

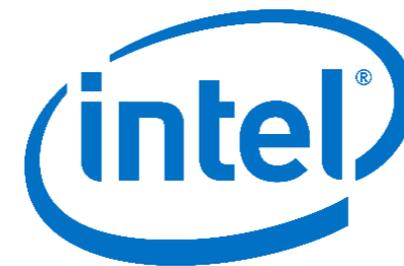
Intel

Taking edge computing from vision to reality



A conversation with
**Caroline Chan, Vice
President and
General Manager, 5G
Infrastructure
Division, Intel**

**By Monica Paolini,
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In collaboration with

FierceWireless

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Edge computing in wireless has been evolving alongside 5G, IoT, virtualization and network slicing. In the process, its traction and acceptance in the wireless ecosystem have grown, and we are starting to see commercial deployment. I talked to Caroline Chan, the Vice President and General Manager of the 5G Infrastructure Division at Intel, about how edge computing fits in wireless networks today and in the future.

Monica Paolini: Edge computing is a hot topic today, and you have been working on it for a long time. What is new about edge computing in the wireless industry and at Intel?

Caroline Chan: I certainly feel I've been working on edge compute for a long time. You've been with us through the whole journey. When we started, remember, many concepts were shown in PowerPoint. We've started seeing real deployments now.

We used to have to convince people. They asked: "Do I need edge computing?" Now the question is "How do I get edge computing out faster? Who in the ecosystem can I partner with? What's the deployment strategy?" It's really going from talking to doing.

Someone recently sent me a draft AR/VR video on YouTube that was done by AT&T in conjunction with the Dallas Cowboys, using edge compute and

VR for the fans to be able to watch this year's NFL Draft with 360° video. What's happening behind the scenes is that, at headquarters, Jerry Jones may be going through the NFL Draft, and the experience for the viewer is so good that someone ends up sending it to me and says: "Hey, you've got to look at this on YouTube," and they ask about MEC, and about edge compute: "How does it enable that?"

It's really gone from a conceptual idea to something that people are working on and rolling out, trialing. It's becoming real; now we need to go into the implementation phase.

Monica: People are willing to open their wallets to start deployments. Is that what you're seeing?

Caroline: We've definitely started seeing that. We're seeing the healthy sales funnel that people are working on. We're seeing requests coming from a few partners asking for help, mostly around helping to sign in with our customers. That's a real signal to us that edge compute has started to take off.

We're still at the early stage. We're nowhere near having hit that hockey stick part of the growth graph, but we've definitely seen a variety of use cases coming in that we used to just talk about. We see some really good signs that the market is picking up.

Monica: In terms of geography, what are the hot regions?

Caroline: In the US, we see a lot around sports, because this country is pretty sports crazy. We see retail, entertainment.

In China, we're seeing a lot of industrial, because the government is focusing on uplifting the industrial sector. One report I saw said there are about a million enterprise, private networks to be deployed. Part of the Chinese government's plan for 2025 is to innovate and help the state-owned entities driving to modernization, so what they call the industrial internet.

In Europe, it is the same thing. We're seeing a lot of transportation and industrial-related interest in edge computing. Sports is always there, too.

I recently attended the Brooklyn 5G Summit, where someone from Bosch talked about how MEC and 5G can help a company modernize. It was a very interesting discussion.

We are seeing a wide variety of use cases, but it's a lot of industrial, automation, entertainment, cities, cars, sports. We see retail. These are the ones that started popping up at the early stage of implementation.

Monica: In the beginning, it was ETSI MEC. That

was the only game in town. Now there are many more initiatives. What do they bring to the edge computing platform?

Caroline: It's both a good thing and a bit disconcerting, because you don't want too much fragmentation.

Inside Intel, we talk a lot among ourselves about how to defragment some of these, how to unify, but I think this is very normal at this stage. We see a lot of verticals.

For example, we're involved in the 5G Automotive Association (5GAA), very much related to automotive. We're involved in the Automotive Edge Computer Consortium (AECC). We just recently joined the 5G Alliance for Connected Industries and Automation (5G-ACIA). AECC was the one that got us started really focusing on extracting the underlying APIs from the networking side all the way to the car side.

Recently, we announced joining Open Edge Computing Project as a founding member. It's an attempt to unite all the fragmented pieces and put edge computing into an open source community. It's going through its growth spurts, but, ideally, we would like to see the industry coalescing around a few consortiums and drive a uniform API. I think that's just critical.

Monica: Orthogonal to edge computing is the centralized model – the cloud. We used to say, centralize if you can, distribute if you must. Now it seems like we're going in the other direction. Is it just a swing back and forth between the two?

Caroline: I think the cloud is here to stay. You're right. I remember having that discussion with you

and with a couple of other analysts. People are always asking: "Why don't you centralize?"

If you centralize, you do get higher efficiency and lower costs. That's the default.

But with all these latency-sensitive workloads with cars and industrial, a hybrid approach is required. There is centralization. But there is also a push to the distributed cloud at the edge.

It's a must, because there's a demand. And people need it. In fact, we're talking with a lot of the public cloud folks, too.

For example, we're involved with Crown Castle on some of the initiatives. Also, we have talked to some of the Colo data centers. Their mission is to build an edge data center. They didn't do this as charity; there are people paying them and becoming their tenant to build these kinds of edge data centers. This is here to stay.

Monica: How is the edge data center different from

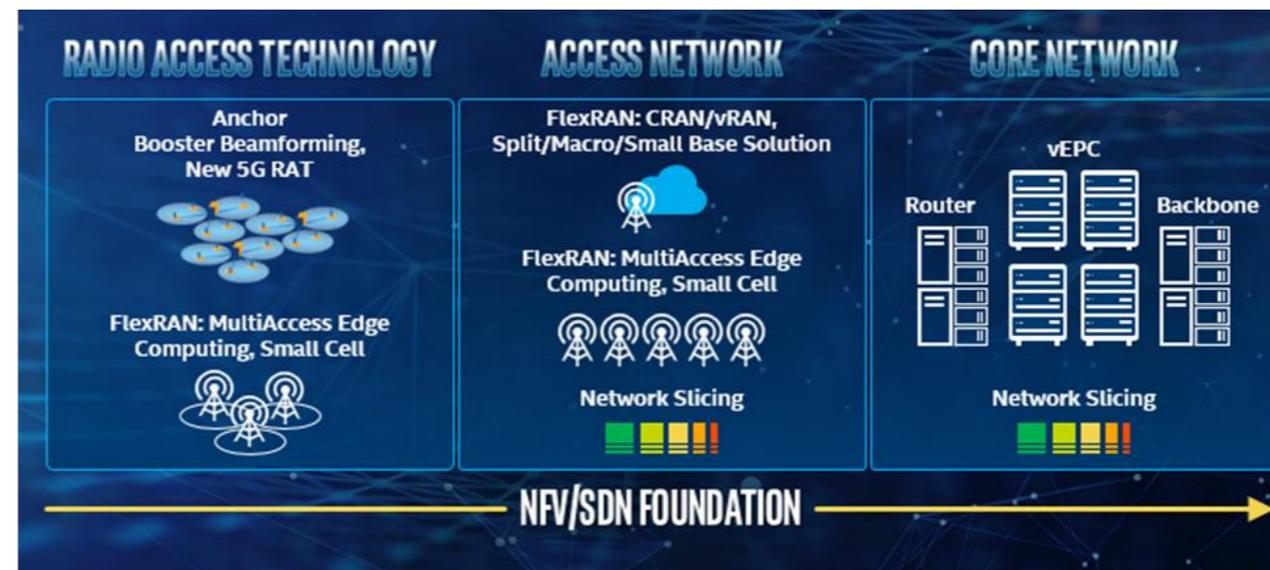
a centralized data center, and where is it physically located? How close to the RAN?

Caroline: A really good picture came from the AT&T CTO, who talks about how the network is reimagined based on latency. Generally, the device is the real edge, and there is a 5–10 ms to 30 ms latency to get to the RAN, and, then, you go to the cloud in the second switch.

It really depends on the workload. The edge data center, obviously, is not the big data center. It's smaller, lower wattage. In terms of the requirements, though, they are still very similar. You still have to have the characteristics of a big data center, but in a smaller form.

We see all ranges, too. We see something called Next Generation Central Office, NGCO, that sits somewhere between a CORD and a RAN.

We also see a lot of on-premises. We're working on some on-prem data centers. People call them all kinds of terms. A lot of times, people just simply



Network transformation to enable capacity and scale

Source: Intel

call it MEC, but it is on-prem.

We're seeing a lot of that happening, to address a very specific latency requirement. There're also, don't forget, a lot of data security issues, a lot of data privacy issues. It really makes it such that you have to have some storage of the analytics running on prem.

Lastly, it's the amount of data. You have to be able to ingest the data. It's not realistic to send everything back to the cloud. Many times, you don't even need to, because some of the data can be consumed locally.

All three of these major factors are driving this proliferation of edge data centers, pushing part of the data all the way out to the edge. The hybrid approach is taking shape in a much greater way than before.

Monica: We now have the technologies to enable this hybrid approach. And virtualization is one of them. It's difficult to imagine edge computing being deployed widely without virtualization.

Caroline: It's funny, we started the business that I'm managing with the idea of virtualizing the network. We started virtualization with NFV in the core network. Then we started pushing that through the RAN. We called that virtualized RAN or Cloud RAN.

MEC benefits from virtualization, because the network is now virtualized at the lowest layers. In the RAN, Layer 3 and Layer 2 are getting virtualized. You are now seeing the CPU core and the storage becoming available at the edge. So it's very natural for the enterprise to see that we got these compute capabilities.

MEC becomes a much easier sell. Because you have the location. You have the information. You have the IP stream sitting right there. MEC and virtualization really benefit from each other, almost going hand in hand.

Now you have virtualized RAN. Now you have MEC. They're sometimes physically in the same chassis, or maybe just in a separate blade that people add on to run the compute workload.

Monica: What about network slicing, automation, AI? They are all happening at the same time and reinforce each other.

Caroline: Yeah, they reinforce each other. Absolutely. Some of the inferencing happens at the edge; the inference workload can run now on a container, or a VM, that's just made available when needed.

It's like this little circle of goodness that keeps happening once you virtualize the network. You're allowing service applications. You get the common

APIs. Next thing you know, all these workloads that run better on the edge cell are landing at that spot: AI inference, machine learning.

You and I were both at the event when the gentleman from Bosch talked about slicing. To them, it is not just a vertical slice. It's more like a little square, because even within the same application you may have multiple use cases. You really start slicing horizontally and vertically. You almost have to get them a little square or a little cube of resources with a specific spectrum, bandwidth and latency.

It's almost like a trifecta that's happening. Everything starts with the network virtualization. Once that gets done, people start treating it like a CIO, and more and more things are landing on it.

You'd be surprised. When you and I first met, I was talking with my traditional customers. Now, I'm talking with people in sports teams, in sports leagues, enterprises. I'm traveling to places I never



5G network slicing for diverse services needs

Source: Intel

imagined I would go to. I used to be really focused on comms. I'm becoming a lot more IT-aware and CIO-focused as a result.

Monica: Enterprises and venue owners are more involved now. What does this mean to the whole ecosystem and business model?

Caroline: This is probably the challenge now that the industry has to solve. It's not just Intel. It takes an entire village to do that.

You may remember, we always had the Intel Network Builders. Just last month, we launched Network Edge Ecosystem, specifically targeting a new crop of partners that we're seeing.

We talk with the tower companies. We're talking with innovators that develop vertical applications. Bringing them together and educating them about what 4G, 5G, Wi-Fi networks can enable for them. Talk about MEC. Talk about NGCO.

The business model is not the traditional model, the here's-a-SIM-card model either. There's a lot of discussion about how the money flows.

Let's take a smart stadium as an example. The question is, who owns the content? How does the content get distributed? How does the money flow there? There's a lot of revenue-share possibilities because, remember, this is still relatively new. You want to incentivize people to deploy, without having to spend too much capex up front.

Some of the ideas we're working on with Crown Castle and others aim at turning some of the capex into opex. Being able to host edge infrastructure or to participate in a revenue share seems to be gaining traction. In other words, de-risk some of

the early pioneers across the board. That's another path.

What happens if it's a private network that runs inside a factory? Who owns it? Where's your liability? Who maintains it? Who are the system integrators?

The SIs become even more important, because many times, you really are not talking with the traditional telco guys. You're talking with somebody who's IT or a CIO. Who manages that network? Who maintains it? What is the life cycle?

You're moving away from this 5-year, 10-year upgrade cycle – to what? Sometimes it is a couple months. Sometimes, it is weeks. All of that means orchestration can't become complacent, or the industry will soften. I know within Intel, we're investing a significant amount of energy to try to solve that issue.

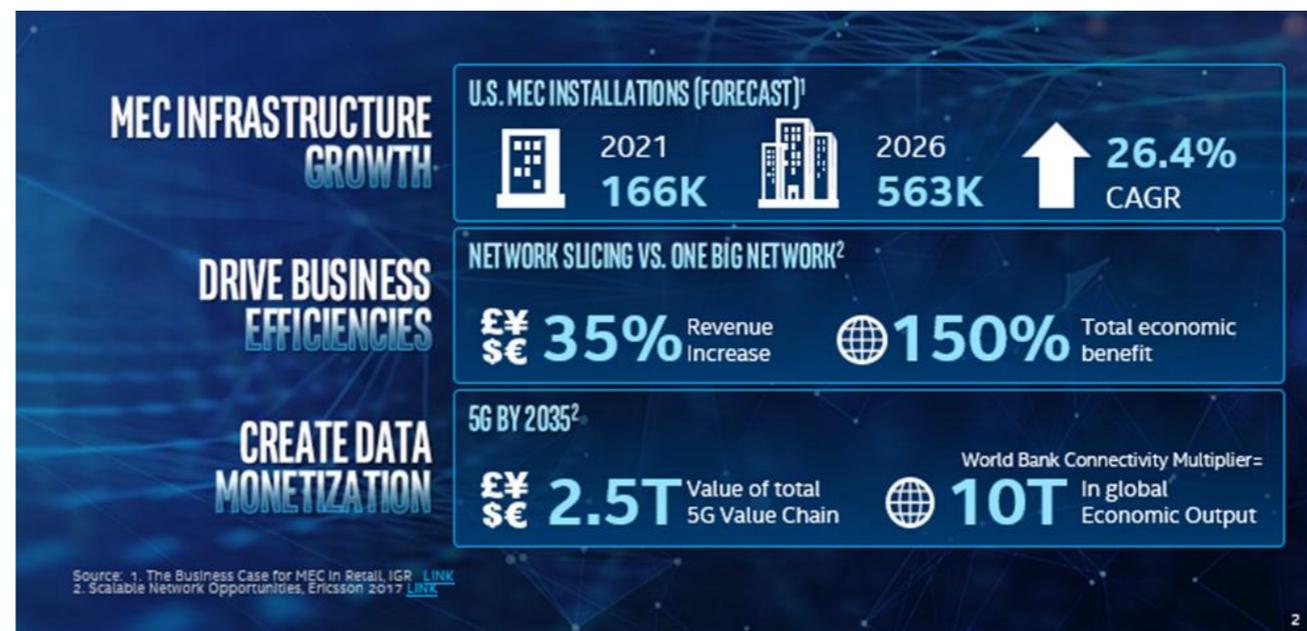
We don't give people a bag of parts. You need to

make it consumable. You need to give them an integrated platform.

We always talk about easy consumption and faster adoption. Ultimately, if the enterprise finds a way to consume it, then you're going to have a problem on the supply side.

Since we sit on the base layer of the supply side, we tried to make our solutions more integrated and easy to consume. That becomes a mantra. Whenever my team comes to me with an idea, I ask: "How do you ensure this is easily consumable for the end user?"

Think of the end user as not just a network operator that is really smart and knows how to do this, but as an enterprise, as a factory owner, as a retail shop. How do they consume this piece of new technology you give them? You must make it a much more integrated platform for them to deploy.



The economic impact of 5G

Source: Intel

Monica: That brings up the issue of the business case, because clearly with MEC you do introduce new elements in the network. There is a cost associated, whether it's capex or opex. How can we justify that? What are the drivers there?

Caroline: That's where you go back to why people even do MEC. Sometimes it is a regulatory reason, because of data security issues. And does MEC solve some operational issues for the enterprise owners? Is there any added monetization opportunity that you have created for them?

Once you get these three principles down, most of the time there's a go or no-go decision. Most of the time, the enterprise will find ways to innovate. There are examples we give them, thinking through how to solve problems one, two, three.

At the end, once they have deployed it, they start putting in more and more applications, where they wind up solving a lot more issues than we initially started with. In some cases, we will go back and do an ROI estimate with the enterprises. In some cases, we found the payoff is much, much faster than we thought.

In one case, in a retail shop, it took five months to pay off the investment. That's tremendous, because it solved a lot of their operational issues. This isn't just about managing the costs. You actually add a lot of other value.

Retail today is not just retail. It's more like an experience. No one just goes in a store and just shops off the shelf. People compare prices. People look at reviews, go to social networking sites, look at recommendations.

It really becomes a multimedia shopping

experience. You have to be able to equip the shop owners with all the tools. Giving them a connected cloud – sometimes I call it a cloud with connectivity – allows them to enhance the shopper's experience, and many times, it leads to a higher return.

I recently attended the Olympics. I was there in PyeongChang. I'm not really a sports fan, but I was fascinated by the experience you get, even though it was cold.

It was just sitting out there. You're not watching somebody skiing downhill. You're having this experience that's much, much more augmented. There's so much more explanation coming in. It really enhances the experience.

In fact, we put out a white paper on what we did in Shanghai at the Mercedes Arena, with Nokia, China Unicom and Tencent. Truly combining a multi-angle viewing experience for people in the stadium, as well as for folks back home who'd subscribed to the micro channel over social media.

That brings in this whole idea that your user experience is much more enhanced now. What if you take that to a factory for the workers? What if you take that to a car shop, to a retail shop?

The idea is, once you have connectivity and you have ways to let the application run effectively, and efficiently, you do open up whole channels, making a whole spectrum of experiences possible.

Monica: It's not just the service. It's an experience. Mobile devices become the lens through which we see the world.

Who's funding the edge infrastructure? Is it mobile

operators that want to go ahead, fund it, and control it? Or the venue owners and the enterprise which want to have more control over the edge computing infrastructure?

Caroline: It was really always the enterprise who wanted this, but even more now than when we started. It's always the enterprise making the buying decision. Use cases are driven by the enterprise.

We do see the network operators getting more and more involved and being part of the decision cycle, because of the technology they can provide and because there're a lot more form factors they can deploy. In some cases, we've just started seeing that right now. It's some of the over-the-top guys that have really started engaging.

Going back to the example of the smart stadium: the first one we did was Wembley. That was just the stadium, the sports team, and the operator. At the time, it was EE – which is now a part of BT.

The second one we did was in F1 Formula racing in China. It was still China Mobile and the vendor, Nokia, working with us. We worked with them from the start.

In the last one – which is the subject of the white paper we published – Tencent, one of the major cloud providers in China, got involved. That became a tipping point. We are now seeing more and more folks in the Olympics.

We were part of the Alibaba MEC pavilion. Inside the pavilion, they have a showcase called the City Break, showing – with MEC, with cloud – what kind of an experience you can get in a smart-city environment. At the same time, they showed

connectivity. We see more and more of that with over-the-top players coming onboard.

Monica: What is Intel doing to promote edge computing? You mentioned many trials. Is that a main way you try to promote growth?

Caroline: Yeah, because we don't do the end system. What we really do is establish use cases. We're doing more with an integrated platform. We are trying to unite the form factors. The fewer form factor configurations you have, the less the complexity of our supply chain. You get better efficiency.

We are promoting something called BKC, best known configuration. Obviously, we don't just dream about that in a vacuum. We talk to the end user. We talk to the customers. We talk to OEMs.

We also have an SDK, software developer's kit, that is free to download from the Intel website. Just a one-click-through licensing agreement. We continue to enhance that.

We started with ETSI MEC. Then we became 3GPP compliant. Now we have different plugins for the public cloud. Most of the public cloud is already in.

Now we've also started working with some of the clouds, our providers in China. We're also going to do some of the Next Wave cloud provider API, as well.

We try to make it as agnostic as possible. It's intended to be a horizontal platform, to prevent fragmentation.

Also, we're actively participating in consortia. Recently, as I mentioned, we joined the Open Edge Computing project in an attempt to unify and

make it easy to consume. We are simplifying the configuration in a hardware platform, providing an SDK, and working with our partners through that framework.

We launched the Network Edge Ecosystem and established use cases. We work through the whole supply chain, from our direct customers to the network operators to the cloud providers.

Because Intel has a sports division, we work with the sports leagues. We just did this extreme game in Australia, where we were part of a 5G and MEC trial.

We try to expand that across all the ingredients that Intel has, such as our AI, machine learning, deep learning framework. We try to bring all of that together and integrate it. Easy consumability is the main angle.

Glossary

5GAA 5G Automotive Association

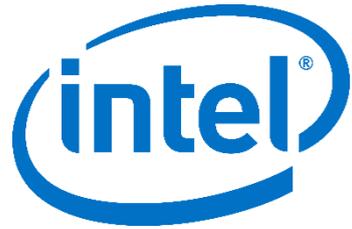
5G-ACIA	5G Alliance for Connected Industries and Automation
AECC	Autonomous Edge Computer Consortium
AI	Artificial intelligence
API	Application programming interface
AR	Augmented reality
BKC	Best known configuration
CORD	Central Office Re-Architected as a Data Center
CPU	Central processing unit
MEC	Multi-access Edge Computing
NGCO	Next Generation Central Office
OEM	Original equipment manufacturer
RAN	Radio access network
ROI	Return on investment
SDK	Software developer's kit
SI	System integrator
SIM	Subscriber identity module
VM	Virtual machine
VR	Virtual reality



An end-to-end approach

Source: Intel

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About Caroline Y. Chan



Caroline Y. Chan is vice president in the Network Platforms Group and general manager of the group's 5G infrastructure division at Intel Corporation. She has overall responsibility for Intel's global network infrastructure strategy and solution development related to 5th-generation wireless technology. Chan and her team identify and develop use cases that incorporate the Internet of Things, innovation in wireless technologies and deployment models, such as mobile edge computing and alternative spectrums that will enable new service providers and enterprise networks.

This interview is part of the report **“Getting edgy. Optimizing performance and user experience with edge computing”**
by Senza Fili in collaboration with FierceWireless

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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, strategy, business plan support, and due diligence. Our client base is international and spans the entire value chain: clients include wireline, fixed wireless, and mobile operators, enterprises and other vertical players, vendors, system integrators, investors, regulators, and industry associations. We provide a bridge between technologies and services, helping our clients assess established and emerging technologies, use these technologies to support new or existing services, and build solid, profitable business models. Independent advice, a strong quantitative orientation, and an international perspective are the hallmarks of our work. For additional information, visit www.senzafiliconsulting.com, or contact us at info@senzafiliconsulting.com.

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.