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PRESENTATION

**Brie Hilliard**

Welcome everyone. I'm Brie Hilliard, Webinar Director for the Switch & 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 SRv6 Mobile User Plane: Breaking Barriers Between Mobile Network and Internet.

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 which 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 will use the information to improve our future webinars.

Today, we are pleased to welcome Babu Peddu from Intel, Satoru Matsushima and Katsuhiro Horiba from SoftBank Corp., and Keyur Patel from Arrcus.

Babu Peddu is 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 at Cisco, which include Cisco NFV and ASR 9K 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.

Katsuhiro Horiba received his Ph.D. degree from K-E-I-O University in 2019. He's now a Director of the Advanced Technology Research Institute of SoftBank Corp. His current research interests are telecom carrier network conversions using SRv6, network virtualization including radio access network, and network automation with model-driven and declarative approach.

Satoru Matsushima, Technical Meister at SoftBank Corp. is an engineer and architect in the telecommunication networking fields. He is a persevering mediator to leap the networking paradigm from legacy to modern, session to routing, and to go beyond Conway’s Law silos in the industry of legacy telecom mobile architecture.

Keyur Patel, Founder, and CTO of Arrcus brings more than 25 years of experience leading and executing complex networking projects at startups and market-leading public companies. Keyur was a distinguished engineer at Cisco where he has played an instrumental role in architecting and developing routing and VPN. Keyur holds more than 60 patents in areas of interdomain routing and security, fast reroute technologies, network service chaining, Layer 2 protocols, IPv6, TCP, VPNs, and routing virtualization technologies like optimal route reflection.

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

Now, let’s take a look at our agenda for today. Intel will start by discussing the data explosion and networking challenges, share a bit about Intel intelligent fabric, and then give a brief introduction to SRv6. SoftBank will discuss new requirements and technical challenges in Beyond 5G, the SRv6 MUP architecture and benefits, and give their insight on a vision for the future. They will then hand it off to Arrcus who will discuss their ACE Platform architecture and benefits, a bit about the ecosystem and integration, 5G mobile edge with SRv6 MUP, and key SRv6 MUP features. Lastly, we’ll close out our webinar with a live Q&A session. So, be sure to submit your questions throughout the presentation.

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

**Babu Peddu**

Thank you, Brie. Thank you, Brie. Hello everyone. Good morning, good afternoon, and good evening depending on where you are located.

Let’s start with some key takeaways. Networks are moving towards software. What it means? Many enterprises, telcos, and cloud service providers are moving towards software and programmable networks. This is due to low cost, reduced complexity, and ease of deployment. Programmable networks also offer better resiliency and optimization.

Next. Edge is transforming and automating every industry. How it is doing it? It is transforming with 5G, AI/ML, and having compute storage and analytics close to end process is gaining momentum. Examples of this would include autonomous vehicles, smart devices, security cameras, mobile devices et cetera.

Intel’s Network and Edge Group was purposefully created to deliver fully-programmable and end-to-end visible networks. Intel has the right vision, technology to partner with customers’ ecosystem, help build next-generation programmable networks.

So, this is a data point from Cisco Virtual Networking Index. If you see carefully here, during 2018, we had 3.9 billion of internet users. That was almost 50% of the world’s population. The prediction is by 2023, we will have 5.3 billion internet users, so that is more than 60% of the world’s population. So, we should ask a question to ourselves, so would the current generation of networks be capable of holding to the demand? Would the current generation of networks be capable of providing better bandwidth to meet this demand? Well, the answer is no.

Proliferation of programmable networks. So, legacy networks are very complex in nature. So, they come up with many layers of hardware. They come up with many vendor-specific protocols which many customers may not be using at all as well, but they have to pay the cost, ultimately, for all these black boxes. So, it also leaves zero room for innovation. So, enterprises, service providers, they are looking for networks that are programmable, that are – where they can go ahead and change as per needs actually. So, this has given rise to the proliferation of programmable networks. Part of Intel’s strategy is also to provide intelligence at the edge. We are doing it with AI/ML. This will significantly reduce the troubleshooting time for some of the networks. We have also registered, in some cases, where we’re using the network packet broker solutions, troubleshooting time has been reduced from four hours to almost 30 minutes, which has been a significant change.

5G networking challenges. So, globally, there is significant mobile data traffic. With 5G, there's going to be even more. This can be attributed to three main drivers. Improved device capabilities and increase in data-intensive content, and more data consumption due to continued improvements in performance of deployed networks. So, many service providers are now on a shift to cloud-native architectures with container-based processing, microservices, network orchestration, and automation. This change of workloads form the need for AI, they form the need for network optimizations as the industries migrate to cloud-native architectures and distributed scale-out architectures. And end-to-end security and visibility is always a consideration, but definitely not a backup.

Bottom line folks, for 5G solutions, networks need to get more smarter while increasing bandwidth.

So, we have looked at many industry insights, we have looked at the challenges, we have looked at all the issues. What is the solution for this? I wanted to present you the Intel Intelligent Fabric Architecture. This is loosely based on the Leaf-Spine technology, but also leveraged for service providers, data centers, and cloud service providers as well.

So, what does this do? It brings together a full Intel flagship portfolio that includes Silicon Photonics, Intel Intelligent Fabric processors, which is Tofino. Intel IPUs. Intel ethernets. These Intel Xeon processors. All of this will inter-op with industry standards that include P4 programming language, IPDK, Sonic operating system, SPDK, eBPF, DPDK.

So, this whole architecture brings more resiliency and optimization to the network architectures.

Let’s look at the benefits of this architecture. The benefits fall into three key buckets.

Number one, intelligence. It provides fully customizable P4 programmable pipeline. It has intelligent packet processing for accelerating AI/ML workloads. It provides an expandable table and buffer sizes with Intel FPGAs.

Number two, performance. It provides performance from 6.4 terabits per second all the way to 25.6 terabits per second. It provides high-speed Intel Silicon Photonics. It provides power-optimized hyperscaler use cases for Intel Tofino Intelligent Fabric processors.

Visibility and control. It provides enhanced congestion control with Deep Insights. It identifies delays or hotspots with real-time In-band Network Telemetry. It analyses packet flows with Deep Insights. Increases INT data available. INT is the In-Band Telemetry with Intel IPUs and Intel Network Adapters.

So, these are the three generations of – I'm sorry… three generations of Intel Intelligent Fabric Processors. The first generation is Tofino. It comes with 16 nanometers and provides up to 6.4 terabits per second. The second generation is Tofino 2, which comes with seven nanometers and provides up to 12.8 terabits per second, with a modular chip design. The third generation, which is sampling out right now to our customers provides up to 25.6 terabits per second, which is massive bandwidth and modular chip design.

So, the key benefits again, P4 programmable, AI/ML acceleration for troubleshooting, highly secure with end-to-end visibility. And performance, as we spoke, it is 25.6 terabits per second for the Tofino 3 generation. So, in-band network telemetry as well.

Programmability, performance, and power efficiency at the same time. So, the programmable switches enable composability, efficient pipelines by restricting the unused or unnecessary protocols. It also provides the ability to implement new or customized protocols as service provider requirements keep changing. This results in an increased performance, optimized power consumption for hyperscale use cases.

Now, we talked about many challenges. One of the significant challenges is the data explosion, and also the device explosion. So, that brings another problem where the IPv4 address gets depleted. So, how do we overcome this?

The solution for that is IPv6. If we support IPv6, we also need to support the services that come with IPv6, which is also called SRv6, Segment Routing v6.

So, what does it do? The internet protocol version adoption is growing at pace. So, Segment Routing is a new way of doing source routing where the source selects a path over a network, placing an order list of 128-bit IPv6 addresses into the header of an IPv6 packet. The SRv6 will be the next-generation torch-bearer protocol that combines Segment Routing and IPv6 together. Utilizing the existing IPv6 forwarding technology, SRv6 implements network programming through flexible IPv6 extension headers.

So, SRv6 has also been eight public – SRv6 has been deployed by eight public large-scale commercial networks including SoftBank. Also, there are many other hardware implementations supporting SRv6. So, the hardware implementation – Intel is one of them and Arrcus is also supporting… is also one of the vendors for that.

Why SRv6? SRv6 is an SDN solution for Source Routing. It provides powerful programmability, and a flexible solution for traffic engineering. It is easy to deploy. It uses IPv6 forwarding plane and does not require any complex MPLS protocols like RSVP or something like that. It also supports full hardware forwarding as well.

The Intel components for SRv6 are we support Intel Xeon processors, Intel Tofino, which is P4 programmable, Intel Ethernet, and Intel IPUs. So, I will hand over this to Katsuhiro-san from SoftBank, who will debunk this technology moving forward.

Katsuhiro-san, please go ahead.

**Katsuhiro Horiba**

Again, thank you for presenting the Intel solution from Babu. And SRv6 and the programmable network hardware like Tofino provides us the good opportunity to evolve the mobile – our mobile network.

Today, I would like to explain the new requirements of the 5G network like MEC and network slicing. So, I think after that, I would like to explain the program of these. And then Satoru-san, my colleague, will explain how SoftBank will resolve those kinds of problems using SRv6.

Yes, but first, I would like to explain the problem statement. Yes, this is a 5G network architecture. Maybe you guys looked at this diagram hundreds of times. Yes, the basic principle is very simple. The user equipment named UE is moving around lots of the radio access network called the RAN. Yes, and RAN is signaling the UE’s movement to the access and mobility management function called AMF. And then AMF creates the session information between the RAN and the UPF to the SMF. SMF creates the flow of information to the UPF, like OpenFlow. And basically, RAN and UPF is communicating with the GTP tunnel, that is very basic UDP-based tunnel to create the virtual socket. Yes, this is very basic mobile network principle.

However, in order to resolve this kind of new requirement, like Beyond 5G, MEC, Multi-Access Edge Computing is arriving at the 5G network. You would like to create a low latency service by putting the equipment and the UPF nearby the radio access network. Maybe you guys have to create a multiple PDU session between the RAN and the UPF, or creating the branching point to break the session to the very near UPF. That is very complex network rather than the simple 4G network.

And new requirement is – another new requirement is network slicing. In the 5G network, we would like to create a very rich service like VR or massive IoT or very ultra-low latency service for the automation – automatic drive or something like that. So, in order or realize those kinds of services, network slicing is necessary to create the multiple performance network using the – on top of the virtual network like these kinds of services.

But this diagram shows that the multiple PDU sessions like I explained MEC. And this is also very complex network to manipulate the mobile network.

Yes, and in order to realize those kinds of new requirements, we have to have new challenges in Beyond 5G. However, the specification is not ready or not implemented in the standard, because most of these kinds of specification is very difficult to realize that. And of course, the application development could be changed drastically because the – if you want to create the MEC services, you have to create the new API to signaling the mobile network. The application programmer has to follow those kinds of new manner. That’s a big problem for us.

And we are thinking about the root cause of these issues are the mobile network is most – very traditional circuit switching network. Yes, before I mention that, we have to create the IP-based tunnel between the radio access network and the UPF. That is kind of the very similar network architecture like circuit switching network. However, we have evolution called the internet using the packet switching network. Packet switching network is something like unlimited connections and very scalable network.

However, sometimes it’s kind of the best-effort quality but most of the internet services working on the packet switching network, and maybe MEC or network slicing features is already implemented in the packet switching. So, why don’t we use the packet switching network for the mobile networks?

Again, this is the diagram that is reality in the mobile network. Yes, of course the 5G network diagram is true. However, most of the networks, we have a very big IP network that is a packet switching network, and the mobile network is a very big – like a very big operator network on top of that.

So, why don’t we use the packet switching network? Very straightforward. So, we are thinking about a time to change the paradigm for the mobile network. Yes, most of the standardization is on top of the circuit switching network at this time. But we have two new requirements like MEC or network slicing, so we have to create the advanced feature on top of the existing mobile network, like a circuit switching network. However, maybe we can create those kinds of features on top of the packet switching network, because packet switching network has already implemented those kinds of additional functionalities. So, we would like to add on the mobility functionality on top of this kind of IP routing packet switching network.

So, this is a very – overview of how to implement the mobility functionality on top of the IP routing network. Yes, dynamic routing is basically advertise the network behind the provider edge network. This is very basic principle from MPLS, not only the SRv6.

Yes, and basically, UE is moving around lots of radio access networks. So, in that case, if we can advertise the UE locations to the IP and routing network, that’s going to be mobility functionality.

So, this is our near-term solution. We would like to combine the mobile network core – mobile core network and the IP routing network. Yes, as I mentioned before, SMF has session information for the UE, so we would like to tell the UE information, session information to the IP routing network. Then IP routing network follows the moving-around UEs. So, it’s very simple, but very good solution for the IP to realize the mobility function on top of the IP routing network.

So, after my presentation, Satoru will present how SRv6 realizes those kinds of integrations.

Satoru-san, please.

**Satoru Matsushima**

Thank you, Horiba-san. I will follow Horiba-san’s presentation with the content of the SRv6 MUP architecture and benefits.

So, as Horiba-san mentioned, the MNOs currently are building up the 5G network, as you can see. We developed the UPF, you can see in the middle of the slide on the left-hand side, smartphone connected to gNB, gNB connected to N3 network. On the right-hand side, DN, outside the cellular network connected to N6 network, which is connected to UPF. The UPF controlled by the 5G core control plane functionality such as AMF/SMF.

So, next slide. So, from Segment Routing point of view, the user plane looks implemented like this. In the middle, you can see Segment Routing network. The Segment Routing network hosts the N3 VPN and N6 VPN. The N6 VPN consists of the N6 RAN VRF, N3 UPF VRF. Each VRF supports to – accommodates the connectivity for the gNB and the UPF side. And also, the N6 VRF provides the connectivity between the UPF and the DN.

So, this is what we are doing with our SRv6 MUP. But from the packet path point of view, the packet forwarded on the detour path, not to just go through the Segment Routing, because all of the traffic needs to go through the UPF for some reason, anchoring the mobility or any other functionality required. So, it’s obviously, it’s not optimal.

So, what if we can do this? The traffic from the smartphone to internet just goes through the Segment Routing network only, not just touch to UPF. So, if it’s possible, we need to do some network priority for interworking between DTP and SRv6. And the left-hand side, we need to do some optimal data routing towards the mobile devices from internet side.

If we can do this, we can save much cost-saving because all the traffic will not need to go through the UPF. We can save the bandwidth of the network to support the UPF connectivity.

To do this, we need architecture. Because the 5G architecture is not suitable for this packet path. We need to establish a new architecture to support this optimization and cost saving. In addition to what Horiba-san mentioned, we need to acquire new architecture.

So, we at SoftBank, and our partner company together propose the SRv6 MUP architecture to IETF. The SRv6 MUP architecture enables that Segment Routing for mobile user plane as you can see in the previous slide. SRv6 MUP architecture is like this. This is actually not required to change the 5G architecture, just plug-in, because the SRv6 network, it’s just a network to carry the 5G packet. Each node no additional node type, because we just use the PE router in front of the access network and DN network. No change 5G, just plug-in.

So, SRv6 MUP architecture consists of three entities of the node: the MUP controller; on top of that, the transform 5G core session information to IP route information, and then advertises that information to the PE router.

On the right-hand side, the PE router translates the GTP and SRv6 in stateless manner. Then no need to introduce additional state in the middle of the network.

On the left-hand side, the GTP router as well, but this GTP router forwards the packet and routes the packet to the mobile device following to the routing information advertised from the MUP controller.

So, let’s see inside of the PE router of the translated GTP SRv6 in stateless. On the left-hand side, you can see the code. I don’t think I can explain much detail now, but you can find the IETF draft to explain the SID code. The SID code actually does this on the right-hand side. The GTP packet – the header includes the IP analysis of the GTP TEID. Although the ID embedded into the SRv6 signature, it’s IPv6 address format. Then its own required ID information embedded in SRv6 identifier enables us to do this stateless translation between the GTP and SRv6. That’s the magic of how we can achieve the stateless translation between GTP and SRv6.

So, the beginning of the phase of our work, we measure the performance by acceleration with the hardware with the Tofino chipset with the P4 coding. The performance measurement was accepted at the scientific paper. You can see the right-hand side, the performance of the GTP and the SRv6 demonstration creates it is negligible. You can find this paper from the IEEE site. Please find that if you have interest.

The latency aspect. The difference, it’s a little bit decreased, but in operational aspect, it’s negligible as well compared to the other basic functionality just GTP encap/decap, and SRv6 encap/decap.

So, let’s see the detail on the MUP controller. Again, the SRv6 MUP is a routing architecture. So, we need to do this networking with the routing manual. So, we need to define the routing protocol extension. We adopt GTP – sorry, BGP to carry the 5G core session-related information. So, this is the other magic of the SRv6 MUP to transform the session to routing. We define the new SAFI to carry the 5G specific information like TIED and other related information.

From the routing point of view, we don’t need to distinguish the other deployment case like MEC, because the routing daemon are running on top of the MEC server. So, then we don’t need to deploy an additional UPF. As we can see in this slide, the normal 5G architecture requires additional UPF to build up the N9 network. And also, the additional N6 network to connect – to accommodate the MEC server. We don’t need to do that in SRv6 MUP.

So, future vision. It is obvious, as Horiba-san mentioned, we just need to transform our network from session to routing. If we continue the session-based networking, you can see the red tag networking, which is fragile and very costly. But if we can transform our network to routing-based, the network would be stable, robust, and very much cost-effective.

So, we have a demonstration movie. I ask Brie to play this video.

**Voice-over**

SRv6 transport network here in the middle. To the left, UEs, a gNB and a SMF exist in the 5G Core simulator connected to the MUP-Gateway and the MUP-Controller. At the bottom PE1 connect to the UPF and to the right, the MUP-PE1 connects to the DN and the MUP-PE2 connect to the MEC Server. All the software on the router is the Arrcus product ArcOS and the MUP-Gateway in particular can run on Intel’s Tofino chip. MUP-Controller and MEC server are running on Intel’s Xeon processors.

This demo topology is instantiated over a virtual lab using these network simulators.

Let’s start 5G simulation. At the demo beginning SRv6 MUP is disabled. So, you can see the MUP-Controller is disconnected from the SRv6 network. However, mobile sessions signaling are flowing.

Let’s pick up one session and look into it. You can see the session is established for user with an IP address, like this. Let’s look at N3 interface packet. Let’s pick up one packet between UE and MEC server. It has GTP-U header, like this. Let’s check inside the SRv6 network.

Let’s pick up one packet. You can see the SRv6 header and it encapsulates the GTP-U packet. This means that packet needs to be forwarded via UPF along the path like where you can see. Now, let’s connect the MUP-Control to the SRv6 network. It means SRV6 MUP is enabled. Here, you can see the traffic graph and find UPF traffic goes down to zero. But still the traffic is flowing end-to-end. This means that the traffic is directly forwarded by SRv6 MUP instead of by UPF.

Let’s pick up one packet in the SRv6 network. You can still see the SRv6 header, but it now directly encapsulates the customer packet and there is no GTP-U header inside. GTP-U header is no longer required as long as SRv6 MUP enables end-to-end traffic forwarding.

**Satoru Matsushima**

Thank you very much. So, I skip the summary statement. But we can see this, SRv6 is not to touch the 5G architecture change, but with much optimization and cost-saving.

So, Keyur-san, please continue to presentation. This is your slide.

**Keyur Patel**

Thank you so much, Satoru-san.

Hi folks. My name is Keyur Patel. And Satoru-san and Horiba-san gave a fantastic overview of how SRv6 mobile user plane looks like and architectural reasons for deploying it in 5G mobile networks.

I'm going to talk about how Arrcus helps bridge the gap between 5G to IP networks with SRv6 MUP as part of Arrcus’s product offerings.

I'm going to talk about our ACE platform, architecture and benefits of our platform. Then I'm going to talk about how SRv6 MUP fits into our platform and its offerings, specifically through ArcOS on gateways, PEs, controllers, and MEC nodes. These are the different components, networking functions that together make up the 5G SRv6-based MUP user plane that we talked about. And finally, I'm going to talk about key features that are required on our side to realize the new architecture that we are talking about.

As you know, 5G provides a lot more faster and bigger bandwidth compared to 4G and 3G. However, the 5G network deployments must address limitations of existing mobile architectures in areas of scalability, programmability, and distributed compute. Some of which Satoru-san described it wonderfully earlier.

We have also seen in the demo that was shown where SoftBank, Intel, and Arrcus has together showcased a new user plane fabric, what we call as 5G Mobile User Plane Fabric, which not only provides simplicity by providing a common underlay, and end-to-end traffic engineering. But addresses these limitations also using Intel’s Tofino platform, Arrcus’s programmable fabric, and SoftBank’s vision to execute this into a next-generation 5G network.

When you look at the delivery of 5G services, what is required out of 5G network is that the network should be very flexible and programmable. From a programmability standpoint, it should support GTP to SRv6 and vice versa, translations using merchant silicon. It should also drive routing programmability through the user controllers wherever it’s needed. It needs to have a flexible network that spans across different networking functions with gateway, PE, and/or controller and helps build an end-to-end network that can realize end-to-end traffic engineering.

And you could do that using SRv6 as a forwarding fabric or a plane, and when you do that, now you have a way to deploy new services like MEC or network slicing in a 5G mobile network wherein you can deploy and yet realize, obviously, the economies of scale that you want out of such a network.

So, SRv6 here becomes the glue and an integral part of such a mobile network that is being deployed to realize the new solutions.

So, let’s talk about what we have to offer at Arrcus. We have something what we call as an ACE Platform. At the very core of this platform is our own ArcOS operating systems that can run on different form factors of switches and/or routers. That’s the basic part at the very low end. Then on top of it, we help build, using the same OS, extend the OS to help build overlays wherein you can have soft routers. We deploy into cloud. The cloud could be AWS, Azure, Amazon, Google Cloud, anything, or on-prem that could help you connect with various kinds of hardware form factors on-prem.

And on top of that, besides our programmability, analytics, and automation layer, it’s an API-driven architecture at that point. It has orchestrators that help you orchestrate and deploy and manage the lifecycle management of soft routers in the cloud and also has a deep visibility platform that can give you near real-time analytics from the control plane as well as the forwarding plane perspective. So, this, when it comes together all the three layers, builds an ACE platform.

The kind of stuff that this platform helps address when you start to look at any networks, but particularly in this context, 5G like networks, any data center deployments for Leaf, ToR, Spine/Splines. Any peering/edge routers that you need to deploy to connect to internet. Anything that requires you to aggregate the port densities that are over and above that is provided by merchant silicon-based routers and switches, and it can scale up to all the way – up to 2,100-Gig loads of a non-blocking system.

And last but not the least, anything that you need to deploy in cloud when you want to interconnect your switches and routers to cloud-based networks and provide a seamless connectivity across these different networking components.

From a switching and routing standpoint, this software allows – the platform itself allows you to address anywhere from one gig connectivity to 400-gig connectivity both on switching as well as the routing side, all provided through a single operating system, what we call as an ArcOS. And to which it connects to any third-party applications on a northbound. When you talk about streaming telemetry using Kafka, gNMI, gRPC. And when you talk about orchestrating it using different orchestrators that support NetCom/AI-based models.

So, you can see through our ACE Platform, we can cover different software components as well as hardware form factors that are required to build this next-generation SRv6 MUP-based fabric.

So, let me tell you a little bit about how we went and how we designed this. The operating system itself has a microservices-based architecture, which means it’s available in container as well as VM form factor. It has the ability to separate the control plane from the Linux kernel, which means upgrades can be done very efficiently and done in a manner that lowers the downtime on the routers, as well as switches, which is pretty good from an HA standpoint. It is very modular. You can choose the components as you want to build what you call as a software systems for routers and switches. Hardware-agnostic, it can deploy on any processors as well as any networking silicon, merchant silicon.

It has a layer, what we call as our Data Plane Adaptation Layer that virtualizes the silicon just in the way the hypervisors virtualize compute. The northbound, like I talked about, is fully programmatic through RESTCONF, NETCONF, and from a modeling standpoint supports open config AI.

For real-time telemetry, we use JSON and we can stream this out very efficiently using Kafka, gRPC, gNMI, or any means of transports that are needed by our operators.

Last but not the least, from the fabric standpoint, it supports IP and MPLS, and obviously, SRv6 as a fabric when you look at it in the context of 5G itself.

So, when we start to look at what Satoru-san and Horiba-san were talking about earlier from 5G MUP user plane standpoint, mobile user plane standpoint, we have gateway functionality that we use alongside with merchant silicon, wherein we use it to convert GTP to SRv6 and SRv6 to GTP, depending on which side of the traffic you are looking at. We have route controllers that can efficiently disseminate routing information using scaled BGP implementations that can support thousands of route updates very efficiently, and can scale up to millions, hundreds of millions of paths as it’s a 64-bit implementation, very scaled implementation.

And then we have the PE side of the functionality that allows us to implement both multi-tenancy as well as direct connections towards the internet where we have an ability to do IP SRv6 or IPv6 very efficiently.

Last but not the least, we have software versions of the implementations that can reside on compute-based infrastructure that can also help terminate SRv6 connectivity when you are trying to enable the MEC infrastructure that speaks natively SRv6 as the fabric.

So, you can see now using Arrcus’s products and its offerings, how through our ACE Platform we can help enable different points in the networks that requires you to build the SRv6 fabric end-to-end.

This is the demo topology that you just saw, and you just saw the demo itself. You can see here how Arrcus and Intel has worked together to build platforms and products that allows us to target various different points in the network for the 5G mobile user plane.

Right, so from the functionality standpoint, here are a list of features from SRv6 MUP standpoint that are needed on gateway, PE, and controller’s point of view. One thing I would like to highlight here is specifically the MUP-PE has the fast-reroute functionality that allows us to do sub-50 milliseconds forwarding convergence in case of network disruptions where it often times like link failures as well as node failures that can allow the traffic to reroute very efficiently. So, a collective list of features. This also includes, moving forward, the BGP control plane changes that Satoru-san talked about earlier.

And with that, I conclude my presentation and over to you, Babu.

**Babu Peddu**

Thank you, Keyur. That’s a very good presentation and I also appreciate the team from SoftBank and yourself for the wonderful seminar so far.

So, guys, I wanted to call out that with P4 and network intelligence, the industry can benefit out of customizing data flows, they can rapidly innovate and adapt to changing workloads. The industry can also benefit out of simplified deployment and newer services, better allocation of bandwidth and resources, prioritizing the traffic engineering, or traffic shaping. They also can get better and improved operational flexibility and enhanced visibility while reducing the operating expenditure and the capital expenditure.

So, P4 is the way to go. Programmable networks are the way to go. So, that’s the conclusion statement.

So, with that being said, what I will do is I will pass it on to Brie if there are any Q&As. So, happy to take that right now.

**Brie Hilliard**

Great, thanks so much, Babu. And thank you everyone for presenting. I’ll bring you all up on screen so that we can address some questions.

We have a few questions that have come in from the audience along the way. So, let’s start out with one for Arrcus.

“Can the software also run on VM environments or in containers?”

**Keyur Patel**

Yes, it can, both in VM as well as containers where – and on any form factor that you may want to deploy.

**Brie Hilliard**

Excellent. Thanks so much. Here's one for Intel. Babu, what are the typical use cases from the Intel Intelligent Fabric Architecture that you mentioned?

**Babu Peddu**

Yes, that’s a good question. So, the P4 programmability enables limitless flexibility with intent-based networking and enables multiple use cases. And they range from customization of network solutions for efficient scale, increased performance, and enhancement of existing networks. Capabilities such as real-time telemetry, Deep Insights, security into the networks, AI/ML, natural language processing, and Layer 4 load balancing are extremely good cases for enterprise network solutions, service providers, and cloud service providers.

**Brie Hilliard**

Excellent. Thanks so much. And then we've got a question for SoftBank here as well. Many operators have just made their upgrade to the 5G network. What would be an additional investment needed to implement the technology to the network?

**Satoru Matsushima**

Thank you. I will take this question. I believe I mentioned in my presentation to do the SRv6 MUP requires just PEs which is not different from the basic 5G core deployment, because the 5G network also needs the IP network. If the network is Segment Routing, we use the PE router the same as – the same as the SRv6 MUP deployment.

So, the additional network programmability requires the GTP SRv6 functionality. But the future chipset or software router can do that thing. So, if you are in the middle of the way of the 5G network construction, you can adopt other options to deploy the SRv6 MUP not to touch to the 5G network architecture change or modification.

**Brie Hilliard**

Great, thank you very much. It looks like that concludes our questions. So, let me just bring up our final slide here again so that everyone closes out with everyone’s contact information.

If you have any additional questions or for our on-demand viewers, feel free to reach out to our presenters directly. They are always happy to receive an email and answer any questions that you have.

And then be sure to join us next time. Intel Network Builders on this channel regularly has webinars that are airing, typically every week or other week. So, be sure to check those out.

Actually, we have one more question that just came in, so we might as well address that.

Let’s see, let’s bring us all back up. We have another minute or two. “What were the most challenging areas to bring this SRv6 P4 programmable capability innovation to the market? Is the major advantage simplification and operations, performance, cost, or all of these things?”

**Babu Peddu**

Keyur, do you want to take that, Keyur?

**Keyur Patel**

Sure, I can take that. From our perspective, doing it on a programmable pipeline meant a lot, because that avoids in the first case use of any ASICs, and ASICs-based architectures are very expensive, we know that. So, in that context, the programmability gave us that flexibility.

The second part is simply looking – and therefore, when you look into the programmability aspect, the challenge was how do you fit the instruction set within a certain limited pipeline is what we were working very hard to get it going with.

And second is the control plane implementation that we are looking to do, which in itself has an interesting set of challenges when you start to design them. Because you really need high-power operating systems that has all the right elements in place before you start to build a control plane like what we are talking about here with SRv6.

**Babu Peddu**

Great, so let me add onto that. It also provides composability as well using the P4 programming language with Tofino. That means whenever customers create policies and if the hardware doesn’t match with that, the P4 will be able to adapt to that new policy and align it to that new implementation. So, there's another advantage of P4 and SRv6.

**Satoru Matsushima**

I want to comment. I agree with him completely. From the operator point of view, we need to be aware of how much resources remain for the pipeline, and also the architecture and control plane needs to develop to utilize the network programmability to deploy—

**Babu Peddu**

Absolutely.

**Satoru Matsushima**

—network.

**Babu Peddu**

Totally, yes.

**Brie Hilliard**

Excellent. Well, thank you all so much. Really appreciate you coming and taking the time to present to our audience today. We are right at the hour so we’re going to close it out right now.

Thank you to our viewers for joining us 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 thank you again. This concludes our webcast.

**Babu Peddu**

Thank you.