TECHTalks | EPISODE 8 | Exploring the potential of Quantum Computing
With Scott Buchholz, Managing Director, Global Quantum Computing Leader, Deloitte Consulting LLP.

Raquel Buscaino: Welcome to Deloitte TECHTalks. I'm your host, Raquel Buscaino and I lead the Deloitte US Novel and exponential technologies team where we sense and make sense of Emerging tech.

On today's episode, we're going to dive into the exciting world of quantum, computing: what it is, how it differs from classical computing and what opportunities exist for businesses today.

I have the pleasure of welcoming our Global Quantum Computing Leader from Deloitte Consulting LLP, Scott Buchholz to help us get beyond the buzzword and to share how organizations are utilizing quantum advancements today.

Scott, welcome to the podcast, it is so great to have you!

Scott Buchholz: Thanks, Raquel. It's great to be here.

Raquel Buscaino: Why don't we kick off with just a general question about how did you get interested in quantum computing? And what really fascinates you about the field?

Scott Buchholz: I have been in and around emerging technologies for a long time, and when quantum computing came along, it was something I was paying a little bit of attention to, but one day somebody knocked on my shoulder and said, "Hey, would you mind figuring out what quantum computing means for Deloitte?"

I originally thought that was going to be an easy question. Little did I know that it was going to involve a couple of years of head scratching and other things before some of that became clearer. And where we are today is there are super fascinating things going on across the domain, and there's always lots to learn.

Raquel Buscaino: And so, thinking about where quantum computing actually sits, how does it differ from classical computing because I think that's one of the questions that people ask is: "what is this new term that we're even talking about?" Could you give us some insight into, just at a high level, how it differs from what we might have traditionally thought about as computing?

Scott Buchholz: Sure. I think sometimes what people think of a quantum computing, I hear this analogy that people think it's going to be like a "super-super" computer: "We've got all this data that we can't make sense of, quantum computers, it's going to be like pixie dust, we're going to sprinkle some on, and magic will happen." And the reality might not quite be that simple...

What's happening, though, is all of our classical computers, every computer we use today, from our phones, to our microwaves to the supercomputers, all are basically doing lots of maths really, really fast. If you were to pick up the covers, you'd see just lots of addition and subtraction, and multiplication, and a bunch of other things going on.

And quantum computers don't work that way. They actually use physics to solve problems. And the best analogy I can probably give is to think about blowing a soap bubble. So if you think about when you were a child, growing up, you had the little soap wand, and you dipped it in, and you blew a bubble, and out came a sphere.

If we wanted to use math to figure out what was going to happen when you blew that soap film, what we would do is we would use quantum mechanics, and we would calculate the properties of the water molecules and the soap molecules, and we'd put them all together, and we'd run a lot of maths, and a couple of months later we'd realize: "Hey, this is going to be a sphere!"

Now, the soap bubbles do this almost instantaneously. So one of 2 things have to be true: either they are maths phenons unlike anything we can ever imagine, or they're doing the job differently. And it turns out that soap film is using physics to solve the problem, not maths. And that's really what's going on with quantum computers. We have a new way of solving problems.

And the challenge that we have is, we've spent 60 or 70 years figuring out how to solve problems with maths. And now we're trying to figure out what sorts of problems might be tractable to physics and quantum computers, because they don't work the same. And so this analogy that they're just like what we have today, only more so probably isn't true.

Raquel Buscaino: That's a really helpful insight, because we typically do talk about emerging tech at large as better, faster, stronger in some capacity, but we don't necessarily always acknowledge that it's an entirely different step-change altogether that we're talking about, especially with something like quantum computing.

Scott Buchholz: Well, Raquel, you know, as I do, that most of the time. What we call emerging tech is a variation on all the previous themes. It isn't all that common that something really do comes along and I think in many ways, quantum computing risks being really new, in ways that we're still kind of getting our arms wrapped around.

Raquel Buscaino: We have been hearing quantum, you know, the term in the public lexicon for several decades now. What makes *now* such an exciting time for the quantum field in particular cause? It feels like quantum has been just right around the corner, but, as I understand it, there's applications, there's industries, there's use cases that are happening right now, that we could be talking about looking at implementing?

Scott Buchholz: So first of all, the important thing to recognize is we use the word quantum really loosely. It means everything from quantum mechanics, which is a part of physics, to quantum computers and quantum sensors, and it covers quantum communications, and sometimes it covers post quantum cryptography, and a whole slew of other things in between.

And as a result, it can sometimes be somewhat confusing. If we focus primarily on quantum computers for the moment, what we're talking about is using atoms, or individual particles, to try to work together in structured ways to do computational work, to solve problems.

It turns out that it's actually really hard to get atoms to do just about anything that you want them to do. That's why some of these systems you'll hear about, they operate at temperatures colder than outer space. You'll have lasers zapping atoms thousands or millions of times a second.
About a decade, probably give or take ago, what started happening was that people started building the fundamental building block of a quantum computer which we refer to as a "qubit", and that's basically

just an information store. And so if you think about it, the capacity of a quantum computer is determined by how many Qubits you can use, and how many times you can connect those qubits to one another to do something useful.

We've gone from a decade or more ago, having one that worked to having pairs that could work together, to having a small handful to now, you can go to a number of vendors, and get access to a quantum computer that has over 400 working qubits.

And as that scale continues to grow, what happens is there are more things which become interesting. There are more and more problems which become tractable, and there are more use cases that start to become interesting.

Raquel Buscaino: It truly sounds even just hearing you map it out from where we were a decade ago to where we are now that we are truly on this exponential curve, at this inflection point if you will, where the number of qubits that we have available, accessible is increasing. Can you talk to me a bit little bit more about that? Is that you, Raquel Buscaino, you as an organization, you as an enterprise, I mean, our enterprise is actually having access to quantum computers right now?

Scott Buchholz: Yes, to all of the above, it turns out that, for example, IBM gives free access to their quantum computers today as it stands, and so people can actually run code on quantum computers today.

You can also do it with your favorite cloud provider. Most of the major cloud providers have access to a variety of quantum hardware, and you can also use what we call simulators which run on your laptop or your desktop or your server.

And those are basically mimicking the behavior of a quantum computer so that you can debug the code before you run it on a quantum computer itself. And that's simply because that access tends to get expensive quickly, if you're not careful.

Raquel Buscaino: Switching gears a little bit if we can, what are some of the industries and application areas that could most benefit from using quantum computing?

Scott Buchholz: There's a spectrum of answers to this question, and I'll start with the easiest things: so what is true today as it stands is there is a special type of quantum computer called a quantum annealer. And those are special purpose machines whose goal is to perform complex optimization very quickly.

It turns out that quantum annealers have some properties that make them very interesting for trying to resolve problems like planning logistics, planning fleet patterns, if you're trying to optimize the use of gasoline in your truck fleet to distribute goods to warehouses, those kinds of problems.

It turns out that there are also some machine learning problems that are actually optimization problems in disguise. So decision trees, or ensemble models which are often used in financial services and other places where you need to be able to explain the results of the calculation are very important, and it turns out quantum annealers can actually generate better decision trees than a lot of classical techniques.

The second thing that people are looking at is, in most cases, trying to figure out how to solve machine learning problems differently with quantum computers. Quantum computers have some interesting properties that mean that, as near as we can collectively tell, they train to higher quality, on less data, than our classical machine learning models, so that makes them potentially really interesting for a variety of use cases.

And the third big area is this idea of simulating quantum chemistry, quantum material science, basically simulating what happens in chemistry. People talk about developing the next teflon, developing targeted precision drugs, developing new chemical reactions to support the green economy.

So basically, atoms ought to do a better job of modeling other atoms than math is likely to do. So that's actually why people are really excited about quantum computers in a number of fields. It turns out that in the range of fiendishly difficult problems, that one is really, really, fiendishly difficult. So it's going to take a little bit longer but there are exciting advances getting made every day.

Raquel Buscaino: Wow, just to recap: optimization problems, machine learning and simulation, and tackling atoms with atoms, I like the way you said it. So, if I'm a business, I'm an organization, and I'm wondering: "Is quantum right for me?" What are the questions that I should be asking myself as a business to see if it's something where I should begin exploring on my quantum roadmap, begin implementing or beginning in just figuring out what it all means for me?

Scott Buchholz: The first thing, I think, that many people need to recognize is you don't have to go this journey alone, and most of the time, if people look around in their organizations, they will probably find that there's already somebody exploring what quantum computing means. We find that to be true here at Deloitte. I almost would say that it's true in most reasonably large organizations. Somebody is already looking at this on their own time.

So what I often tell people when they're trying to go on a new journey is "phone a friend, don't feel like you have to do it yourself". Once you've figured out how you're going to get help, what I would say is what you're looking for tends to be places where small percentage points of improvement generate outsize returns: fraud detection in financial services, routing for large logistic fleets, you can think through a variety of different problems in that range where the ability to do better actually demonstrates material returns on the other side.

The reason to look for those is because those are often easy places to start figuring out if I can do better here, it has some outcome that I care about on the other side.

The thing that we're finding, here at Deloitte, is one, once people have figured out their use cases, and they've decided which vendor or vendors they're going to work with, and they start training people in quantum computing technologies, it's not instantaneous.

What I would say is, we found that it often takes people a year or two to go from novice to some reasonable degree of proficiency, because the technology is so different. So part of what people need to plan around is not just how to find a friend, where to go and look in your enterprise, but also when to start the journey, because a little bit like the Data Science journey of yesteryear, where it takes a while to train a data scientist, you can reasonably expect that training a quantum information scientist is going to take time, and therefore starting in advance of needing the help is probably the right way to think about the problem.

Raquel Buscaino: And as I think through well, honestly, most different emerging technologies, quantum included, I think there's the optimistic, positive side of the house where we say: "look at all the things we can do now that we couldn't have done before" but part of me also thinks about the downside, you know, the risks, the challenges we might face. Could you speak to what some of those are?

Scott Buchholz: All tools that are useful can be used in positive and negative ways. And one of the things that, you know, beyond the many questions about ethics and other things that hold as true for quantum computers as they do for any other classical computing technology, quantum computers have a special consideration, which is that about 20 years ago, a very bright professor named Professor Shore, postulated that if you could build a sufficiently powerful quantum computer, that you could actually decrypt the majority of information that is encrypted in the world today. That is part of what invigorated the goal of actually building quantum computers, or at least reinvigorated efforts.

It turns out that, those capabilities are a number of years away, but the important thing to know, is that what's likely going to need to happen is that every enterprise and every individual is going to need to upgrade the encryption that we use in the coming years.

There is currently a process to figure out what the right new encryption standard should be, and many of those things will be transparent to those of us who are consumers because it will come in and update at some point in time.

Enterprises have a somewhat different problem, which is they actually have to manage the process of making sure that those upgrades happen. We can't just count on them happening, or at least arguably, we shouldn't just count on them happening. That means that we all need to understand what data we've been collecting, what's the sensitivity of that data we've been collecting, where and how it's stored, how is it secured, and that inventory will enable us to actually plan our remediation.

Coming up with that list of things and managing the long tail of data that's secured - that's really important, is something that people need to spend some time thinking about and a lot of that is going to accelerate over the next 12 months or so, as the encryption standards start to become finalized.

Raquel Buscaino: Thinking about all the exciting things we've talked about so far, what are you most excited about when it comes to the future of quantum computing?

Scott Buchholz: I'm actually really excited at this point, just to see it go Raquel, you know, I can't wait to the day when businesses start saying, "Oh, I can see material value to using this in production."

And, by the way, that's going to be a gradual process, and I think you know as I do, that emerging technologies creep up on us, and then they seem to be ubiquitous one day, when in fact, they just went through this gradual growth pattern.

I'll be excited when they become ubiquitous. I'm really interested to watch the journey, and the thing I think I'm really excited about is, if I think back, having watched the journey that we went on in classical computing, and the things we've learned along the way, and the bright minds who show up and come up with clever things we never thought to do before, right? So, I can't wait for the steam-coming-out-of-my-ears moments that I expect that we're going to see in the coming years.

Raquel Buscaino: I love that, and you know, from the outside, if you're not, you know, looking at the space, it might seem like a revolution. In some ways it is, but for someone who's so actively in the space, you can appropriately appreciate the evolution, the dedication, the time, the knowledge, all the power that's gone into making this industry and sector what it is. So, truly, truly, Scott, I can't thank you enough for such an incredible discussion. To all our tech savvy listeners out there, if you enjoyed this episode, please share and subscribe, and if you'd like to learn more about the future of quantum computing, you can also follow myself and Scott to stay up to date. Our socials are listed in the episode description. Thanks for tuning in, and I'll see you all on our next episode. Until then "Stay Savvy"!