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PRESENTATION

**Brie Hilliard**

Welcome, everyone. I'm Brie Hilliard, webinar director for the Switch and Fabric Group at Intel Corporation, and your host for today's webinar. Thank you for taking the time to join us today for our webinar titled “Next Generation Disaggregated Open Broadband Network Gateway (OpenBNG)”.

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 that pertain to 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.

Today, we are pleased to welcome Babu Peddu from Intel, Andy Furnell from Meta, Ayman Hamza from Vodafone, and Alexander Jeffries from APS Networks.

Babu Peddu is a product marketing manager with over 15 years of experience in the technology and telecom industry. His experience includes working at Cisco, Ruckus Wireless in the past, and did the planning and launch for some of the flagship products that Cisco, which includes Cisco NFV and ASR9K feature lines. He also launched the industry’s first 802.11ax technology access point at Ruckus, which drove the revenue multifold for Ruckus. He's now responsible for the technology planning and go-to-market activities for Intel’s cloud networking portfolio.

Andy Furnell is the technical lead for TIP Fixed Broadband Project Group at Meta. As connectivity technologies and ecosystem manager at Meta, Andy works closely with the Telecom Infra Project (TIP) members to help build, test, and deploy open and disaggregated technologies for Fixed Broadband networks through partnerships with vendors, operators, and other telecom ecosystem players.

Ayman Hamza is a senior solution architect of IP Broadband in Vodafone’s Center of Excellence department. He has over 25 years of experience in telco broadband networks and FMC solutions. He is currently responsible for developing, designing, and evaluating new broadband fixed access solutions within Vodafone’s Center of Excellence department. He's also a member of the TIP OpenBNG project group.

Alexander Jeffries has been working in the information technology sector ever since starting his career during the heights of the new economy. He led the development of the Advanced Programmable Switches (APS) series from the beginning in 2019, which now forms the base of the current APS Networks activities. In his role as CEO, Alex is in charge of overall company strategy, sales and marketing, social responsibility, corporate structure, and risk mitigation.

Welcome to all of our presenters, and thank you so much for taking the time to join us today.

Now, let's get started. Babu, I'll hand it over to you to start off.

**Babu Peddu**

Thank you, Brie. Hello, everyone. Good morning, good afternoon, and good evening, depending on where you are located. The agenda for today is I will cover the IP Fixed Broadband networking challenges, and introduce you to the Intel Intelligent Fabric architecture, and also introduce you to the OpenBNG. And upon that, I will go ahead and pass it onto my partners from Meta who will cover a deep dive into the OpenBNG solution. So let's go ahead and get started.

In today's world, telcos, enterprises, and cloud service providers, they are considering programmability in their networks. The reason for that is programmability offers a lot of innovation. It offers a lot of reduced complexity, reduced costs, in addition to availability and flexibility in their networks. Edge computing is transforming the way how data is being managed and delivered to billions of devices across the globe. We are having these new services like 5G, AI/ML, high-performance computing that are gaining momentum. All these services make it imperative to have some services like compute, storage, and analytics closer to the end-user. This is to avoid latency, to avoid congestion environments. So examples of that would be autonomous vehicles, Smart Cities, Smart Homes. All of these things, it would be nice to have the services like compute closer to them.

So at Intel, we found the Network and Edge Group. This was purposefully created to deliver fully end-to-end programmable networks with deep visibility into them. Intel has the right vision, technology, and we developed a partner ecosystem and customers to help build next-generation programmable networks.

So this is a data point from the Cisco VNI (Virtual Network Index). As we can see here, in 2018, we had 3.9 billion internet users. That is almost close to 50% of the world's population. So it is projected that by 2023, we'll be having 5.3 billion internet users. That is almost 60 to 66% of internet users. Just imagine these internet users having multiple devices. That means it is predominant growth. Do you think we have efficient networks or broadband networks to handle this growth? I wouldn't think so.

So legacy networks are very complex in nature. They come with many layers of hardware. They come with many vendor-specific protocols, and these protocols are not even being used by the customers, but in fact, they bear the costs for these protocols. In addition to that, the legacy networks offered zero room for innovation. These disadvantages are causing a seismic shift to programmable networks, combined with the Intelligent Edge. With programmable networks, the developers will be able to innovate. They will be able to write their own code. They will be able to customize their networks. They will be able to fast process their DevOps. So everything combined with AI/ML, the shift is getting towards programmable networks into your networks because of the cost, design, customization, et cetera.

So IP Fixed Broadband networking challenges. With the ongoing pandemic, many things changed in today's world. A majority of employees are working from home, who will be utilizing enhanced videoconferencing and Voice-over-IP services. A number of people are seeing their doctors online. Online tutoring has gained momentum. There is an uptick in online sales and marketing. Also in the healthcare ecosystem, access to a good broadband connection increases the ability to use electronic medical records, wireless medical devices, and capacity to collect and analyze patient information. Also, we are noticing an increasing adoption of IoT technologies, and industrial IoT as well-- Smart Homes, Smart Security, Smart Devices, and whatnot.

So having said that lack of an efficient high-speed broadband connection can negatively impact economic growth, household incomes, educational performance, healthcare access, and even the ability to work from home as well. Bottom line, folks, we will need improvements in our existing broadband networks. We will need intelligence in the broadband networks, more disaggregation networks with support to open standards and reduced complexity, there will be a go-to broadband solution. We should also notice that all of these challenges will cause root cause network slowdowns. And one other thing is telcos are also moving towards cloud-native architectures with container-based processing orchestration and automation as well.

So, we have seen many challenges, many key data points. How do we address these challenges? I wanted to introduce you to Intel Intelligent Fabric architecture. So what is this? This is based on the leaf-spine topology. Though it is initially aimed at data centers, many telcos and enterprises successfully implemented this. So it brings together a lot of Intel's flagship products, Intel Silicon Photonics, Tofino, Intelligent Fabric processors, Infrastructure Programmable Units, Intel Ethernet, Intel Xeon processors. All these products interop with the open standards, that is P4 programming language, IPDK, Sonic operating system from-- that is a networking operating system, SPDK, EBPF, and the Data Plane Development Kit. So this architecture, together with the open standards and the Intel portfolio, will provide better resilience and optimization for improved density, power, and costs for the overall generation of networks.

So let's look at the benefits of the Intel Intelligent Fabric architecture. So the benefits fall into three buckets: intelligence, performance, visibility and control. For intelligence, it is a fully customizable P4-programmable pipeline. It provides intelligent packet processing for accelerating artificial intelligence/machine learning workloads; expandable table and buffer sizes with Intel FPGAs. On the performance side, we can start from up to 6.4 terabits per second all the way to 23.6 terabits per second total throughput. So it comes with 112-Gig SerDes lane, high-speed Intel Silicon Photonics, and better power optimization. And on the visibility and control, it provides better and enhanced congestion control. It will be able to identify delays or hotspots with real-time in-band network telemetry. That's a feature that we support. It will better analyze packet flows with Intel Deep Insight Network Analytics Software.

So at the heart of the Intel Intelligent Fabric architecture is the Tofino form factors. So the explosion in new services like 5G, IoT, augmented reality, virtual reality, AI/ML will require an unquenchable demand for bandwidth. The current data centers have outgrown and cannot scale to these new services, so we cannot solve the future problems with old techniques. That means we cannot squeeze more and more bandwidth from the existing silicon. We will need better processors. So, the Tofino 1, which comes with 16 nanometers, provides up to 6.4 terabits per second throughput, and then the second generation Tofino 2, which is built on 7-nanometer technology, provides up to 12.8 terabits per second throughput, which is just the double of Tofino. And then most recently, we launched Tofino 3, the end of last year, which is built on 6 nanometers, and provides up to 25.6 terabits per second, and also provides a modular chip design here. So, that's the best bandwidth you can get that’s available in today's industry.

So programmability, performance, and power efficiency. So the programmable switch enables composability, efficient pipelines by restricting the unused or even unnecessary protocols, and provides the ability to implement new or customized protocols, as service provider requirements or even enterprise requirements keep changing. This results in increased performance, better power optimization for hyperscale power use cases.

Intel's OpenBNG solutions. So Intel's OpenBNG solution utilizes disaggregated hardware and disaggregated software to create flexible and efficient network architecture. So by utilizing an open and disaggregated architecture, a whole ecosystem of collaborators can come together to provide the best fixed solution for service providers, enterprises, or whoever is implementing this OpenBNG solution. The legacy BNG, its functions are locked within a single piece of hardware, which is nothing but a black box, and zero room for innovation. This makes it quite difficult to manage and scale to the number of users. Our collaboration with Meta, APS Networks, Vodafone for the Telecom Infra Project will produce cost-effective and real-world solutions. The goal is to develop a solution that overcomes some of the most relevant and curious issues operators presently face when deploying services for fixed customers. For example, residential services; SOHO, that is Small Office/Home Office solutions. Our objective is also to overcome the challenges for continuous traffic growth, which not only affects design performance, scale, but also determines the most adequate location for broadband network gateway functionality, whether it is going to be a centralized location or it is a more distributed location. That is what we are going to specify as well. The Intel flagship products, as you see here, Xeon scalable processors, Tofino programmable processors, Ethernet ASICs, Intel Stratix, Intel Ethernet solutions seamlessly will fit into the openBNG solution, and on top of it, we have the P4 where it will be able to customize the solution as well.

So the TIP (Telecom Infra Project) is bringing together a lot of customers, ecosystem partners, so we have at least six service providers who are participating in the Telecom Infra Project with Vodafone, who you will be talking to in this webinar in a few minutes. British Telecom is contributing, Telefonica Brasil, Deutsche Telekom, TIM (Telecom Italia) are going to be our ecosystem partners for the Open Broadband Network Gateway partners.

So with that being said, I will hand over the baton to Andy Furnell from Meta. Andy, please go ahead.

**Andy Furnell**

Great, thanks, Babu. My name is Andy Furnell, and I'm an ecosystems manager for Meta Connectivity, focusing on Fixed Broadband technologies, and over the next few minutes, I'm going to give a quick overview to some of the work we've been doing in the Telecom Infra Project in that area.

So first off, let's talk about TIP. TIP is a global community of ecosystem players, who are collaborating together to develop a new generation of open technology. We're not a standards organization. TIP is not a standards organization. We saw many of them on the slides from Babu earlier. I think there's a lot of people operating in this space. TIP is something different. So TIP is taking the standards that are developed in those organizations, working to build technologies that are based on those standards, then working together to test those technologies, and then working as a community to get those technologies deployed, with really the focus here on getting the technology deployed. And I will explain over the next few minutes how we make that happen.

So first off, let's look at the technology that we build, and again, we heard from Babu earlier talking about the importance of openness and disaggregation, as well as some of the issues with some of the technologies that exist in the market today. When we talk to operators, the thing that they tell us the most is that they want more choice, that the existing solutions and products that they have available today to build their networks are based on proprietary equipment, with vendor lock between hardware and software, with proprietary interfaces between that hardware and software, and that limits the flexibility that they have in the technologies they use to build that network, which in turn impacts the level of innovation that they can show to their customers.

So what we're doing with TIP is we're enabling a new paradigm based on disaggregated hardware and software, building on similar work that's happened in the data center over the last 10 or 15 years from hyperscalers, and increasingly enterprise as well, to build these modular, open, disaggregated solutions that in turn enable operators to build multi-vendor open and disaggregated networks. In turn, those platforms are built using boxes that are enabling new supplier business models. We're breaking traditionally very large problems of hardware and software and integration between them down into a larger number of smaller problems that are enabling new business models for new and existing suppliers. The operators who are using those products are able to deliver new and innovative services to their customers, and in turn, improve the economics of their network, not just with a more competitive marketplace with more attractive capital commercials, but also with more cost-effective and more operationally-efficient devices and equipment that they can use to build their networks with.

So, let's look quickly at how we work with TIP. TIP is a member-led organization, and when we start a new initiative with TIP, it starts with an idea, a problem that operators want to solve, a new opportunity that they want to develop. We work together as a community to develop technical requirements for solutions that will address those ideas, and then together, we issue an RFI based on those technical requirements to understand where the markets are. That is a two-way process. It’s suppliers learning what operators need, as much as operators learning about what suppliers are capable of. When we complete that RFI, we then bring a test and relation framework into play. Again, a lot of focus on collaboration here. We collaborate together to build a common test plan, common across multiple operators, developed in collaboration between operators and suppliers. We work together to bring supplier solutions into shared labs. You can see some of them at the top right-hand corner of the screen at the moment. And then again, we work together to share the results of that testing back to the ecosystem and back to the industry at large via TIP exchange, where the whole industry can see a list of open and disaggregated products that have been tested by TIP members, and that are ready for deployment into production networks.

So that's the introduction to TIP. Now let's look at where BNG fits into the picture. So TIP has initiatives that span the entire telecoms network, from RAN to packet core, from Wi-Fi access points to optical networks, and everything in between. Last year we charted a new project group called Fixed Broadband with the objective to open up the telecoms ecosystem in that domain with a new generation of products.

We have two anchor technologies that we're currently working on. So a new initiative looking at the access network that began in January, and the group is about to publish our first multi-operator white paper describing a set of use cases for desegregated LTs that are useful for operators looking to build PON-based fiber access networks. And then we have Open BNG, which we're here to talk about today.

So before we get into OpenBNG, let's talk briefly about what a BNG is. For a fixed operator, the BNG, it's the point of concentration for all of their traffic and their services. It's the beating heart of their network, sort of analogous to a packet core for a mobile operator, and it provides many functions. We can see some of them on this page. There's simple things like routing and switching, but there's also much more complicated things like policy control, hierarchical QoS, and all of the interfaces northbound towards the IT stack. The BNG also provides the attachment point operators used to anchor services in their networks. Again, there's simple things like internet connectivity, but there's also more complex and valuable things like value-added services such as content filtering, managed security services, enterprise services, et cetera.

So OpenBNG, as it exists today, we're not inventing the-- OpenBNG as it exists today, we're not inventing the BNG from scratch, but what we're trying to do with OpenBNG is a little bit different to traditional BNGs, and there are three main components to this.

First off, OpenBNG is based on open hardware. That means that an operator can choose to install a variety of different softwares on top of that hardware, and there are no limitations on the software that can be used on top of a particular hardware, or the hardware that can be used to run a particular software. So a large part of the work so far has been for operators to describe what they're looking for from this open hardware, expressed using, again, common open standards. ONIE, Redfish are also standards coming out of ITU, IEEE, and other standards forms. And now, we're starting to see suppliers come forward with products that meet those requirements, with a diverse and global supply chain, which is a great thing for the industry.

At the heart of that open hardware is a chipset solution, some sort of silicon forwarding engine. And as you might imagine from the previous slide, the BNG function is very demanding in this area. We need deep buffers and complex hierarchical schedulers to manage the breadth of services. And we need resources to handle tens of thousands of subscribers, hundreds of thousands of queues, and millions of counters, which underpin all of those services at scale.

And there's a number of interesting solutions here. ASIC and FPGA, but also SmartNICS, x86, other options as well. So, the talk today is primarily about programmable ASIC and FPGA, but really this is only a part of the OpenBNG story. And there's a very vibrant community of options around the chipset space.

And then on top of this hardware, we have open software. We're not necessarily talking about open source here. But we are making sure that operators have the choice about which hardware and software combinations they want to use in their network, and the ability to change this over time. And Ayman is going to be talking about this in a minute or two.

So, for the next slide, I'm just going to be talking about the progress so far. The OpenBNG project started in 2020, with a group of like-minded operators working together to develop their technical requirements. Middle of last year, they issued the first RFI for OpenBNG. And as a result of that activity, they shortlisted eight suppliers, including APS Networks, who are here joining us today.

Through 2022, we've been working to bring those supplier solutions into operator labs. We have various POCs underway that are showcasing different capabilities and different suppliers in different use cases and scenarios. And we're also starting to work on the more rigorous evaluation of those products, which will ultimately lead through the TIP test and validation process to listings on TIP Exchange and commercial deployments as I described earlier. And you'll be able to hear more about this, we have an event later in the year in Madrid in October, TIP Summit, where we will be providing more updates about what we've been doing in test and validation.

That brings us up to date. So, please, any questions you might have, please feel free to ask them in the chat, or you can get in touch with myself or the other speakers directly if you want to find out more. And with that, I will hand it over to Ayman from Vodafone, who's going to be talking about what makes OpenBNG so important and valuable for their business.

**Ayman Hamza**

Thank you, Andy. Really very much appreciated your explanation here. I will start with my slides there, it talks about what it means for the operators from the OpenBNG perspective as a technology.

My agenda for today is focusing on three main topics. The first is the problem that OpenBNG solves. The second, what OpenBNG solution for the operators. And the third will be what OpenBNG technology is giving the operator from the business benefits point of view. Let's start with what problems OpenBNG, as a technology, is solving.

Well, currently, we are seeing the broadband operators are facing four major problems in the broadband market. The first one is the complexity of the multiple deployments modeling in the broadband network. Well, you have – mainly you can deduce that you have mainly three modeling like distributed deployment model of the BNG, centralized, and hybrid. While each model has its own operational risk versus capacity of bandwidth efficiency against a certain cost, all of these factors are mainly increasing the complexity of deployments. And also, at the same time, each operator has his own business values and architecture that he is trying to satisfy.

So, there is a high diversity of deployment modeling. This increases the bar against any new entrants as broadband operators going newly to the market.

The second problem that any broadband operator is facing is lack of competition. Lack of competition in the market, well, actually coming from the fact of having established players in the BNG market, each player has his own shares, established shares in the industry. Because of this, the innovation is slow and the CapEx is high to deploy for each established player or vendor. We are lacking the openness and the virtualized solution both together for BNG. This is due to the fact of having non-open standard OpenBNG hardware and software at the same time to deploy broadband infrastructure services for the operator subscribers.

The third problem or major problem that OpenBNG is trying to solve is the fact of having BNG as a point of focus in the network or a focal point of the network. Because everything is aggregated, I mean, the services and the subscribers are aggregated on the BNG, so the BNG can look like a bottleneck of the network. And also, this adds to the complexity of integration of the northbound APIs for BSS/OSS integration. This significantly will lead to the vendor lock-in for the broadband infrastructure.

The fourth problem that OpenBNG is trying to solve is the complexity in operation. The integration of BNG, because we have a lot of deployment models, as I said earlier, there are a lot of installation and operation activities and efforts. And also, this configuration and provisioning of the service and subscribers on the BNG might lead to a misconfiguration, which means a lot of risks in the operation and costs for the network to operate. That means also that you need automation and orchestration tools to openly automate the services of the subscribers in your broadband infrastructure.

What OpenBNG solution is bringing for the operators. Well, the solution itself is, as an OpenBNG technology, is mainly depending on three main pillars.

The first factor is the hardware and software disaggregation. The second is openness. And the third is the control plane and user plane disaggregation.

The first factor, which is the hardware and software disaggregation means I am decoupling the layers of software, hardware, and APIs integration of the BNG or the OpenBNG. That facilitates three main factors for any new players in the broadband market.

First, it increases the competition because every new player or every new entrant, as a vendor, will reduce the cost of ownership for the operator. This is due to the fact of decoupling the hardware from software. So, any operator can select the right software for his business lifecycle model, or the right hardware for a certain period of time of his business lifecycle. Also, it facilitates and speeds up the innovation based on the business roadmap of the operator as well as the roadmap for the new player in the broadband market as a vendor. Third, it facilitates the ease of swapping the pieces of hardware and software, whenever there is a better alternative solution available in the market. For example, if the operator has a certain feature that he wants to deploy, due to the fact of new technology or new business architecture for his business life cycle, he can easily swap the hardware or the software of the BNG or the OpenBNG.

The second factor of the OpenBNG solution is the openness. Well, from its name, you can imagine that I'm talking about the openness of the APIs and the northbound integration between the application of OSS/BSS and the OpenBNG through standard opened APIs. This will reduce the cost of two things.

First, the automation of the subscribers and services provisioning thanks to the ZTP. And also, it reduces the operation and cost of the network upgrades for the lifecycle of the management. For example, you want to upgrade due to a fix or due to the feature availability in the network operating system of the OpenBNG. Also, the openness is augmented with SDN. SDN will provide you with the automation tools for the services of the subscriber that drives the application being anchored to the broadband infrastructure of the operator.

Third is the control plane and user plane disaggregation. Thanks to the CUPS, the control and user plane separation technology broadband technology, the TR-459 standard. This will bring optimizing the network resources because the OpenBNG or the BNG itself will be part of the cloud. Augmented with subscriber session steering, the subscriber session steering, as a technology, will provide the right user plane selection for the subscriber session. For example, if we want to serve the subscriber with the right quality of experience parameters, for the sake of serving his application with the right quality of service parameters, or quality of experience parameters. Redundancy is a main factor for control plane and user plane, and the OpenBNG with CUPS and with redundancy, which is something essential, will provide reliability for the broadband network.

Interoperability is a key factor, and Vodafone, as a major operator, has done the first world testing for multivendor testing of broadband CUPS standard. And this link, which is at the bottom of the slide, you can click it during any leisure time of yours, so you can read the press release of our tests. You can see the involved vendors who were involved in the CUPS testing for our broadband technology standard testing. And you can see some information about these tests and what has been done for these tests. Also, this link is provisioned in the Attachment tab of your screen.

Now, I am heading towards the business benefits of the OpenBNG technology for the operators. Vodafone believes that there are three major technologies that brings benefits for the operators. And those technologies are available and satisfies all the business needs of operators. Those three business technologies are disaggregation, openness, and modularity. And as I said, all of them are available in OpenBNG. The OpenBNG business benefits are actually – which we will discuss later – are acceleration of innovation, increasing the freedom to select the right hardware and software. And this will increase the average revenue per user and, at the end, will reduce the total cost of ownership for the operators.

Let's start discussing the disaggregation as a technology. You will disaggregate using OpenBNG the hardware, software, and API layers, in order to mix and match software and hardware based on your business lifecycle needs as an operator. For example, you can start with software from Vendor A and hardware from the same vendor to start your broadband service. Maybe later for your business operation, you might need a new hardware with the same software vendor in order to scale ahead your services being provisioned for the subscriber. Maybe later as a third phase, you want to change both the software and the hardware from two different vendors in order to satisfy your business needs as a broadband operator.

The openness, as I said in the previous slide, will provide you with the augmentation of the SDN and opened hardware to integrate with whatever northbound applications seeking certain applications and business strategies for your business lifecycle as an operator. Thanks to the zero-touch provisioning as well, you will orchestrate and automate the provisioning of the services for your end subscribers, whether they are home users or enterprise.

The modularity that OpenBNG is picking up, as a technology, is providing the operator the freedom to choose between multiple packages according to their business. If you want, as an operator, to start OpenBNG with a lot of MPLS features, then you can start with PE software package or routing, and switching, or BNG subscriber management.

Benefits are very broad. We have discussed some of them like open APIs, best-in-breed selection of mix and matching software and hardware. No vendor lock-in because you can select, as an operator, which software and hardware you can choose. and the increase of flexibility for the business lifecycle that you can bring as an OpenBNG technology.

Open APIs will also provide a wide range of developers to develop applications for the broadband network.

Decoupling the hardware from software for the lifecycle of the business is very fruitful because this will increase the ARPU and will lower the total cost of ownership. And at the end, you will lower the cost of [commodity] of your hardware because, as an operator, you can select the right hardware for the right OpEx and CapEx mixture.

With that, I'm ending up with my slides. And I will hand it over to Alex who will present the part of the APS presentation. Alex, the platform is yours.

**Alexander Jeffries**

Many thanks, Ayman. Much appreciated. My name is Alexander Jeffries, I'm CEO of APS Networks. And I'll give you some background about APS Networks.

So, we're a European company with a huge amount of experience in open disaggregated networking going back many, many years. We also have got a huge amount of cybersecurity, network security background within our organization as well. So, we focus on developing and designing fully programmable hardware solutions for different industries. And whilst doing so, we do follow various security standards in the product designs and also how we develop software. And yes, we are a very close partner with Intel. And so, all our products are completely based on Intel and we are an Intel Network Builders Gold Circle member. And as you heard earlier, what Andy mentioned, we're also one of the shortlisted OpenBNG hardware suppliers. And in general, we do fully support open frameworks and standards and are subsequently also a member of TIP, and the OpenBNG project or Fixed Broadband project. Also, a member of the Open Networking Foundation, BBF and also the OCP.

So, Babbu earlier on talked and gave us more details on the Intel Intelligent Fabric, and what it's made up of, and the benefits that it actually provides to different industries and specifically to the telecommunications industry. So, what we've actually done, and we've designed numerous products based on the Intel Intelligent Fabric components. So, we've been working on this for many, many years. And we're making full use of the P4 programmable Tofino chipset, and also FPGAs with high bandwidth memory.

In addition, with additional high-speed memory of Peraso or formerly MoSys. And in general, our designs are completely modular. So, we do have a choice of multiple different CPUs with different configuration options around the storage and memory capabilities. So, all this is based on lots of feedback from different service providers who do have different requirements. And so, we can be flexible there.

Also, every CPU module or board is actually equipped with a TPM module, allowing for the TCG 1.2 and 2.0 applications, and also to add further security enhancements on top of the TPM module.

Apart from this, we do have a modular BMC support or BMC board in our products, which is based around the RunBMC framework by the Open Compute Foundation. And also here, we can add additional security features on top of this and we make use of OpenBMC. Apart from this, we do have additional PTP modules, which every product can be ordered with or without. And we have looked into the environmental footprint of our products and do look into the power efficiency and packaging materials used. Also, try to avoid unnecessary shipping paths. And subsequently, also all our products are built in Europe, and we source most of the components locally.

So, yes, with the P4 programmable hardware, this allows us to actually use the resources of the chipset effectively by just programming specifically the functionality we require. In this use case, it's BNG functionality. So, this allows to… it gives flexibility of using… you can scale the amount of users and subscribers on these platforms by using the resources efficiently. Also, what is key with this, with the programmable platform is that we can reduce the amount of software on the device. Hence, we understand fully the software bill of material, and it also reduces the security risk vectors by having less software on the device.

By adding the FPGA technology around this, we can actually support multiple layers of HQoS, and are fully flexible depending on the service provider’s requirements. Some operators have four layers of HQoS they need, others have seven. So, we do have the full flexibility with our products.

Our products are generally fully scalable, hence we can add a PTP board and do support Class C PTP accuracy and can support Classes A and B across the entire switch. And we do support different PTP profiles ranging from telecoms to default, or power, or media profiles, and also support the latest PTP secure protocols as well and profiles. And by using the programmable hardware, we do have the capability, as Babbu mentioned earlier on, to have telemetry and in-depth analysis and details of what's happening in a network. We can actually do advanced DDoS identification and understand if there's an attack happening on the network and prevent this from happening by using these kinds of technologies.

On the security side, we closely work with a company called A6 Labs in the UK where we can offer a complete turnkey end-to-end solution. Solutions around deep packet inspection, NetFlow IPFIX, and these kinds of security features within our products.

Our devices, they've actually been designed fully from scratch in Europe. So, we've looked massively into the whole security-by-design principles. We do take a big look into how we procure the components, where they come from, where they are sourced. For example, our PCBs, they're completely manufactured in Austria, so we know exactly what's in the PCB and that they're fully secure.

And we do look into the entire hardware, and also software supply chain, so we do fully understand where every single line of software within our devices actually comes from, specifically when we're using different open source technologies.

Also, with our products, they are very flexible, so we can have different security mechanisms in place ranging from secure boot to trusted boot options. We can protect the firmware on the devices or digitally sign the firmware on the devices. And in general, we do have a full secure supply chain management in place for our products.

So, what's also important, what we've heard quite a lot now by Andy and also Ayman is with a disaggregated BNG, what's very important there is that the hardware and software is interchangeable. So, this means one must actually make best use of open standards. As has been used in the server world for many, many years where you can buy servers from different vendors, have different operating systems on them, and also different applications. So, this is what's really happening in the networking world with disaggregation. And more and more standards are being met and brought into this ecosystem by the Broadband Foundation, Broadband Forum, sorry, and the Open Networking Foundation, or OCP. And things like SDN and zero-touch provisioning, open APIs to look into. So, we're following completely the open standards here making it easy for NOS vendors or for open source-based options to actually be deployed on our devices and supported.

And here's an example of how our products are actually deployed within a broadband network environment and we've borrowed these graphics from the TIP. So, we can actually be deployed from the access as like a BNG leaf to the core or spine. And speeds can really range from sub-one gig to 400-gig and beyond by using platforms like the Tofino 3 platform in combination with programmable FPGAs in our devices. So, the scalability is very large, and very flexible on all directions possible.

So, many thanks. And I'll hand over now back to Babbu.

**Babu Peddu**

Alex thank you very much. That was a great presentation. And also, thank you to Ayman and Andy.

Folks, I would like to close the webinar with just a couple of points. One, P4. If you might have got lost, what is P4 for some of you? P4 is a high-level programming language for expressing how packets are processed by the data plane of any programmable packet processing device, be it switches, network interface cards, network processing units, and programmable gateways, that is FPGAs, software, software switches, et cetera.

So, we at Intel, we are promoting a lot of P4 workshops which are free and you can definitely make use of them to get speed on P4. We'll provide the links for that as well. And one other thing is I also wanted to distinguish a bit on Intel's P4 FPGA hardware design against other available solutions in the industry.

So, Intel FPGAs provide extra scalability in delivering hardware-based quality of service and also, hierarchical quality of service. Intel's FPGA packet processing path for QoS and hierarchical QoS within the hardware enables better performance, better processing power for any tailored processing capabilities, or desired processing capabilities. When we need to do any customized packet processing using the P4, and software development kit capabilities. These are all implemented in the hardware.

These software capabilities include Layer 2, Layer 3 security, access control lists, headers, manipulations, and parsing actions, Layer 2, Layer 3 tunneling. And all these features are hardware-based and due to the FPGA existence contrast to other solutions doing it in hardware, but not in the FPGAs. That's the most important and vital point that I wanted to specify.

And then, so we already talked about P4 programmability, the business benefits of Intelligent Fabric, and OpenBNG solutions. So, we are having this Telecom Infra Project, that Andy mentioned earlier, later this year in October and November. We will soon start advertising that, so we will display our OpenBNG solution along with all of our partners and ecosystems. So, please look forward to that. And let's move on.

So, Brie, with that, I will hand it over to you for any Q&A. Please go ahead.

**Brie Hilliard**

Excellent. Thank you all so much for presenting today. Let's bring everyone back up on screen. Make sure that everyone’s cameras are working. Here we go. Thank you all for that great presentation. We do have several questions that have come in today. So, I'm just going to start at the top and go down.

The first one is “How do you expect operators will manage the contact point between software and the hardware platforms? And who will be the contact point for customer support?” Who would like to take that one?

**Andy Furnell**

Shall I start off with that one? And maybe Ayman can chip in from the operators here as well. I guess that, fundamentally, we're talking about something quite different to something that's existed before. And I think we see increasingly that operators are looking to have that direct relationship, both for hardware and for software.

In some cases, we see operators are taking on that integration, that contact point, or integration point between hardware and software themselves. In other cases, we see that there is one of the parties, typically the software partner, who is fronting that relationship and providing the contact point for the operator but also handling some of the integration between their software and multiple hardware solutions. And in other scenarios, we see that it's a third-party systems integrator who's coming in and taking care of the hardware and software integration. But also, quite commonly also, integration of that solution northbound into the IT stack, as well as east and westbound into other parts of the network as well.

So, I don’t think there's only one answer to that question. I think that there are, as with disaggregation, lots of choices of hardware and software. I think there's lots of different answers for how people are tackling that challenge as well. It depends really on what the operator wants to do.

**Ayman Hamza**

I want to just add a little comment from the operator perspective. Well, it depends on the troubleshooting, also experience, and modeling of the operator. For example, we are in Vodafone have our own troubleshooting, operation tools, and team. So, we are dealing with the problem as an interface from the first-level, second-level, and third-tier as well. And then we are integrating with the system integrator or the software vendor or the hardware vendor or all of them as Andy explained.

**Brie Hilliard**

Great, thank you very much. The next question is “Is there a list of OpenBNG requirements somewhere? Is it possible to see it and find out more?”

**Andy Furnell**

Absolutely. So, the technical requirements document that was produced last year, the high-level requirements for OpenBNG have been published. I believe we may have provided the link in the Attachments tab. If not, we'll provide a link for the attendees somehow, where you'll be able to access the high-level technical requirements for OpenBNG, which are giving really a sense of the business context as well as the high-level parameters of the solution. If you want to have a more detailed view of the requirements become a TIP member, join the Fixed Broadband Project Group and collaborate with us to help develop those more detailed views. Ayman will attest, we spent a lot of time over the last 12, 18 months. We have almost 2,000 technical requirements now for OpenBNG and a very, I think, refined and nuanced view of what OpenBNG should do. That, we'll be happy to share and discuss more with participants who are interested in engaging with the project.

**Brie Hilliard**

Excellent. Thank you very much. Well, with less than a minute left. I think we're going to end questions at this point. But I want to thank everyone for attending the webinar today. Thank you to our presenters. And if anyone has any future questions, please feel free to reach out to everyone directly. I've listed everyone's contact information here. And again, we will add some additional references in the Attachments tab as well as a full copy of these presentation slides. So, stay tuned. Those should be up within the next day or so.

Thank you everyone for attending today. Please don't forget to give our team a rating for the live recording so that we can continuously improve the quality of our webinars and be sure to join us next time. Intel Network Builders is regularly releasing webinars. So, there's always something of interest to everyone.

Thank you again for joining us today. This concludes our webcast.

**Ayman Hamza**

Thank you all.