach is to have an architecture that’s optimized to adapt, to scale in a massive way, evolve, and evolve with agility. So, you need to have architectural flexibility and have an open system.

And so, I'm going to talk about these two different systems and how they are quite different from each other. So, the first thing we’ll cover here is the legacy BNG, which is chassis. Typically, it has a couple of control modules and some line cards. The Benu virtual BNG has no chassis. We have Control Planes, which are essentially the control modules, and User Planes, which are the line cards. And instead of a chassis, though, which has limited slots, usually up to 12, and each chassis needing a control module, the Benu BNG is quite different. We can support up to 256 User Planes. That’s sort of like having 256 line cards.

The User Planes can be sized however you need them. You can have very small ones, very large ones depending on different parts of your network that require different scale. And they can also be tuned for consumer services, enterprise services, low latency services, or even something else. So, there's no certain limit in terms of how you could tune these and have specialized User Planes.

And on any given node, say, like a server node, you could have multiple User Planes, one that is focused on consumer, another one that’s focused on enterprise with different levels of capability and feature sets.

We also have a very big difference in scaling. The Control Plane versus the User Plane of the scaling in a chassis is typically tied together. So, if you want to extend the Control Plane, you need to add an entire chassis in a legacy system. If you want to extend User Planes, you usually have to add an entire chassis. Well, as long as you don’t have slots left. So, there's no independent scaling. Every

time you're adding a new chassis, you're adding new User Planes and new Control Planes. You can't have the chassis without a Control Plane and User Plane.

With the Benu BNG, you can have Control Planes that can be extended simply by adding more Control Plane instances. And similarly, you can extend the User Plane by simply adding User Plane instances. So, completely independent scaling. So, if you need more User Plane capacity, like primarily for either a new geographic market or a new amount of bandwidth that's coming onto the network, you can add the User Plane and not even have to touch the Control Plane. And you can add 100 User Planes without even having to add more Control Planes potentially.

So, there's a lot of flexibility in terms of how you scale. And it's, of course, easier to scale if you're not having to impact your Control Plane while you're scaling your User Plane, which is probably the-- if you think about what's going to scale most over time, probably the User Plane, given the fact that there's going to be bandwidth growth.

The other thing to keep in mind is with a network-- and we're using the US as a sample market here-- with a network-wide scaling situation, you have, for legacy, BNGs many independent systems to manage. And each one of these typically requires some level of redundancy, oftentimes, using a one-to-one redundancy model. And frequently, there's no or limited geo-redundancy.

So, from a resiliency standpoint, it's not particularly strong. And not only that, when you have your Control Plane and User Plane modules, they need to simultaneously failover if you're going between chasses. So, if a system goes down, the whole thing has to failover.

In contrast, with a Benu BNG, you have just one system to manage. It's M-to-N redundancy or N-to-one redundancy, which is much more cost-efficient. And this allows you to not only reduce cost in your network but have the same level of resiliency. And also, geo-redundancy is supported, both between Control Planes, but you can also have User Planes that are in different locations, being redundant for others.

So, a lot of flexibility in terms of the redundancy, as well as then your Control Plane and your User Plane have independent failover. And this is important because when you failover both at the same time like you do with a chassis, there's a lot of things that can go wrong. But if you just have the User Plane failing over, and it's still talking to the same Control Plane, it's a much simpler process and much less risky. And similarly, if the Control Planes failover, the User Planes can continue forwarding while that occurs. So, it provides a better user experience.

And each one of these BNG systems can support millions of users, as well as hundreds of-- like 256 User Planes. So, for an entire country, you might have, I guess, more than one system to manage, but you don't have to have hundreds and hundreds or maybe even thousands. There's networks that have thousands of BNGs in them. And in this case, you can probably reduce it to dozens. So, it's a pretty dramatic change in terms of the complexity. And if you're trying to distribute User Planes to the Edge where you want to then allow for mobile Edge compute and low latency compute, this is a much simpler architecture to do that, and more cost-effective.

I also want to highlight that the ability to add services and evolve is dramatically different. So, when you look at your typical legacy BNG, it's quite a closed architecture using proprietary ASICs that typically have only certain features that they can support, really stifling innovation. And the hardware and software needs to be tightly coupled. There's, oftentimes, a lack of open APIs.

The Benu BNG has been architected to be open and for innovation. So, it's software-based, which means pretty much any feature can be supported. There's really no limitations based on any kind of ASIC. And the hardware and the software have been disaggregated, allowing you to have different lifecycle management for hardware versus software, and also to have a much broader diversity of suppliers for the hardware.

And then like I mentioned earlier, we're very focused on keeping this as an open system, so we do support open APIs to integrate new services. And the nice thing here is we can integrate a lot of different services into the same packet processing pipeline. So, we can do a combination of BNG and CGNAT with SASE and content filtering, all in one pass of the packets inspection. We can add on SD-WAN,

we can do deep packet inspection. We can even provide virtual CPE instances where you've virtualized the CPE capability. So, there's a broad set of services that can be enabled on top of this platform.

So, at this point, we're going to go and talk a little bit about the scaling and performance results. I'm going to hand it over to Paul to talk a little bit about the collaboration between Benu and Intel, and some of the Intel technology that's being leveraged in this particular testing that we did.

Paul.

Paul Mannion

Thanks, Mike. So, as Mike has said, we've been working with Benu for seven years now, so right back almost to the start of the ETSI NFV Foundation. Initially, we were working with them on some other services, their enterprise services that they offered, the Wi-Fi access gateway, and some of the security services. And we were optimizing those for NFV.

Latterly, we've focused more on the, I guess, heavier-grade User Plane gateways, such as the BNG and the AGF. And we've been working on getting them to a cloud-native platform and the type of impressive performance that we'll show you in the coming slides.

Bullet point two is just highlighting the fact that Benu has reached the highest level that they could in the Intel Network Platform Builders Program, that's the Titanium level. Well, I guess that mirrors the fact that they have-- they're a global NFV-scale partner, as Mike said, they have 25 million connected homes now, so they have been truly, truly successful.

So, what are the types of work we do with Benu? We meet with them bi-weekly at the engineering level. They are an engineering-led corporation. So, we really do see the value of those engineer-to-engineer discussions, and we enable those. We have weekly and sometimes-- sometimes weekly but mostly bi-weekly discussions where their issues are raised with Intel engineers and architects. We go away and work them, and we come back with solutions and give them to Benu.

So, that type of continuous improvement and, I guess, prefacing customer problems has really reaped the rewards for us and for Benu. So, we learn more about our platforms in the real world and how they're being used for customers, and we can innovate and release platform performance for Benu.

So, if we look at the type of solution that Intel offers a partner such as Benu. So, we're now on our 3rd Generation of Intel scalable processors called Ice Lake. And in that actual CPU-- in other words, in the package on which the CPU is built, that you plug into a server board-- we have innovated so that we have I/O capability through PCIe Generation 4 that allows you to get optimum performance from the User Plane. And that's been built in over the last four to five years.

That's not enough, though, because building the CPU is just an ingredient. So, what we've also done is we've worked on how to bring that architecture and User Plane performance out in an actual server. And we use our Intel Select Solutions Program to do that. And the solution that is aimed at User Plane performance is called the Intel Selection Solution for NFVI Forwarding Platform. And in that platform, like I said earlier, we have actually innovated in the CPU for User Plane performance, and it's in that platform we bring it out.

So, for something like a BNG, for instance, where you're aggregating lots of access ports, you have to have the port capability, the port scale capability and the NIC attach capability in a balanced manner. That means you can't be worried about which CPU is connected on what. All of that is thought through, and all of that is made available in that Intel Select Solution Forwarding Platform, and then we give that to our partners, our OEM partners. So, companies like Dell, HPE, Quanta Lenovo and all those companies, and they build out the User Plane solution for the industry.

So, the types of solutions that we deploy on that, very similar to what Mike showed earlier in the Benu portfolio. CGNAT, the SASE or the vCPE, the enterprise CPE services. Obviously, the heavier-grade performance items like a BNG, a Broadband Network Gateway, or the Wireline-Wireless Conversion gateways that are coming to market now.

So, why is this important? Mike touched on it earlier. So, if we keep going the same way we've been building networks, you have an appliance for each one of these. So, you have a disparate amount of appliances in your network. What this type of approach does is it allows you to-- it allows you to invest your capital cleverly and protect your investment. So, any of these applications or User Plane gateways can be implemented on this technology. And that gives you the flexibility that Mike talked about earlier but also future-proofs your investment as we heads towards the unchartered territory that he described, and he talked about Wireline-Wireless Convergence.

So, the underpinning technologies for the actual hardware, we touched on the CPU. We also have a series of NICs, which have a very clever technology called Dynamic Device Personalization, which I'm going to go into a little more detail on the next slide. And also, now embedded in the CPU, we have our QuickAssist Technology. That is actually a cryptographic engine, which is now part of the Ice Lake core, so you get it on the CPU. This picture here shows an adapter version, and that flexibility is there. But now, it's built into the CPU, so that would be used for something like an Edge IPSec or security gateway. That's all the hardware and the server.

Then we also have developed and innovated in the software layers. Again, it's probably an industry-standard, now the Data Plane Development Kit which, I guess, came to market around 2014, but we've since evolved it and made it cloud-native. We can put in the additional functionality that's required in our NIC features. And what that does is-- Mike touched on some of the platforms earlier, the Red Hat OpenStack platform, the VMware Tanzu Grid platform, then we make that technology available to those operating systems and independent software vendors and they take it and they build solutions using that software. So, it's a boilerplate standard approach that, again, allows huge flexibility and preserves investment.

But just to deep dive on one of those technologies, which is very important, that's the Dynamic Device Personalization. It's available in our Columbiaville, which is our E810 NIC, and also in our Fortville NIC, which is the precursor or the E710 NIC. And what this technology does, if you can imagine, up top here, you have a little CNF or a container for each User Plane BNG. So, you could have many. You could have 10, 20, 30 containers doing the User Plane's performance on CPU, and you have to be able to direct the packets to the correct container, which is doing the BNG User Plane.

So, what DDP does is it allows you to configure your NIC so that, for instance, the Q-in-Q tag for a BNG, which identifies a home or a subscriber, it's programmed in here and it's connected through a virtual function to your container. So, it allows you to direct the traffic based on a wireline tag to the correct virtual function, which is connected to a container, which implements the User Plane.

And the power of this, really, is that it allows you to scale performance to the cores. And we'll go deeper on the type of performance you can achieve shortly, but this is one of the real innovations and tricks on our technology that, when leveraged, is extremely powerful.

Our latest NIC is 200-gig capable. That's the E810. And with our Ice Lake architecture, you can attach two of those to each CPU, which gets you a platform that is, in theory, 800 gigs of User Plane.

And the other thing that you can do-- interesting thing that you can do with this technology is Control Plane redirect. So, on an earlier slide, Mike showed you what a centralized Control Plane for a BNG looks like on a distributed User Plane, so you have to have some technology that recognizes Control Plane packets and the User Plane, and redirects them to the Control Plane. And that is CPRI, Control Plane Redirect Interface. And again, that technology is available on the NIC, so something like a PPPoE Session ID, over here on the right-hand side, would be recognized on the NIC, and it would be punted to the remote Control Plane, so it doesn't take up any User Plane resources. It doesn't go any further in the pipeline than it needs to be, and it's quickly redirected to the appropriate User Plane.

And the last thing I'd say on this slide is that the technology has been enhanced for Wireline-Wireless Convergence. So, on our NICs using this technology, flexible parser technology, you can implement Wireline and Wireless Convergence, which means on one side you can detect and redirect wireline packets. And on the other side then, you can detect and redirect some of the wireless packets, so GTP-U, for instance, the GTP User Plane, TEIDs.

So, yes, that's all been developed, innovated on, and made available to Benu who are currently using this technology to achieve the performance that they're currently getting.

Mike's going to talk you through that now, the type of testing that we've done, and the types of innovations that we're working on in our bi-weekly calls. So, back to you, Mike.

Mike McFarland

Thanks, Paul. Yes, we're definitely taking advantage of the DDP technology from Intel. It does provide for a higher-performance BNG platform. And in this test, we were using that along with the E810 ethernet network adapters, and we were using the latest 3rd Generation Intel Xeon processors. We had two of them in the server, actually, just testing on one of them, I think, at the time. And we tested with Hierarchical QoS, and without Hierarchical QoS. We also had a full BNG configuration on this platform, both v4 and v6 traffic, ACLs, routing, accounting, DHCP et cetera. So, it wasn't just a packet forwarding test, it was a full configuration.

We were also running with our Control Plane separate from the User Plane, as I described earlier in the presentation. And we had a traffic generator that was pumping traffic through-- on a per-subscriber basis.

So, what we found is that there is an impact using Hierarchical QoS versus no Hierarchical QoS. We were very pleased with the results of the testing using IMIX traffic. We were able to achieve five gigabits per second per virtual CPU. And so, virtual CPU is-- you get two of these per core with the hyperthreading that the Intel Xeon processors provide. And we get about 10 gigabits per second without the HQoS. So, the HQoS does have an impact, but even with the 5 gigabits per virtual CPU, we're very pleased with this performance.

And basically, what you're seeing here is we're showing some testing that we did for five, 10, and 20 virtual CPU User Plane functions, and we usually configure many, many of these within a BNG system. But any given instance would support-- if you were using HQoS-- around 80 gigabits per second per User Plane instance.

So, if you have a two-socket server with 50 cores, you could easily support over 400-gig for that server. And so, that's a significant amount of bandwidth. You're almost approaching about half a terabit of traffic per User Plane with a full BNG configuration. And if you take that to the next level and you say, well, you're doing a little over 400-gig per User Plane and you've got 256 User Planes connected to a Control Plane, you now have a 100-terabit network BNG. And that's supporting millions of subscribers.

And not only that, you've got-- along with that high, high scale, you have a highly resilient system with N-to-one redundancy, geo-redundancy, User Plane and Control Plane failovers are separate. You can scale up and down anywhere as needed, so just add User Planes wherever you need in the network. You can move capacity very easily as needed. You can tune the User Planes to specific needs. So, just a tremendous amount of flexibility along with this scale.

I want to also highlight, though, scalability is not the only thing. So, software unlocks a lot of value. For one thing, we're running these on off-the-shelf servers, and so there's no lock-in with some proprietary hardware. It allows you to have a different lifecycle or switchover of hardware when you want to, separate from the software. You're not paying 50% plus margins on the hardware, so it's more cost-effective. You have a lot more supply chain diversity and supply chain agility. And I think in these times, we're learning how important that can be.

Some of the networking gear right now has very long lead times, but the lead times on typical x86-based systems is much lower. And you can get them from a far broader set of vendors, instead of just one single vendor.

The other thing is a software-based solution can evolve in any direction you need it to. And so, it's 5G-ready, and already can support cloud-native. This also establishes a footprint for Multi-Access Edge Compute. So, if you're putting x86-based BNG User Planes out at the Edge, and you leave some extra capacity within that server for Edge compute, you already have a footprint there. And so, when the low latency applications start to come out to market, whether it be a metaverse application or some sort of video analytics or cloud gaming type of applications. Or maybe you just want to move your content distribution network further out to the Edge to save bandwidth in your network, all these things are possible with using Edge compute and by pushing your BNG User Plane further out to the Edge.

And of course, this solution allows you to future-proof to manage risk, and not get caught off-guard. Because let's face it, we probably don't know all the things that are going to evolve in the next 10 years, and what new capabilities or features are going to be required on a BNG. And of course, then capture those opportunities when they arise.

So, to sum it up, we talked about some of the market conditions and the requirements. And so, working with Intel, Benu has been able to create this architecture and solution that is highly adaptable, as you can see, and very agile. You can add new features because it's software-based. You're not limited to any kind of ASICs. You can add capacity wherever you need to and scale up as needed in various parts of the network. It's relatively straightforward to distribute to the Edge because User Planes are part of a larger system, and it's not like you're adding thousands of new individual BNGs out to your Edge. You're just adding additional line cards, essentially, to your BNG system out at the Edge.

And this really also provides a much lower TCO. Again, you're not paying for the high margins on the hardware. You have this much better flexibility in terms of how you scale the network and how your resiliency scheme is architected. So, instead of using one-plus-one, you can use N-plus-one to save a tremendous amount of cost. And you can also add new services like we have customers running our SASE service, and that provides a big differentiator for them versus just providing raw broadband.

And then lastly, of course, with Wireless-Wireline Convergence coming, this provides you an architecture that can evolve. And you don't have to worry about is the platform going to be sufficiently scalable or have the right capabilities to support the features required for a 5G Wireless-Wireline Convergence solution like the 5G AGF and UPF.

So, that's sort of an introduction to what is explained in more detail, actually, in our whitepaper. And you can get that on the Benu website as well as the Intel Network Builders website. And this gets into more detail about not only some of the architecture benefits, but into more detail on the performance, testing, and results. So, feel free to go to those sites and download.

I think, at this point-- we did have actually one poll question I wanted to quickly ask. Let's see if I can find the poll. Lilian, I don't know if you can help with the...

Lilian Veras

Sure, yes. The question is-- I'm going to start it now. "Were you surprised at the performance numbers presented today?" It's already there, so you guys can go ahead and vote.

Mike, can you see the results?

Mike McFarland

Yes, OK, great. So, that's good. It's quite a wide distribution. I guess most people-- so we've got about 41% thought... they weren't surprised, they expected it. Another 41% were-- thought it was possible, so they were somewhat surprised. Only 16% thought-- never thought it was possible. So, that's great. A lot of people are starting to understand the performance that you can get with Intel Xeon-based processors and the great strides in performance that have been achieved.

So, at this point, I think we can go to the Q&A, Lilian.

Lilian Veras

Sure, let's get started. Thank you both so much for such great insightful information. We do have a few questions that have come in while you were presenting, so let's get started on those.

First of all, there's a member of the audience asking if this webinar is being recorded. And the answer is yes, it's recorded and it's available on our INB Social Hub. You have the link to our ecosystem webinars in the Attachments tab. You can watch this and other previously recorded webinars by clicking on that link.

The first question we have here-- let me go back here-- OK, “Had the pandemic and working from home et cetera had any effect on the take-up of cloud BNG?”

Paul Mannion

Do you want me to take that one, Mike?

Mike McFarland

Sure.

Paul Mannion

Yes, certainly. Yes, absolutely, working from home, homeschooling... I guess I've been working on the cloud BNG for three, four years now, and what I was always wondering was what would the impetus be to drive that transition? Because it’s not like 3G, 4G, 5G, and the pandemic was definitely that. We've seen huge global investment across, I guess, the operator domain in enhancing the broadband network. So, there was a realization that they had fallen behind and were non-existent in some cases, mobile-centric countries being that case. And that huge investment, tranche of money has definitely driven an impetus into the cloud BNG operators who are now looking at alternative, flexible, and lower-cost solutions. And we’re involved in many, many RFP responses now with partners on this technology. A huge impetus right now.

Mike McFarland

Yes, I'd have to agree. A couple of different things that we've seen. One is when you extend the enterprise network into a home, there's sort of a new level of security requirements required. And so we have some customers that have used our BNG platform to also enable, essentially, teleworker services that have an enhanced level of security.

If you think about broadband today, you sign up for broadband and it’s kind of this wild-wild west, good luck, hope you don’t get hacked. And it’s a little surprising, it’s kind of like buying a car without the locks on it, and you’ve got to go get your own set of locks to keep the people out of your car.

And so, one of the things that we've been able, in our platform, is make it easy to just provide at least some basic level of security. For example, the most common type of attack on an enterprise is phishing attacks where you get a link, it looks like it’s Google or whatever, some cnn.com or bbc.com, but it’s got a slight modification. And what they do then is you go to this fake site that when you put in your credentials, your username, and password, the next thing you know, they're trying it on every single site they can possibly get their hands on. Oftentimes, that’s the same password you use for some of your enterprise accounts. Voila, they're inside your enterprise network.

So, just providing that kind of basic phishing and malware protection, I think, over time, will become more of a common capability that’s offered as part of broadband. And one of the reasons it’s not been provided, I think, in the past is because those legacy systems that we've used in the past can't support it very well. And the performance of adding capabilities for that wasn’t very feasible.

But now, with a completely software-based system, we can look at anything in the packet, and that includes the full URL and even beyond just the domain or the DNS. And so, now we can provide an additional level of security for all these things that are occurring at home like enterprise business usage, and providing a higher level of security.

Lilian Veras

That’s awesome. Thank you. Question number two. “What interest levels are you seeing across the industry regarding Wireline and Wireless Convergence?”

Mike McFarland

Paul, do you want to start or should I?

Paul Mannion

I can start. We are seeing-- I guess, we worked with heavy reading earlier in the year to try and understand how fast this industry was happening. And I think it's fair to say that some early adopters have already deployed this technology with normal residential gateways. What we are seeing is a lot of pre-trial activity this year, which obviously means that operators are getting ready to deploy it through '23/'24. That would be the type of timeline I'm seeing but, yes, huge activity. It's imminent. The standards have aligned. The Broadband Forum, they've released through 3GPP Release 17, which obviously allows the innovators such as Benu to go build product. And as Mike has outlined, that product is ready.

So, yes, pretty imminent, I think.

Mike McFarland

Yes, I would agree. Some technologies are a little bit more vendor-driven, others are more operator-driven. This is definitely operator-driven. There is strong interest among some of the largest operators in the world around Wireless-Wireline Convergence, and the ability to manage their fixed-line subscribers, essentially, via the 5G core.

But not only that, sort of consolidation of the subscriber management, I'd say the big benefit that they're looking for is the consistency of services and being able to offer consistent policies and services across both wireless and wireline. And that really is something that's been a challenge for carriers that have both assets, the mobile network, and the fixed network. They oftentimes have a completely different set of services for each, and it's a lot of overhead to be trying to build services for both networks as well, instead of just building it once, but enabling it for both mobile and fixed customers.

And of course, it's a better customer experience if you have the same services and policies just on fixed versus the mobile network. Something as simple as parental controls, and being able to offer that across fixed and mobile, so that my teenage son has got parental controls set, not only when he's on Wi-Fi but also when he's on cellular. And not only for his phone, but his laptop, or tablet, or whatever device he might get his hands on. So, I think that there's a lot of end-customer benefits, as well as then big differentiators that carriers can derive from it.

But it does require-- if you're going to go down that path or you're thinking about that, it's probably well within 10 years if you're making investments now on your network, you really need to know that the platforms you're investing in can evolve to that and aren't going to have any kind of limitations. And that's where, I think, the flexibility of our solution comes into play.

Lilian Veras

Great, thank you. A member of the audience is asking, "What if we're not familiar with virtualized systems, what options do you have for us?"

Mike McFarland

I'll take that one for the start here, Paul. So, like I mentioned, if you haven't used a virtualized system yet, that's not a problem. We have, actually, a lot of customers that take our software, run it as a bare-metal software on an x86 server, and they still get the same level of adaptability, evolvability, flexibility, all the scalability that comes with what I've described in this webinar, and what's described in the whitepaper. So, there's no limitations there.

And then, not only that, you can upgrade and migrate to virtualized or cloud-native, you can skip right to containers and cloud-native environment with that same software from us, and it doesn't cost you anything. And so, you can make that migration in a seamless way when you're ready. So, that's a big part of our value prop.

Lilian Veras

All right, “And is there a minimum size server configuration that would typically be found in a network deployment of various-sized User Planes?”

Mike McFarland

Well, it really depends on your needs. We have run the BNG even on small 16-core, even eight-core systems. Some of them even using the lower-end processors from Intel, like the Denverton processor. So, it really depends on the scale that you have. There's no, necessarily, limit. I guess, at a certain point, why bother, but you can go to quite small systems.

And that’s one of the flexibilities of a software-based system is you're not constrained to five or six line card modules or three or four chassis. Basically, you’ve got a very broad list of server configurations you can use to set up your BNG.

Lilian Veras

Great. Another question here. “How does the network part adapt to redundancy scenarios in the event of a User Plane failure, which requires the communication equipment to support?”

Mike McFarland

Paul, do you want me to take that?

Paul Mannion

Yes, I can't actually see it here. Yes, go ahead.

Mike McFarland

So, the question was, “How does the User Plane adapt…?” Say it again once more.

Lilian Veras

“How does the network part adapt to redundancy scenarios in the event of a User Plane failure, which requires the communication equipment to support?”

Mike McFarland

Yes, so normally the User Plane redundancy is done using what's called VRRP, and that basically allows for one User Plane fails, another one takes over. And the network then, from MAC learning, determines that it needs to send the traffic to the other User Plane, and so that’s typically how it occurs. So, it all happens automatically.

Lilian Veras

All right. “Is there currently ongoing work involving the use of the P4 programming language or plans to utilize it in the future?”

Paul Mannion

Yes is the answer. We have the-- we acquired Barefoot. As you know, they were one of the early innovators around P4, that language and that toolset. Intel has recently brought a series of SmartNIC products to market, which we've launched, they also use P4. And right now, we’re looking at how that could be applied to cloud-native technologies like we've just described.

But the industry right now isn't on P4, it's on just standard software like Mike described in a bare metal or on a virtual hypervisor. But yes, there is work being done on P4, and there is some industry momentum around it, and we have that technology, and where applicable, it will be applied.

Mike McFarland

Yes, we've done some work with P4 and specifically with Intel-based platforms as well. So, I think it's an exciting area that's developing.

Lilian Veras

That's great. Another question here. "The performance results presented are impressive. How does this architecture compare in terms of cost over time versus a chassis-based system?"

Mike McFarland

Well, so like I mentioned in the webinar, it's definitely a lower total cost of ownership. If you just consider a few factors, one is with any kind of proprietary hardware, you're generally paying 50% plus gross margins on that, so they take the cost, they double the price of the product. And of course, that only is-- typically, the lifetime of that hardware might be seven or 10 years, so then you're buying that expensive hardware again. And in a virtualized or even just using these x86-based systems, it's just a much lower markup, and you can also have your hardware replacement lifecycle be different from the software. So, that's the other thing with proprietary systems is you're not only replacing the hardware, but you're usually rebuying the software licenses or you have to pay a fee to move them over. And so-- and you may even have to change the software load because it's for a specific type of hardware. And this is really not something that you have to deal with when you have a virtualized or an x86-based system.

And I think the other factor, of course, is the cost of managing that risk and the ability to adapt and evolve over time and add new features that maybe you don't realize you're going to need in seven years and you could be caught off-guard. So, that could be a very expensive mistake.

Lilian Veras

All right. We're running out of time, so I'm going to ask you one last question. "You mentioned SASE, can you tell a bit more about this?"

Mike McFarland

Yes, SASE stands for Secure Access Service Edge. It's a rapidly growing market. I think people have realized you don't necessarily have to pile a bunch of security appliances at every single branch office to secure it. You can have the traffic basically directed to a Secure Access Service Edge, which enables the security functions there. And this has become particularly relevant for not only branch offices but also for home offices like I was mentioning earlier. How do you secure home offices in an economical way? You can't send an expensive firewall to every single home. But you also can't just rely on the residential gateway at home either, because that's not going to be sophisticated enough, at least not to secure an entire enterprise network. So, the solution is to have the traffic secured at a point where it's going through the network, like the Broadband Network Gateway, and being able to integrate that service natively, basically, into the BNG.

Or you can run it separately and have it as like an overlay solution somewhere behind the BNG. And it can be offered for... the thing about SASE is it's very flexible in terms of offering different services, so you can have top tier enterprise-class services, all the way down to SMB services, and it's not like you're deploying different hardware to those, it's just you're turning on different features within the network, so you have a lot of flexibility there.

And the other thing is there's great economics of scale. So, rather than, again, dedicating a piece of firewall equipment at every single site, you can have... you have a system that's more centralized that's serving multiple sites, and it doesn't have to-- not every site is

sending max traffic at the same time. So, you have great economies of scale by pooling your security processing power into more centralized locations, not fully centralized, but within the network instead of at each single customer premise.

Lilian Veras

That's awesome. Well, thanks to you both again for sharing such great information with us. To our audience, I would-- just a quick reminder, please do not forget to give our team a rating for this live recording, so that we can continuously improve the quality of our webinars.

This concludes our webcast today. Thank you both.

Paul Mannion

Thank you.

Mike McFarland

Thank you.