A Spectrum of Opportunity with 5G

A conversation with Rob Topol, General Manager of 5G Advanced Technologies in Technology, Systems Architecture and Client Group, Intel

By Monica Paolini, Senza Fili

This interview is part of the "5G: Redefining the Connectivity Paradigm" series

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The technology, standards and ecosystem for 5G are getting to the finish line. But do we need 5G? And do we need it now? And, just as important, can we afford it?

Rob Topol, General Manager in the 5G Advanced Technology Clients and IoT Business Group at Intel, shared his perspective on these topics during a conversation on the opportunities that 5G opens to service providers, users and communities – in both high-density and resource-scarce environments.

Monica: Rob, can you give us an introduction about what you do at Intel?

Rob: I work in 5G Advanced Technologies, which is a group that focuses on pathfinding of wireless technologies and puts together the right pieces of a technology.

We have a new air interface, new spectrum, and new use cases that we're experimenting with. We are a team that puts together the initial prototyping, the initial use-case research, as well as the necessary standards work that can put together study items and work contributions, so we can be active participants in different standards bodies.

When we decide that a new technology has a viable business case or has the necessary performance metrics, we take it forward and commercialize it as a company.

Monica: What is Intel's role in promoting 5G?

Rob: The way we look at 5G at Intel is perhaps a bit broader than how a lot of our ecosystem partners do. That's because Intel brings in a heavy, experienced background in compute technologies. We look at 5G as not only the fifth generation of wireless, but also as the first generation of connected compute.

We're seeing is a greater level of intelligence and connectivity of things around us – whether it is wearable devices, PCs, smartphones, or even just the different machines around us. We need a new air interface to support and connect these devices and to leverage the intelligence they have.

We look at previous wireless generations as a way to enable data and talk, or to move into applications. LTE has primarily catered to media and mobile broadband capabilities. With 5G, we're looking at functions that provide a broader scope.

5G will not only support broadband and faster speeds, it will also focus on low-latency applications, mission-critical functionality. It will also connect all of the machines in a way that it is not necessary for them to be talking to a cell tower, going up through a core network. This will be enabled by new machine-to-machine protocols.

Intel looks at this broader functionality for 5G and the need for a new end-to-end architecture for service providers to build the right infrastructure. We need to look at the way that the cloud, the core network, the access networks, and the client work together to support it. It's a broader architecture than previous ones. It does require more investment from an end-to-end perspective.

Monica: It's more investment, and also concerted effort from different parties. There are many moving parts, and many more things that you can do. As you said, it is more than a new interface. Now, let's start with spectrum. What is new in the way 5G uses spectrum?

Rob: With 5G, we're looking at bands beyond what's been in the traditional range of, say, 1 GHz up to 5 GHz for Wi-Fi and cellular usage today.

We're looking at a much broader spectrum range. In the lower ranges, we have narrowband IoT that will eventually transition to a 5G IoT specification.

Moving up into the millimeter wavebands, we have what was previously considered junk spectrum because of the logistics and the difficulty in working with the propagation characteristics of high-frequency bands. We're finding that now we have the right ways to build antenna arrays to support certain types of throughput and experiences across those bands.

We've seen a lot of early use cases and trials on millimeter wave, and it's going to take quite a while

to perfect them. We have started many of those trials early, in hopes that they will complement 5G as it starts down its path toward deployment.

It's very important for the broader set of spectrum bands to be available, because they can support different use cases.

As I mentioned earlier, it's not going to be just about broadband. It's going to be about how we support highly-dense environments that need low latency and/or high capacity. Millimeter wave is a great way to support connectivity in highly-dense environments, for instance a smart city or a stadium.

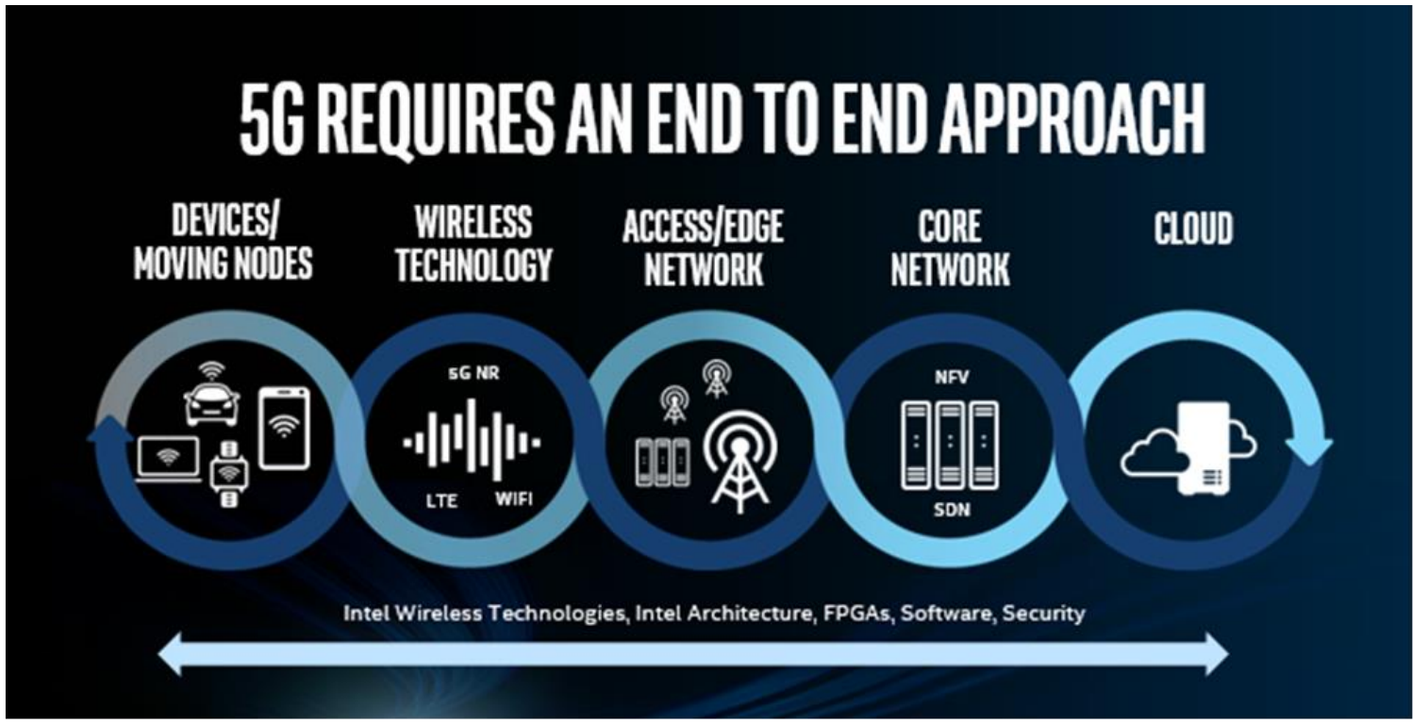
Monica: Millimeter wave in 5G opens a way to use spectrum that right now is greatly underused, and to serve new use cases. Do we have the regulatory support the industry needs?

Rob: We're seeing great progress by many countries moving forward on making both lower frequency and millimeter wave bands available for auction.

We and many other companies in the industry have been working on spectrum strategy, putting together the right proposals of how wireless technologies will work together seamlessly with other industries that are in the same bands. There will be many auctions later this year in preparation for 5G commercial launches in 2019 and 2020.

Monica: How is 5G going to change our connectivity experience?

Rob: 5G is going to do a few things differently than previous wireless generations. It's mainly because of the broader use-case research that's being done in preparation for it.



Source: Intel

Smartphones will be a device that will be a part of the initial ramp-up and deployment on 5G. However, they're not the device that the technology is being developed for. 5G is going to be about connecting all of the other things that are around us.

Some of the new and exciting use cases are going to evolve from the current ways that we use technology. For example, it may be the functions we do through our phone today that will evolve.

If we think about the evolution of productivity, for instance, we started with writing, then moved to typing, then to touch. Finally, we've moved to voice. Now we're on the verge of ambient intelligence, where technology is contextually aware of humans – our presence, and what we're doing. 5G enables connected things. And when artificial intelligence and ambient science come together, they will require a different plumbing.

I often make the analogy of building a new home. How one structures the plumbing and electrical into a foundation will determine what the building can support, such as the number of floors, along with the other complexities of the structure.

Likewise, it's important to develop the proper type of plumbing for the 5G infrastructure during its early days. That's why Intel has spent quite some time field testing prototypes and IP, as well as experimenting with a broad set of use cases, whether that's fixed wireless, automotive, industrial, different cases of mobility, or smart city.

We don't know what winning use cases will come from 5G five years from now. However, it's

important that we conduct broad, industry-wide experimentation to ensure that we're building the right plumbing into the specification and the standard.

It's exciting to look at 5G as a technology that will propel us beyond the smartphone – beyond just the mobile device that sits in our pocket.

Monica: This brings up the issue of the evolution from 4G – or even from 3G – to 5G in underserved areas. Where you don't have much infrastructure, can 5G come in to bring the capacity you need for new use cases?

Rob: It's a good point. 5G is initially being brought up as a non-standalone technology. That's where it has some interdependencies with LTE.

But adjacent to that is the development of the standalone specification for 5G, which is a basis for the way the air interface operates. It doesn't require legacy technology. It doesn't require that you have an investment or infrastructure in 2G, 3G, or 4G.

Standalone 5G will be very exciting growth opportunities for emerging markets and areas where there's no legacy infrastructure.

There are new revenue opportunities for municipalities and for enterprises, and new business-to-business-to-consumer models. There, standalone 5G gives a more flexible way to deploy the wireless infrastructure, at a much lower cost than 4G.

We think many companies and countries will look to 5G standalone as a great technology that scales.

Monica: But can we afford 5G in underserved areas or developing countries? Can a developing country where there is no 4G, for instance, afford to move to 5G directly, possibly skipping 4G?

Source: Intel

Rob: The cost-per-bit metric of 5G will be critically important in how 5G can scale. It's important to look at metrics like the per-bit cost: 5G needs a 10- or 20-times lower cost per bit than LTE.

We know that a 10 times per-bit cost reduction is just to match the increase in data usage that we're seeing grow exponentially, both for personal use or enterprise use. We have to be very aggressive in the cost-per-bit goals for 5G.

We're seeing activity across the ecosystem today in this direction. We are setting up the infrastructure, the air interface, and client devices into a cost structure where we are providing an exponentially higher benefit in lowering the cost per bit, so the services can scale.

Without this per-bit-cost reduction, it will be difficult to build and monetize new services with a significant performance and cost benefit. As such, a primary focus of many of the early trials in which Intel participates in is monetizing and testing new services, and we're seeing this across the ecosystem.

Monica: Right now, many emerging countries don't have much infrastructure, and many services are not available, because the cost to support them is too high. As you bring the per-bit-cost down, you need more capacity. That's where you need 5G. They go together: as per-bit costs go down, you

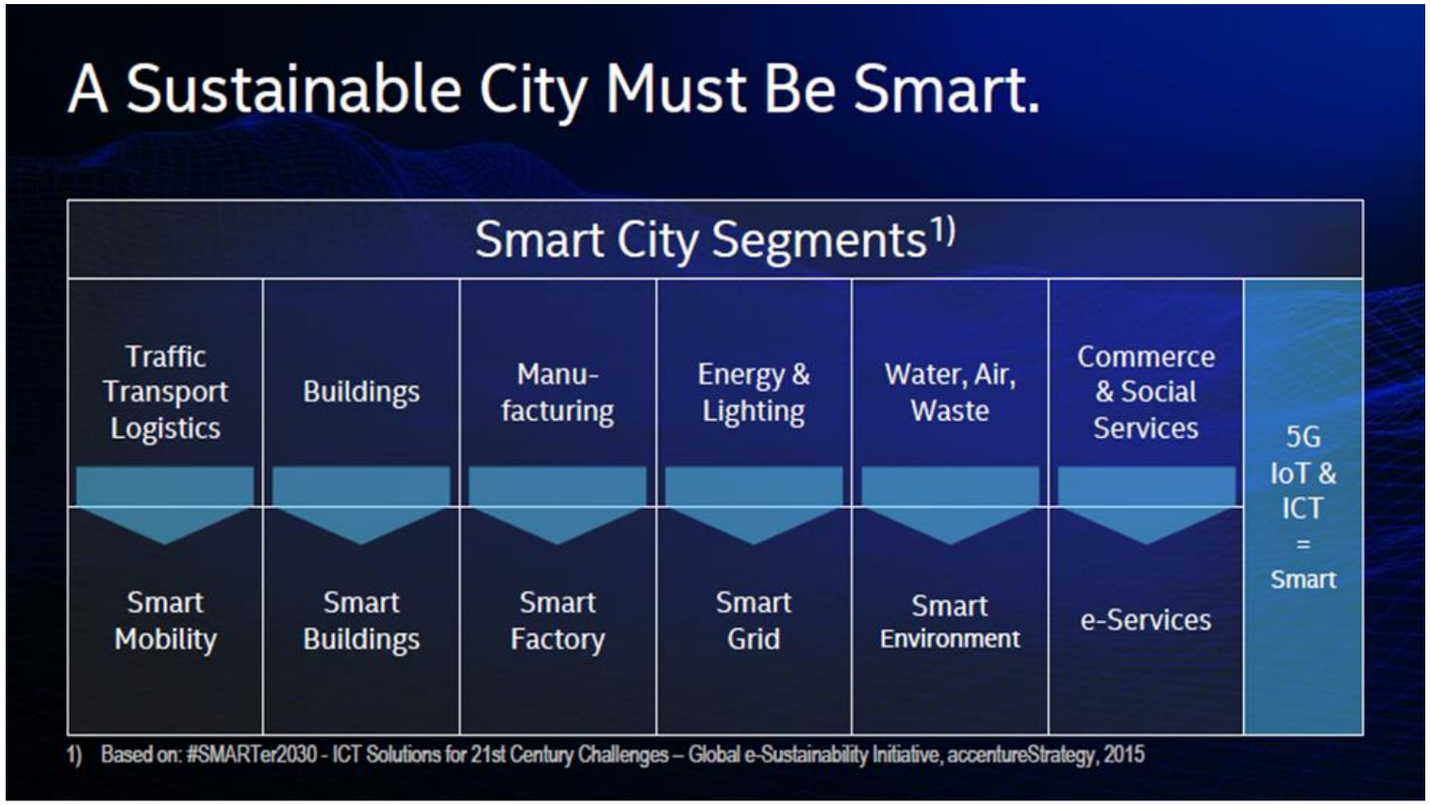
need more capacity as you support more services.

Rob: Absolutely. This is also about helping both municipalities and companies that don't have experience with wireless. A big part of ecosystem trials is to help municipalities and companies understand how to use a wireless air interface, and how to make their operations more efficient, as well as providing new services.

We do look at 5G as something that's not just going to bring efficiency, but that will bring a whole new set of opportunities for services as well.

Monica: Currently, the enterprise uses the cellular infrastructure provided by the operator in a pretty basic way, providing connectivity. What is going to change with 5G?

Rob: The initial deployments of 5G will support broadband use cases – smartphones, as well as media consumption, broadcasting and production.



Source: Intel

Then, we expect a couple things to happen as we start to connect more and more things to a 5G network.

One is that there'll probably be a move to business-to-business-to-consumer models, where wireless services will be more embedded into the product or service being rendered. We fully expect that type of business model to scale. Essentially, wireless becomes a part of the things that we go about and do on a daily basis – services or otherwise.

Secondly, we do expect that the technology will open up new types of revenue opportunities for the enterprise. That's because of the ability of 5G to go beyond the broadband perspective, with low-latency and high-reliability functions – e.g., for mission-critical and safety-critical functionality.

We're talking about a broader set of use cases and expanded markets around verticals such as healthcare, construction, remote management of things, as well as VR and mixed-reality technologies that allow you to virtualize what's being done across a network.

This opens up markets whose size is tough to predict today. We do expect that enterprise is going to benefit both from services through new industries and from new market opportunities, because of the breadth of machine-to-machine communication use cases and low latency being fundamental features of 5G.

Monica: With the standalone version of 5G, enterprises can roll out their own private networks, or they can use carrier networks. How do you see that going?

Rob: I fully expect to see rapid growth in private networks. That's not only because of the readiness of 5G and the cost-per-bit goals that we talked about earlier, but also because we're seeing healthy improvement in the use of unlicensed technologies.

We see Wi-Fi going through a transition right now from 11ac to 11ax, as well as new features that are coming beyond 11ax, which Intel is busy working on as well. Also, the ability of Wi-Fi and 5G to hand off and work together with shared access brings a great opportunity for enterprises business models of how business-to-business-to-consumer will

operate, standalone 5G gives a more flexible way to deploy the wireless infrastructure, at a much lower cost. We think many companies and countries will look to 5G standalone as a great technology to scale.

Enterprises are looking for wireless networks that support both licensed cellular functions and perhaps certain types of quality of service or coverage aspects. But, also, they are looking for the ability to put a lot of traffic on an equally fast and capable unlicensed network, whether that's Wi-Fi or some other protocol.

Not only are 5G and Wi-Fi working together better in handoffs and shared access, they are both improving in latency and throughput. This brings new opportunities for enterprises that are looking for ways to set up their own private networks.

Whether it's for their own IT management and services, or it's the fact that they're looking for certain performance characteristics in their networks, an enterprise 5G private network might be different from an overlaid 5G coverage across a city and area.

A certain industry vertical might be looking for tailoring around low latency specifically, more so than enhanced mobile broadband or other benefits.

Intel has been a big proponent of network transformation and software-defined networks. Bringing together software-defined networks with the capabilities of 5G and unlicensed technologies is a great recipe for private networks. Some early trials have started to happen already.

Monica: Is there any vertical you think is going to move earlier or that is of particular interest?

Rob: There are a few. They're starting at different places, because industries have different maturity curves.

For instance, in oil and gas, there is tremendous interest in modernizing the infrastructure. Many oil and gas companies are running on very old – in some cases, a few decades old – IT infrastructure. Bringing in new compute capability, with the advancements in 5G networks, brings tremendous opportunity and efficiency in the way they run their operations.

We're seeing some of that initial interest today through the industrial standards bodies, with companies and saying, "Look, we're looking to wireless technologies for help in how we modernize our services."

In industrial IoT, we're seeing initial work in warehousing and logistics. We are actively working with a key partner that has been great in warehouse modernization, as well as in various logistics functions.

We've started some early trials over this past year, and we are defining new ones and starting to experiment in robotics. Robotics will have a much longer maturity curve, because there are other things beyond wireless we need to work on, such as how determinism and latency factors apply to robotics. We're excited about that.

Monica: Sometimes, you hear that there are not enough use cases for 5G, but it may be almost the opposite. You cannot even list all the things you can do, because there are so many verticals.

Rob: As you just mentioned with the use cases, I often describe it as a funnel that really has to start fairly wide.

If we were doing this interview 10 years ago and we were talking about the use cases of LTE, I don't think we would have talked a lot about the smartphone, or how we would use it.

Back then, the iPhone and other smartphones were shipping in very low volumes. We thought the technology would be more geared towards productivity environments – PCs or other types of compute form factors.

The winning use cases really come in about halfway through the deployments of a network. It's important that you keep that funnel very wide, and keep the ideas open and ambiguous, and try different things. That's essentially what we've tried to do at Intel over the past couple of years.

Monica: How do smart cities fit within 5G?

Rob: The smart city use case brings many of use cases together, because it focuses from the start on having the necessary fabric to bring connected things together, and to aggregate their intelligence.

For instance, when you start to see connected cars on the road, as well as embedded sensors, you can imagine data capture functionality within cities and municipalities, and the ability to aggregate that data, after you sanitize it out of privacy, security, and personal-related concerns.

You can add these data sets into models to improve the services in an iterative way. As you get a new data set out of what's been collected, it creates an iterative cycle of improving information management.

This is going be a big jump forward in the way municipalities operate. It's not going to be an additional expense to them. It's something that's

going to bring tremendous efficiency to the way they operate.

Smart cities require more of those initial use-case ingredients to be in place to start to be able to aggregate and build a base from them. Smart-city use cases can be very difficult, because they require municipalities that are actively engaged and looking at how they modernize these services.

Municipalities need to be looking across services, at public works, utilities, traffic management, and other areas. We're seeing some cities show interest, and moving forward in working in partnership with both public and private enterprise.

This is especially exciting for places where resources are scarce, because 5G is something that can bring tremendous efficiency at a time when you're actually building your infrastructure.

Monica: Low latency is one of the main strengths of 5G. But what do we need it for?

Rob: 5G low latency brings the response time of the network down to levels that we've not seen historically. Latency was a metric and a focus in LTE. It's been a focus in Wi-Fi, but we're now talking about much lower levels.

5G is targeting less than a millisecond latency at the edge of the network – from the closest access point to you, to the client, to the device or thing that you're using.

When you bring latency down to a millisecond, you're opening up opportunities for virtual reality and mixed reality, for example. Much of its ability to be a great experience, and be something that has great motion and flow in the way that it moves, is highly dependent on low latency. Latency is the biggest factor, and as you move, what you're viewing has to move with you at the same pace.

Source: Intel

A millisecond latency does open up a lot of the virtual-reality and mixed-reality use cases that may be a niche market today, but that will become more commonplace in many verticals.

Also, low latency is a factor with any safety-critical functionality – for example, having the ability to do any sort of remote healthcare management will require low latency.

Low latency becomes a big factor for vehicles and moving objects that require an incredibly quick response time to have up-to-date information about what is happening around them.

We do expect low latency to become a great function and feature for bringing 5G and wireless into new markets, beyond the places we see it today.

Monica: How do you see Intel's role as we move forward and need to establish a solid ecosystem to support 5G?

Rob: We're building 5G at Intel alongside the entire ecosystem that includes enhanced broadband, low-latency, and machine-to-machine communication. And, using the previous analogy, we have laid down the plumbing today and are about ready to pour the cement. As we start to build the deployments, the features will be built on

top of the work that's been done.

To do this, we have to make sure that 5G technology is scalable and that it's hitting the right metrics for these new industries.

We are building 5G for services and features beyond the smartphone. We need to make sure we're bringing the right partnerships together.

At Intel, we are reaching out and bringing in partners across the broader ecosystem, including network operators, infrastructure vendors, and chip makers like ourselves.

Whether they are in the industrial, smart city, automotive, healthcare, mining, drones, image capture, or media production verticals, it's important that we bring in the right partners now, and work together on trials to make sure we provide services that improve their businesses, so they can grow and scale on these services.

Source: Intel

Without these early trials, 5G becomes a standards exercise, and becomes a technology that provides a faster speed for existing segments, but that is doing a disservice to the ecosystem and industry.

5G is something we've been excited and enthusiastic about as a company. We've been looking for ways to provide both the compute and the wireless capabilities to our partners. We have demonstrated this in the vast number of trials we've done, whether it's in fixed, wireless, cars, industrial, or other areas.

Monica: Part – or perhaps most – of the excitement, must come from bringing in parties that are not yet in wireless. Wireless is not their core business. You bring them in to expand the scope of the wireless ecosystem. By working with new people, new parties, new things, you can bring in a qualitative change – and this is more than adding capacity.

Rob: Absolutely. You need more than capacity to bring these new partners in. Many of us are out evangelizing and explaining wireless technology. But many new players are also coming to us, saying: "Help us understand how to use wireless. We know this can become a great framework, a great foundation for the way we build services over the next decade." The ecosystem engagement is critical to scaling a new wireless technology.

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About Rob Topol

Rob Topol is the General Manager of 5G Advanced Technologies in TSCG (Technology, Systems Architecture & Client Group) of Intel Corporation. He is responsible for business and ecosystem development for pre-standard, pre-product wireless pathfinding activities at Intel, including 5G and future unlicensed technologies. He leads use case research, user/UX experience, technology management, as well as field test engineering, carrier network deployment, and demonstrations. Rob also sits in the Corporate Strategy Office, supporting the Olympics program office to deliver innovative wireless technologies for the Olympic Games, partners and organizing committees.

Joining Intel in 2000, Rob started as a commodity specialist in the Technology Manufacturing Group (TMG). He held several rotations in the Technology Manufacturing (TMG) finance organization, including Assembly/Test strategic capacity planning, Fab/Sort manufacturing, Supply Chain logistics, and Corporate Capital. Rob has spent the last 8 years in Wireless and System-on-chip design, including Atom CPU and SoC development in Austin, Texas, as well as the Mobile Communications while based in Beijing, China. Rob earned his Bachelor's Degree from the University of Utah, and Masters in Business Administration from Brigham Young University.

About Senza Fili

Senza Fili provides advisory support on wireless technologies and services. At Senza Fili we have in-depth expertise in financial modeling, market forecasts and research, white paper and report preparation, business plan support, strategic advice, and due diligence. Our client base is international and spans the entire value chain. We work with vendors, mobile operators and other service providers, enterprises, system integrators, investors, public agencies, and industry associations. We provide a bridge between technologies and services, helping our clients assess established and emerging technologies, leverage these technologies to support new or existing services, and build profitable business models. Independent advice, a strong quantitative orientation, and an international perspective are the hallmarks of our work.

About Monica Paolini

Monica Paolini, PhD, founded Senza Fili in 2003. She is an expert in wireless technologies and has helped clients worldwide to understand technology and customer requirements, evaluate business plan opportunities, market their services and products, and estimate the market size and revenue opportunity of new and established wireless technologies. She frequently gives presentations at conferences, and she has written many reports and articles on wireless technologies and services. She has a PhD in cognitive science from the University of California, San Diego (US), an MBA from the University of Oxford (UK), and a BA/MA in philosophy from the University of Bologna (Italy). You can contact Monica at monica.paolini@senzafiliconsulting.com.