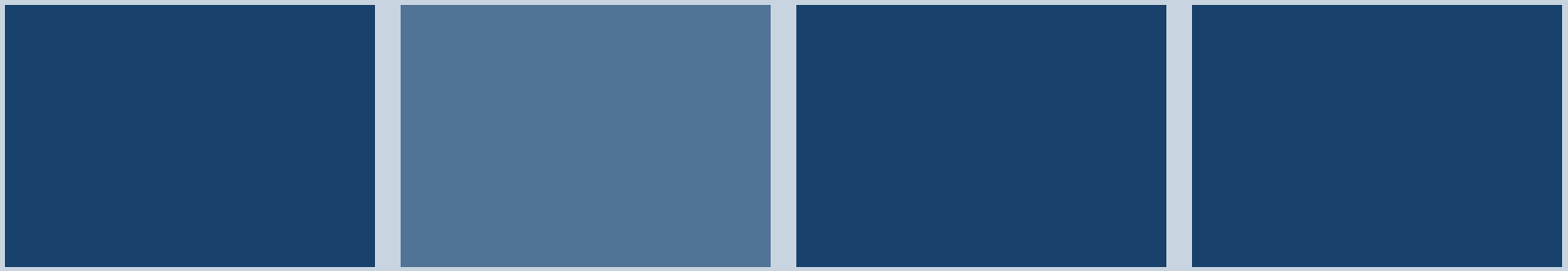
# MOVERS & SHAKERS



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## INFINERA
### *WITH DR. STU ELBY*

December 2015

*"We Accelerate Growth"*

# Movers & Shakers Interview *with* Dr. Stu Elby SVP for Cloud Network Strategy and Technology at Infinera

**By Ronald Gruia, Director Emerging Telecoms, Frost & Sullivan**

We were honored to have a chat with Dr. Stu Elby, SVP for Cloud Network Strategy and Technology at Infinera. Dr. Elby has over 30 years of experience in the telecoms, video and data center domains. Prior to Infinera, he had a long tenure at Verizon, where he served as the VP and chief technologist of Verizon Labs and was responsible for developing Verizon's technology vision and target network architecture to support emerging products and service.

***Ronald Gruia: Dr. Elby, thank you for chatting with us today. We have a full agenda of questions that we hear from our clients as we go through some transformations, such as SDN and network traffic keeps on growing by leaps and bounds. To kick things off, when do you think we will hit an inflection point for 100G+ metro optical buildouts worldwide for telco operators, MSOs and Web2.0/ cloud providers? Are carriers typically having fewer routing nodes in their metro networks than in the past, and are they increasingly leveraging optical transport and switching capabilities whenever and wherever they can?***

***Dr. Stu Elby:*** I believe that for most carriers and MSOs, 2016 will be an early inflection point, marking the start of the ramp up, and 2017 we will see an even higher uptake. Service providers that build FTTH solutions are early adopters of the higher-capacity Metros. The 10G wave is most prevalent in the metro environment for now. Having a large wireless network also drives a lot of this buildout activity, but I don't think this is a universal drive. There are two different architectural approaches: one in which you centralize a lot more of the traffic, and the other using a number of appliances running software in the cloud (the so-called "smart edge routers"). The latter one is the NFV/SDN use case at the edge, providing services that way, solving the same problem. The bandwidth increase requirements will

be high, with broadband access and a lot of services to go with that, so edge routing can get quite expensive, hence NFV to the rescue…. We started seeing some 100G metro optical activity at the end of 2014 with initial deployments, with the ramp starting in 2015. The industry projects this to take off in 2016, with telcos, MSOs, Web 2.0 and cloud providers being engaged.

***Ronald Gruia: Stu, based on your Verizon experience, how do most carriers plan out their rollouts for metro and long haul? Are these typically independently funded? How can we model the carrier CAPEX spend—is it associated with end-customer demand and traffic load patterns in their networks?***

***Dr. Stu Elby:*** Well, for a large operator, typically, the metro capacity management is separate from capacity management for long haul. The 100G+ metro and long-haul rollouts are independently funded. The CAPEX is pegged mainly to the next few years' growth rates in end customer demand and the traffic loading patterns in the network; it's a granular model.

The buildout will take a while, more like three years, and depend on end-customer demand for metro optical services. The backbone network modeling is all about capacity, while the metro is about capacity growth, but also delivering services. A large operator like Verizon has business customers asking for Ethernet services and such; coupling that with other demands on its metro network, such as 4G traffic backhaul, will make it necessary to have 100G optical transport speeds in metro regions, which aligns with its 100G long-haul optical network.

***Ronald Gruia: Will 4G backhaul traffic make it necessary to have 100G optical transport speeds in the metro regions?***

***Dr. Stu Elby:*** We are in the middle of the 4G rollout cycle right now, so it will take a while…. If you are looking at North America, there is not really that much coming up in terms of spectrum auctions. The LTE tower traffic is growing, and there is still a lot of 10G out there. Things such as social networking, video, bandwidth-intensive applications and sharing of user-generated content that is going to your laptop—it's a lot of small pieces that will drive up the requirements. Also, don't forget about small cells, and eventually 5G, which will be another step-function coming up starting around the 2020 timeframe.

***Ronald Gruia: What is the role that SDN will play in these rollouts? Is the technology mature, particularly when it comes to orchestration, or do we need to see some more progress?***

***Dr. Stu Elby:*** It's definitely mature enough to be rolled out. Infinera did this back in March with a large carrier, delivering Layer 1 packet services (Telstra's Pacnet deployment). This deployment has been live since then, and offers high-performance, self-provisioned, dynamic network services across the points of presence of the old Pacnet footprint. It's a globally connected, on-demand networking SDN-enabled platform.

The business model allows customers using their datacenters to pay for bandwidth at the packet or optical layer—no contract needed. Let's say you need 50G from Hong Kong to Sydney for an event—you pay for this one-time, network-on-demand without needing a contract, so it's quite unique. We helped set up an automated, multi-vendor network with centralized management and control. This is the essence of SDN.

The setup also involved a self-service Web portal that their customers use to make the request (i.e., when

they want it to start and when they want it to end, etc.). The orchestration layer is fundamental, for it enables a new business model: bandwidth on demand, or pay for use, like the voice minute in the old POTS network. This without having to lay down a circuit, which leads to more sharing of the resources, higher utilization or better resource efficiency, giving the customers the capability to order a service on demand. This is one example of SDN in action, but there are many other business models that are possible.

***Ronald Gruia: Related to this question is the notion of orchestration, automation, network management—are these very distinct topics or do we have some sort of overlap among the three of them?***

***Dr. Stu Elby:*** SDN and network management are two separate topics—they can overlap, but if you look at the whole topic of network management, it involves all sorts of things such as fault management, configuration, etc. When you look at what the ONF (Open Networking Foundation) focus is, it's mainly about configuration management; that's what they are trying to solve.

Based on my experience, only about 20% of an operator's time is spent doing fault management, and 80% of the time is just for provisioning—that's the 80/20 rule of operations. This rule is an industry-wide number that keeps getting mentioned at various conferences.

With SDN, you are taking functions that are perhaps in silos across the layers of a network, or across vendor-specific infrastructure, and bringing them together via a centralized view. You are providing automation for provisioning tasks such as adding new nodes, capacity or services.

SDN is all about configuration management in an automated fashion. More automation means fewer hands-on, manual processes. Then you also have the topic of OSS/BSS, which can get very complex. The promise of SDN is that it can also create a next-gen OSS/BSS that is more automated and self-learning. We could be solving a big problem here.

***Ronald Gruia: What is the market opportunity within the orchestration or the control plane, considering Ciena's purchase of Cyan for approximately $488 million? Do we look at those two TAMs separately?***

***Dr. Stu Elby:*** Well, that is a subset of the overall OSS/BSS market, which is huge. Most large infrastructure vendors have their own solutions, while other players rely on partners. It is a big area, no doubt, and perhaps it's a number that can be a multiple of a few times that figure. But it is also a very complex problem to solve. From a carrier's perspective, you can view orchestration as your own business layer, and that is unique to every operator, whether you are talking about a hyperscale Web 2.0 player like Google or a carrier like Verizon or AT&T. Often, you might also need to bring in professional services in order to help the carriers' IT departments. But to create orchestration, you need to have someone integrate it into the business layer. So it's no longer a "shrink wrap" product, and you need to bring in talents from different arenas—for instance, Accenture for integration and professional services, and Mirantis for OpenStack.

***Ronald Gruia: Consequently, given the recent focus on SDN and NFV, are players like Infinera and Ciena moving "up the stack," transforming themselves from optical vendors to packet optical vendors and then augmenting their offerings with SDN/NFV (witness the Ciena acquisition of Cyan)?***

***Dr. Stu Elby:*** This is certainly the trend. That said, quite a few previous attempts of following this strategy have failed. For instance, Nortel buying Bay

Networks—they did have the vision about the "right angle turn," but in the end did not quite execute. Ciena also did this a while ago, buying World Wide Packet in order to deliver Ethernet-based carrier services.

If you buy a small company and bring them in, you have to do a good job integrating it… particularly if their expertise is in the software domain. But the combination can be a good one. For instance, for the packet switching card that we have, adding services (such as IP VPN) requires a lot of software expertise and traditionally the optical engineers did not have that.

With SDN, which separates the control layer from the hardware, you can spin up a team that writes the software—the packet logic for the hardware. SDN lowers the hurdle to make this blend of talents a successful one. Also, software is a lower-cost business to be in, with people writing code rather than doing ASICs, which entail a multi-year investment. You take less risk with software…

***Ronald Gruia: Who do you expect Infinera to run into the most within the context of SDN? What about multi-service domain orchestration? Would it be a different set of competitors?***

***Dr. Stu Elby:*** Our competitors have historically been in the optical domain, so you can think of a player like Ciena, with which we split the market in North America. Then there are quite a few newer competitors such as Huawei (not in North America, but in many other parts of the world), but they are multi-faceted network equipment vendors.

The packet players are definitely taking a very keen interest in SDN and also augmenting their capabilities elsewhere, so you can think of a Cisco, which also bought Tail-f, then more networking-focused vendors such as Arista, with which we have a partnership. SDN still is an emerging market, and there is no "shrink wrap" SDN. If you look at what Telstra did with Pacnet, they had to create an ecosystem and simply could not go to a single vendor. Because of the nature of SDN, we will not see a single, all-encompassing package put together, but you will see a bunch of vendors, each focusing on a separate piece of the puzzle and contributing something to the overall solution.

The market is wide open right now, so you should not try to build everything, but instead see what the problems are with the customer base that you have and focus on solving them. Our own approach is to do it in an open fashion without vendor "lock-in," so if a carrier wants to use someone else's controller, that's fine. This was the philosophy behind our relationship with Arista, as we complement each other well.

***Ronald Gruia: What about the datacenter optical, i.e., the interconnection of Web-scale datacenters at 40/100G+ throughputs? Is that opportunity beginning to be realized now? Are those Web 2.0/Cloud/SaaS datacenters running ~100k+ servers per data center beginning to deploy optical interconnects between datacenters?***

***Dr. Stu Elby:*** Earlier this year, we launched a 100G optical platform for datacenter and carrier network interconnects as part of our Cloud Xpress datacenter interconnect family of products. We're very pleased with our early traction, and we believe we're still the only company with a purpose-built solution that is on the market today. We're still at the early stages but in a great position to succeed as ICPs continue to deploy new datacenters and built their DC infrastructures in a way that will require state-of-the-art DC interconnect solutions to handle traffic demands.

Ramp-ups in 100G metro, long-haul, and datacenter interconnect will continue to be the story in 2016,

with an inflection point happening. Our datacenter business unit at Infinera is seeing that, and the Web-scale players are going to push the envelope—companies like Google, Facebook, Amazon and Microsoft; it's a pretty broad category in which we have strong customer traction.

***Ronald Gruia: Photonic Integrated Circuit (PIC) technology—can you explain it in a bit more detail? How is Infinera positioned in this particular area with its 500G+ PIC-based optical systems?***

***Dr. Stu Elby:*** We already are on our third generation, and our first one went commercial back in 2005. Some people get hung up on the name. ICs allow multiple functions to be integrated onto a small form factor, and Moore's Law says you will get a big jump in performance every 18 months, so we applied that to photonics. The latest generation is from 2012.

We have the DTN-X, our multi-terabit optical transport platform, which leverages the 500G super-channel PIC on a line card. The same PIC is used in the Cloud Xpress. The advantage of ICs: power, reliability… you control the solution out of the box—the system is incredibly reliable; the Cloud Xpress draws 1W per Gig—that's the entire box—the chassis, the power supply, the interfaces to the routers, etc. That cannot happen without photonic integrated circuits.

By producing our own PICs, we are able to reduce our cost per wafer as demand grows. That's a true differentiator that is evident from our increasing gross margins. As I said, we have the third-generation chip and have been using it since 2012. We also have a roadmap where we will be going to terabit and multiple terabits, and we have that sustainable roadmap thanks to integrated circuits. Going forward, PIC technology is the key building block for the scaling of bandwidth. And PICs will be a must have in order to get the cost points and the densities that carriers like a Verizon are after.

***Ronald Gruia: Moving forward to the future, when do you think a carrier like Verizon will be interested in 200G and 400G upgrades for metro and long haul? Is there a desire by operators to optimize their fiber usage with the maximum optical transport capacity that is technologically and operationally possible?***

***Dr. Stu Elby:*** Verizon is already doing 100G today. They have 200G in the long-haul environment, and will likely be doing it in the metro environment. Also, you have to consider two things: the capacity of the fiber and the speed on the channel. Infinera is already at 500G speed on the channel.

Obviously, carriers want to optimize their fiber usage with the maximum optical transport capacity that is technologically and operationally possible. There are a lot of schemes out there—BPSK, QPSK, 8-QAM, 16-QAM…. The idea is to get more bits per Hertz—more fiber capacity.

We are achieving the 10 terabit range now, but next you go to 20 terabit range. But you still can't take a 16-QAM over several hundreds of kilometers. What's really needed in the longer run is a flexible modulation scheme so that as you turn up, say, 16-QAM and when needed for longer reach, you drop it down to 8-QAM. That's something that doesn't exist yet, but I think that's something that could happen. The other piece is fiber, with a whole bunch of wavelength ranges (bands). You have C-band, S-band, L-band, with more frequencies that could be used on top of what is being used by fiber today.

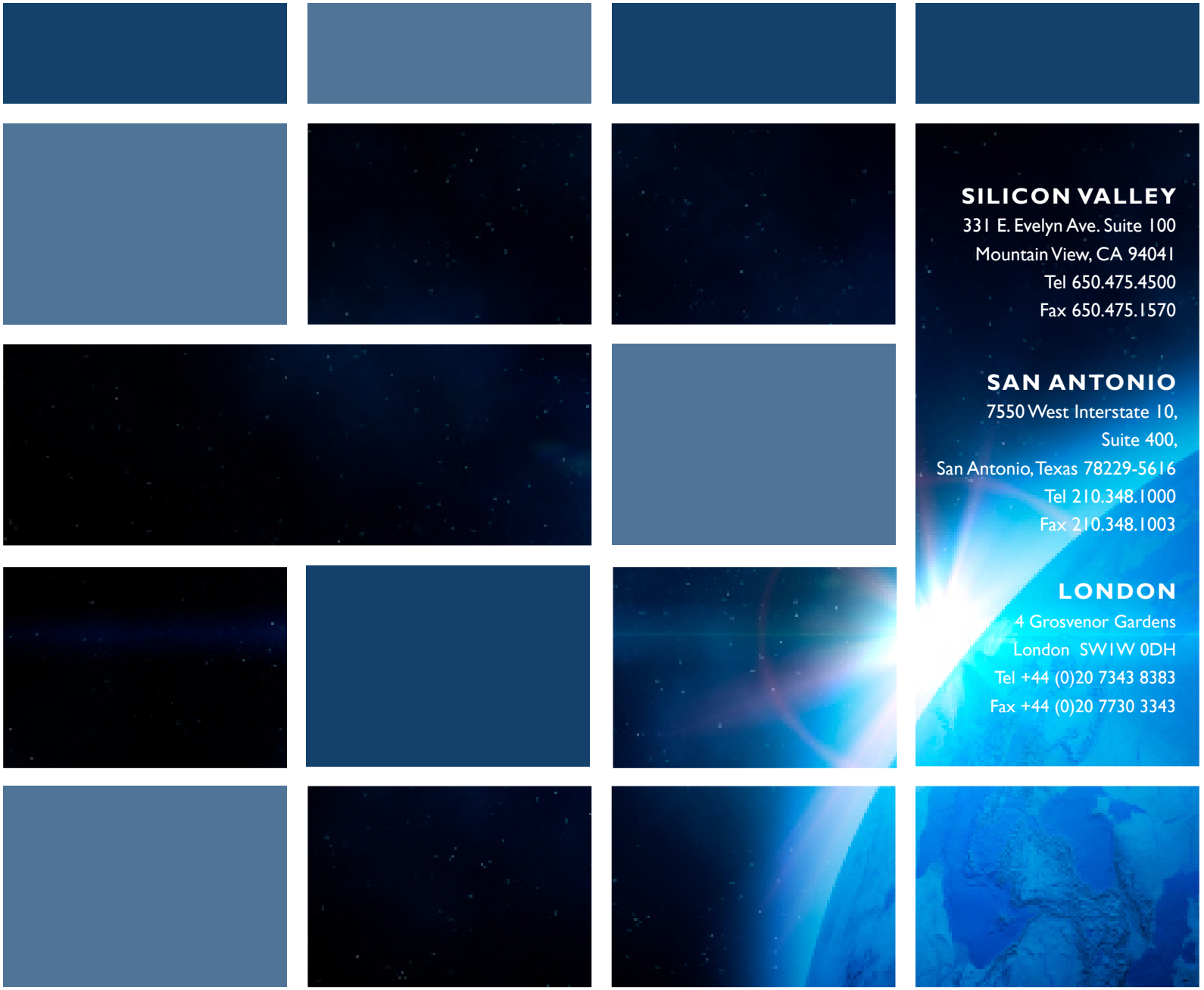
***Ronald Gruia: Related to that but on the datacenter side of things, when will Infinera have a Terabit scale datacenter optical offering?***

***Dr. Stu Elby:*** We published some material on our portal, including white papers, a video demo, etc.,[1] on the industry's first single-card terabit PIC field trial. This was done last year with Dante on GÉANT's production network between Budapest, Hungary and Bratislava, Slovak Republic. This was a single-card, single-chip super-channel, and large-scale PIC technology makes that a practical reality. Of course, we cannot reveal our going forward plans, but you can certainly expect terabit optical boxes in the future that will improve on the cost basis of existing boxes.

***Stu, on behalf of Frost & Sullivan, I wanted to thank you for taking time out of your busy schedule to talk to us today. Your insights are really appreciated, and it was extremely useful to hear your views from both the demand and supply side. Special thanks also to Reno Ybarra from Engage PR, who helped set this up. Again, our gratitude for your input, and we look forward to continuing our dialogue going forward.***

**Ronald Gruia is the Director for Emerging Telecoms at Frost & Sullivan. He can be reached at rgruia@frost.com**

1 For more detail, please visit: http://www.infinera.com/go/terabit-trial/



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