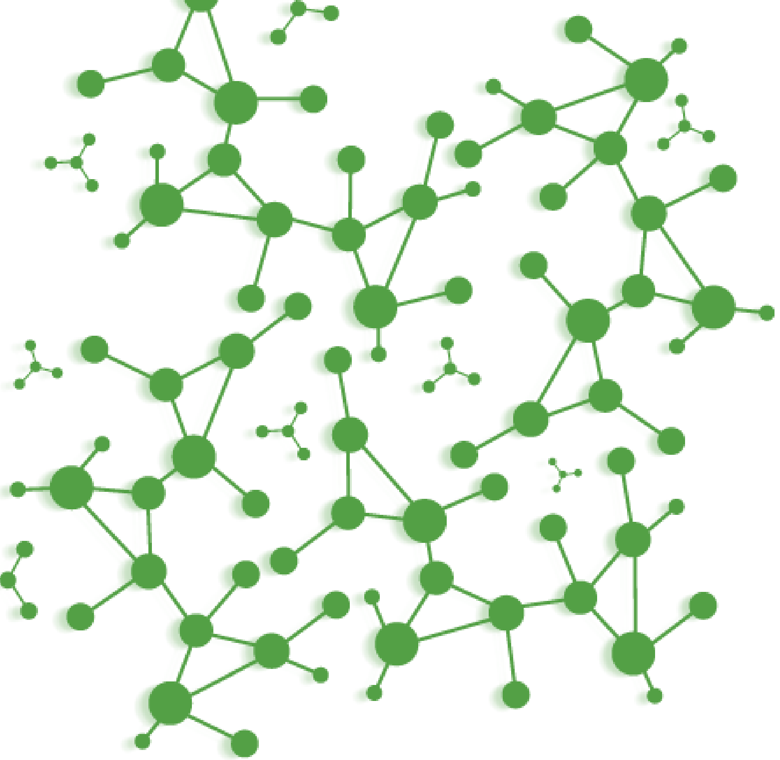

Multiband, adaptable small-cell backhaul

A conversation with Adam Button, CEO & Mike Pettus, CTO VubIQ

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By Frank Rayal
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Frank Rayal. Hello, and welcome to this conversation with VubIQ. My name is Frank Rayal. This conversation is part of Senza Fili's report on small-cell backhaul, which gives an update on small-cell backhaul solutions and on the evolution of the mobile operator's requirements for small-cell backhaul. Today we are talking with Adam Button, CEO of VubIQ, and to Mike Pettus, CTO of VubIQ. VubIQ is an innovator in the small-cell backhaul space, particularly focusing on the 60 GHz band.

I would like to turn it over to you, Adam, and start off by asking you to give us a brief introduction about your company and your small-cell backhaul solution.

Adam Button. Sure, Frank. Thank you very much. VubIQ has been around for about 9 or 10 years now, exclusively focused on 60 GHz technology. We have developed products in the R&D market (for example, components and development systems), and we also build video links, creating products that transmit uncompressed high-definition video wirelessly at 1.5 gbps. These are for broadcast applications.

Our video link offerings led into a nice order with the National Hockey League to equip every net in the NHL – all thirty teams and all thirty venues – with GoalCams. These are high-definition cameras looking at the goal area to adjudicate whether or not a puck crossed over the line. The GoalCams are positioned in the back of each net, with the HD camera on one end of the unit focused on the goal line, and the other end wirelessly transmitting uncompressed video at 60 GHz up to the judging booth.

So we not only have theoretical and lab applications, but real-world applications of 60 GHz links. We are now moving into telecom, and are developing some very interesting products for small-cell backhaul utilizing both the 60 GHz band and also another unlicensed band, 5 GHz spectrum, for a dual-band solution.

Frank Rayal. This is a very interesting proposition, so the solution you have, the HaulPass, is a dual-band product that covers both the 60 GHz and the 5GHz bands. Can you elaborate on that?

Adam Button. Sure. We are unlicensed spectrum advocates, and I believe that there are tremendous advantages to using unlicensed spectrum versus paying for licensed spectrum. Both the 60 GHz band and the 5 GHz band we are using are unlicensed, and we are incorporating both of them into a very efficiently integrated unit that will be able to transmit backhaul for small cells, both line of sight over 60 GHz, and non line of sight over 5 GHz.

The 5 GHz band can act as a failover – for example, if you've got a line-of-sight connection at gbps speed and something happens, like a huge rainstorm, a truck passing by, or tree growth over time – anything to block that line-of-sight path – our system will immediately and automatically fail over to the lower 5 GHz frequency to maintain availability.

Frank Rayal. What sort of capacity and throughput can the HaulPass provide in the 60 GHz and 5 GHz bands?

Adam Button. At 60 GHz we are at a full gbps speed. Actually, the overall data rate is 1.25 gbps in full duplex, but the payload is basically one gbps, full duplex. At 5 GHz, we are using a 4x4 MIMO implementation of Wi-Fi that allows us to achieve 600 mbps. So with both radios operating at the same time in a line-of-sight condition, the total aggregate throughput will be 1.6 gbps in both directions.

Figure 1. HaulPass SC 5/60 GHz small cell wireless backhaul system featuring automatic antenna alignment. Source: VubIQ

Frank Rayal. Achieving 600 mbps per second for the 5 GHz band is tough to do. How do you achieve that?

Mike Pettus. The interesting thing about what we are doing is that we are using 802.11n technology in the product and 4x4 MIMO. 600 mbps, of course, is the peak physical-layer bit rate that we can achieve. There are four antennas at each end of the link for the 5 GHz band surrounding the horn antenna for the 60 GHz band. There is good antenna diversity in terms of the 4x4 MIMO, with both polarization and spatial diversity.

The other advantage of using 802.11n in a point-to-point application is that we have the ability to optimize the controls. These systems are not being used as access equipment, of course; they are being used in point-to-point bridge mode, and in so doing, we will optimize for maximum throughput, maximum bandwidth, highest interference mitigation with the knowledge that the other end of the link is us.

In other words, it is a closed system, and because it is a closed system, we do not have to deal with 802.11n access point issues, and the system is basically in a point-to-point bridge mode. We have turned on all of the high-throughput, high-bandwidth controls in the 802.11n MAC, such that we maximize throughput for our benefit.

Frank Rayal. One issue that is associated with unlicensed-band solutions is the interference and latency, especially when it comes to 802.11n-type products. How do you address operator requirements? Can you comment on what you hear from operators on the latency requirements?

Mike Pettus. The expectation for millimeter wave is very low latency. Our latency, including forward error correction, is less than 20 μsec on the 60 GHz link, and the 802.11n latency is less than 1 msec. We achieve those very low latencies on 802.11n because we have full control over the MAC and we turn off a lot of the access point features on the MAC. So the interesting thing is that the 802.11n does have the ability to be a very low-latency link if you have control of both ends, and that is what is important.

Frank Rayal. What other requirements do you hear from operators on small-cell backhaul, and how does your product meet those requirements?

Figure 2. HaulPass micro SC 5/60 GHz small cell wireless backhaul system. Antennas are fixed. Source: VubIQ

Mike Pettus. The other requirements that are becoming very, very important in carrier-grade networks are not only the physical layer requirements – getting throughput and latency down to where they need it for LTE – but also at the next layer, we will call it layer 2 or even layer 2.5: Synchronous Ethernet, IEEE 1588, PTP timing, for the new LTE-Advanced systems.

In order to achieve the capacities they need, they are moving to time-division duplex (TDD). When you use time-division duplex in a very dense network, you have to give very accurate timing and phase information to the small cells in order for them to achieve their capacity.

Our radios are fully compliant with 1588v2 and have GPS timing availability, and we are using a combinational algorithm in our synchronization and timing – I will call it 1588 with GPS assist – such that there is a fallback mechanism. Some carriers are saying GPS is great, and they are even using it in their small-cell base stations as a method for synchronization, but they do not count on it. There may be interference or a situation where small cells do not receive the GPS satellite signals, and in that situation we fall back to 1588 completely. In that mode, the version and the implementation of the 1588v2 that we are using gets us to less than 500 nanosecond phase error at the small-cell base station, and that is very important for synchronization.

Frank Rayal. Can you maintain the same type of synchronization over the 60 GHz as the 5 GHz band?

Mike Pettus. The 5 GHz will probably have a wider window of synchronization error than the 60 GHz, simply because of the packet delay variation numbers that you incur at 5 GHz versus 60 GHz. So, again, the theme behind this product is that we have multiple methods of delivery for both payload and synchronization.

We have two bands, and 1588 and GPS. We feel by putting all of the tools from the tool kit into a single product is how we achieve extremely high reliability in this system.

To answer your question further, we also handle full security. Not only we are transparently transporting IPsec, which operators may use in their network for security, but we also are implementing MACsec 802.1AE, MAC layer security so that every segment – if there are repeated segments of wireless backhaul – is protected and encrypted with AES 256-bit encryption, as well as being able to transport multiple streams that are isolated from each other.

What we see happening in the business model is that backhaul networks may actually transport competitive carrier streams in the future. Your equipment has to be ready to isolate and encrypt for each payload stream, and we are fully implementing MACsec at the layer 2 portion of the product.

The other features that we provide are full MPLS and full QoS capability. The customer can configure the QoS parameters and a full set of OAM capability for monitoring and configuration. So, more than just a physical radio link, we see these units being placed out into the backhaul network as very capable network nodes. And what is going to happen is an evolution from a point-to-point network to a partial ring, partial-mesh.

Adaptability is the key word here, because when operators get out into the field and they realize where they have to put their small-cell base stations, it is not as clean and as nice as it was when installing macro cells. They just have to adapt, and the products have to be ready to work in that kind of an adapted environment.

Adam Button. One reason we have some expertise in this area is because Mike ran engineering at Metricom for about eleven years. Metricom, as you may know, put out wide area networks, wireless networks for people to access the internet before Wi-Fi even existed. They were putting up radios on top of street lights and light poles outdoors in the city that were talking to each other in mesh configuration. This is remarkably similar to the current challenge for the small-cell infrastructure that we are looking at today – the major difference being that the radios today are about 1,000 times faster.

So we've got a lot of experience in real-world issues, and are developing our products knowing that when a truck rolls, what is listed on a plan or a map is not always the case, because there may be a building, a billboard or a tree or something in the way, and you have got to be able to adapt when you are out in the field.

Frank Rayal. This is very interesting, and there is actually a whole different area in terms of the logistics. What are your thoughts on this, having had this experience of doing it in the past? And how did you design your product in order to make it even easier to deploy and save cost from a deployment and implementation perspective?

Adam Button. I will make a quick comment on that before Mike answers, but – one of your questions before was: what are the carriers looking for, and what are we offering the carriers? Cost is clearly of huge importance to the carriers.

Now I am not talking just capital cost of the equipment itself, we are talking total cost of ownership. While our units will be very competitive on a cost basis alone, where they really shine is by minimizing the total cost of ownership because of the second major feature of this unit, which is automatic alignment and maintenance of a link.

So when you set up the link, it makes it very easy for a low-skilled installer to plug it in and walk away, without requiring the time, sometimes hours, needed for two installers, one on each end of the link, to get them set up and aligned, and to optimize the link and minimize the bit error rate. That takes a lot of time, and when you multiply that by the hundreds of thousands of small cells that are going to be deployed over the next few years, you see the installation cost is going to be tremendously high.

This is another feature that differentiates our product, not only from other categories, but from other 60 GHz solutions, and we think that it will be of great benefit to the carriers.

Mike Pettus. The auto-alignment and auto-stabilization feature of the HaulPass SC is key for carriers whose business models require a lower opex. In other words, if they want to minimize installation time and installation labor, the HaulPass SC is the product to go after which provides the auto-alignment. Because the installer can put it up, and he has no idea where it is pointed, he just installs it, connects it and goes away. It is literally a ten-minute install, and what happens is the system itself automatically provides alignment of the link.

In millimeter wave this is critical, because the antenna beamwidths at those frequencies are on the order of 2 to 3 degrees, so it requires very precise alignment.

Auto-alignment is a great thing for reducing the opex, because many of the platforms that they will be mounting on, like light poles, move in the wind, and for millimeter-wave links, this can be a disaster, because you can fall in and out of the beam as the pole is swaying. So the same mechanism that provides alignment also provides stabilization within a half degree. This is a big win in terms of the ability of the carriers and the installers to minimize their overhead and maintain a very reliable link.

To answer your second question, of how we provide an answer to an adaptive environment, you hear a lot these days about self-organizing networks, or SONs. Most of what they are talking about is at a logical layer, and of course we do that. It is a given that you have to be able to adapt addresses and new nodes that appear and disappear in the network, but because we have the auto-alignment feature, we can physically do self-organized networking.

One of the carriers said that they move things around from time to time. They want to move the positions of their base stations around, and this is a big win when you have an auto-alignment feature.

Frank Rayal. So in terms of availability of the link and also in terms of the ongoing maintenance, that is a major cost saving. How wide can the alignment be? Can it be done vertically or horizontally?

Mike Pettus. If you look at the HaulPass SC product, the auto-alignment range in the azimuth – we will call it the pan – the range is 360 degrees; and the auto-alignment range for the elevation – which is rotating up and through, on the vertical plane – is plus or minus 120 degrees, or 240 degrees total. So it has a lot of adaptability to point just about anywhere.

Adam Button. And it can be installed inverted, upside down. So you essentially have omnidirectional capability.

Mike Pettus. Yes, so if you are on a tall building and you have to point down at a steep angle, you can actually invert the mounting of the unit and it will point down that way.

Frank Rayal. Going back to the 60 GHz technology, is there anything that you are doing that would be differentiated from other 60 GHz solutions? Can you also give us a flavor of the 60 GHz market and how you fit into that?

Mike Pettus. The 60 GHz technology that we are using is now on the order of four years old, and we have a lot of history of developing 60 GHz. Our fundamental core technology is at 60 GHz, and the key issues with developing a reliable and manufacturable 60 GHz product are in getting around the problems of packaging.

You know about integrated circuits: they have little leads, and then you put them down on the board, and it is very simple. At 5 GHz it is a simple matter: you buy chips and you put them on a board and connect them to an antenna. At 60 GHz you cannot use the same techniques to get the energy on and off the die or the chips, because of such a high frequency.

Our waveguide module – you can see it on our website – is the core technology inside these radios, which is a very producible and reliable 60 GHz element in the radios. This points to the fact that our manufacturing cost is low for producing a millimeter-wave radio.

The other performance issue with these products is that some techniques at 60 GHz are lossy. If you do not do this right, you will lose energy or signal. We measure it in decibels, and if you have enough loss, you impact your range. Our packaging is patented – the entire packaging that we use for waveguide interfaces and 60 GHz die interfaces are all protected under our IP. The losses incurred in these packages are less than a decibel, and at 60 GHz this is very important. This points to performance, simple performance.

Adam Button. And, Frank, we have been shipping silicon-based 60 GHz products since May of 2008, just about five years next month. So we have a tremendous amount of experience and IP: whether it is actual patents or just trade secrets, we have a tremendous amount of experience and knowledge when it comes to building highly efficient, low-cost 60 GHz products.

Frank Rayal. You obviously made a conscious decision in going into unlicensed bands, 5 GHz and 60 GHz. How do you see that comparing to other solutions on the markets? Solutions that use, for example, microwave frequency, line of sight, point-to-point or point-to-multipoint, and also non line of sight.

Mike Pettus. Faster, better and cheaper. Adam said earlier, we are unlicensed-band advocates. We absolutely believe that technology solutions are going to be faster and more effective than policy-driven solutions, such as licensing.

That is the first thing, and if you look at all of the current technologies that are going to be deployed in LTE – such as OFDM, MIMO, coding – were developed in unlicensed technologies, specifically in IEEE standards, five to eight years before the cellular industry adopted them. So unlicensed technology usually gets more quickly to market with very high-technology solutions, very effective solutions, before the licensed users get to them, number one.

Number two, interference is a big question, and you asked that earlier, and I want to address that. Interference controlled by allocating fixed spectrum for users has been used traditionally in radio ever since the FCC came into existence – that is how interference has been controlled on a licensed basis. What has happened in the world of radio is the big word: digital. Digital radio techniques – OFDM, dynamic frequency selection, coding, and also MIMO, which is one of the biggest things during the last ten years – are the best solution to interference. Rather than saying, "I'm going to allocate a piece of spectrum, and no one else can use it but a certain entity or the licensee."

The third reason: Licensed spectrum by definition, especially below 5 GHz, is narrow-band. You might get a 10 MHz or a 20 MHz license; you might get it for an area, or you might get it nationwide at great expense. But the 5 GHz unlicensed band is on the order of a few hundred megahertz wide, and the FCC made a statement at CES in January that now another 195 MHz is being added. So it is not only a better technical solution – the policy makers are now realizing that unlicensed solutions are a good way to go, such that they are giving more and more spectrum to unlicensed operations. So we are big advocates of it.

On interference mitigation, at 60 GHz interference mitigation is basically the physical layer. 60 GHz has a very narrow beamwidth, and the falloff due to oxygen absorption, which at one time was considered a bug, is now a feature, especially in dense networks. The isolation, and therefore the network density, that you can provide at 60 GHz is unbelievable compared to other spectrum bands.

And at 5 GHz the impact of using MIMO for beam steering and also beam nulling, if there is an interfering source at a given angle from the radio MIMO, has the ability to null out that source dynamically on a packet by packet basis.

So our answer is: let technology figure out the interference solutions, rather than policy.

Adam Button. You also mentioned e-band and 70-80 GHz solutions that are also millimeter wave. These are light-licensed solutions, and people would say, "Okay, it is very simple: you get on the web and you fill out a small application for the link and pay a small fee and no problems, it is a minor issue." Again, when we talk about rolling out tens of thousands, hundreds of thousands of small cells, each requiring backhaul, that becomes an entire huge process, another administrative process that is going to add cost to the carriers.

Frank Rayal. I've got one final question and that is about your roadmap and the evolution of your product. Where do you see taking the product next?

Mike Pettus. The roadmap for this product, which is a high-bandwidth backhaul product, simply points to one major area, which is bandwidth. We see the bandwidth going up over the next few years in the 60 GHz spectrum; at the end of our roadmap, we see 60 GHz carrying up to 10 gbps and we see more spectrum being added to the 5 GHz band, which gives us, again, more spectrum and more wide-band channels.

The first parameter that you will see change as products move along in the backhaul is bandwidth and, of course, the LTE-Advanced Release 10, and Release 12 coming around the corner. What is the major change that they need? More bandwidth, and that is at the top of the list.

Below that you will see a product lineup, with a variation of products that fit certain needs. There will be variations on the number of ports, the capability to cascade and mesh, and these types of things. So as the network complexity grows, the products have to adapt to be able to work in those highly complex networks.

Frank Rayal. Well, thank you very much, Mike and Adam, for a very insightful conversation. This conversation is part of a Senza Fili report on small-cell backhaul that provides an overview of small-cell backhaul solutions along with in-depth conversations, like this one that we just had, from leading vendors who participated in the report. The report can be downloaded from the Senza Fili website at **www.senza-fili.com**. Thanks again, Adam and Mike.

Mike Pettus. Thank you again for having us. We appreciate it.

Acronyms

AES	Advanced encryption standard
CEO	Chief executive officer
CES	Consumer Electronics Show
CTO	Chief technology officer
GPS	Global positioning system
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual property
IPsec	Internet protocol security
LTE	Long term evolution
MAC	Medium access control [Layer]
MACsec	MAC security
MIMO	Multiple input, multiple output
MPLS	Multiprotocol label switching
NHL	National Hockey League
OAM	Operation Administration and Maintenance
OFDM	Orthogonal frequency division multiplexing
PTP	Precision time protocol
QoS	Quality of service
R&D	Research and development
SON	Self-organizing network
TDD	Time-division duplex
v	Version

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About the author

Frank Rayal is a telecom industry professional with over 20 years of experience working with network operators and system vendors to develop and deploy innovative wireless solutions. He is a founding partner at Xona Partners a boutique management and technology advisory firm specialized in TMT and a founding member of small cell backhaul pioneer BLiNQ Networks. Frank held senior product management, marketing and business development positions at Ericsson, Redline, and Metawave. He holds a BS in Electrical Engineering from Case Western Reserve University, Cleveland, OH, and a MSc in Electrical Engineering and an MBA from the University of Toronto, Canada. Frank is a Senior Member of the IEEE, and a member of Professional Engineers Ontario.