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Driving commercial value from Quantum with James Cruise, Cambridge Consultants

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[00:00:00] So great. Just a, just a word about podcasting. It's an audio medium. Yeah. So yeah. They can't see me thinking, sorry guys. Yeah.

Welcome to Cloud Realities, a conversation show exploring the practical and exciting alternate realities that can be unleashed through cloud driven transformation. I'm David Chapman. I'm Sjoukje Zaal, and I'm Rob Kernahan.

This week we'll be talking about quantum Quantum computers. Exactly. What are they and how do they differ from classical computers, and most importantly, how do you apply them for commercial value?

Joining us this week is James Cruise, head of Quantum Algorithms at Cambridge Consultants. Welcome James. Great to see you. Can you [00:01:00] say a little bit about yourself and tell us, uh, about Cambridge? So, I am leading up our efforts in quantum computing at Cambridge consultants looking to build a capability before client need here.

We're always looking to be at the cutting edge of this, and so quantum computing is an area we feel is going to be really valuable to the world and bring about a huge revolution in the future. I have a background in mathematics originally, but through various bits and pieces I've end up working in quantum computing and thinking hard about how to make them valuable and commercially useful.

So let's start the conversation, James, by demystifying Quantum a little bit and just, I. Helping us understand a little bit about actually what it's so clearly, I think from, you know, just, just reading around the subject without delving too deeply into the science and the technology of it, what it appears to be is, you know, a substantially higher capacity processing.

Computer that allows different algorithmic approaches to [00:02:00] drive different answers. But I, I wonder if you wouldn't mind just dipping a layer deeper than that and just educating us a little bit on what quantum really means. So fundamentally, quantum is a different way of doing computation. So we all think of our traditional computers and they've completely revolutionized our world of doing traditional ones and zeros, and that's all about our control of electronics.

But fundamentally, we're coming to a new revolution where we're going to control the quantum mechanical world. And the world has always been driven by changes in control. And so the ability to control the quantum mechanical world allows us a different form of computation. So that was our traditional computation, which is built on zeros and wants.

We're going to build a computation built on matrices and linear algebra and just just gives us a different way of tackling problems. And so it allows us to do computational tasks, which we thought were currently impossible. And makes them possible, but it also makes things we currently think of as easy, as hard for these sort of devices.[00:03:00]

Okay. And when you say control of the quantum mechanical world mm-hmm. For the layman, what is that and what, how? How does that show up if you see what I mean? Okay. So now we're going to start control of smaller and small things. So we're getting the ability to control how atoms behave and interact with each other.

Quantum mechanics is really about a language to describe how atoms and the smallest particles in our world interact with each other. And so we're now getting the ability to control that and say, we want this particle to be in a particular state and to interact in a given way with another particle. And so enabling that interaction and controlling that.

So in the same way that we control water in water wheels or steam in steam engines, but now controlling those smallest particles allow us to do things we just couldn't do before. Absolutely. Mind blowing. And the, the other concept I've heard talked about before when it comes to quantum is the notion of super position.

Mm-hmm. I wonder if you wouldn't mind setting out what that [00:04:00] is and what its relevance is. So fundamentally, when you get to the quantum mechanical world, when you. Look at a particle, it has the ability to be in two states at once. And until you actually look at it, you don't know what state it is in. So for example, fundamentally we could have a particle, which is both at an energy, at a sort of low energy level or high energy level.

They could be two possible states it could be in. Mm-hmm. And until we look at it, we don't actually know. What state it's in. But when we look at it, it collapses and it collapses into one of those two states with some given probity. And the quantum mechanical control is controlling how likely it is to be in each of those two states.

Is that Schrodinger's cat? That is Schrodinger's cat. Yeah. So now that's, that's the cat either dead or alive and you dunno, which it's in both states in some sense until you look in the box. Right. And how does that, how, how does that, that notion then, Help and forgive my sort of [00:05:00] lump and phraseology here, but how does that make computers faster?

So what, that's the most eloquent question you've asked ever. I'm try. I'm trying my best. I love it. Absolutely cracking. But it is a very good question. How does it actually create the revolution here? So in some sense, the revolution is about the fact that rather than traditionally when we do computation, we just take binary strings and we add them together.

What we're going to do is we're going to add and change those probabilities of being in zero one. And if you think about the sort of size of the computational space we live in, so if we think about the binary, when I add one more, I. Bit to my string. I just get two extra states into that string. Whereas in a quantum case, when I add an extra qubit, I get a multiplicative effect.

So my space doubles in size. And so this allows me a much bigger space to computation for a much smaller number of sort of qubits. So [00:06:00] these are fundamentally the, the unit that we use in quantum computing is qubits rather than a bit, so this is a single unit which. When we observe it, it always takes zero or one.

But when we're doing a computation, it's this mixture of zero and one, which then collapses upon the obs observation. And, and from a perspective of, you know, we've tamed the electron, we know how to control it. Chip gates, uh, silicon manufacturer is, is well. Um, understood and has been mastered from this new style of, um, computing.

What are the, the challenges about controlling this new environment to be able to create something that I can do a calculation in? It is, we know it's complicated, but the, what's the main barrier to being able to build a quantum computer on scale? So the big issue is that in some sense, everything is quantum mechanical.

So everything wants to interact quantum leading mechanically with everything else. So the big challenge in quantum computing and sort of building these things is actually [00:07:00] isolating your qubit away from the rest of the world because every time your qubit interacts with the rest of the world, it loses information.

I. So fundamentally we need to isolate these qubits. So in, in, there are different types of modalities, so different ways of making a quantum computer, but fundamentally, we needed this every time. So in the superconducting devices, they use resonators and they need to keep those at micro calden because the way they're isolating them, the world is by keeping everything else around them still.

Whereas for trapped ions, they use vacuum chambers. So they remove everything away from the. So you're either trying to stop everything from being able to interact or you just clear everything out of the way. So there's nothing to interact with fundamentally. Yes. Yeah. Okay. And, and this is the problem. So we always want something which is sort of, we can make it interact when we want it, interact, but making it but it being able to easily interact with things is also a problem because then it.

Interact with everything else. Yeah. And so the other technology, [00:08:00] photonic quantum computing, which is light. Light is great 'cause it doesn't like interacting over everything. But light is also painful because it doesn't like interacting with anything. It's one ace property also makes it its worst property.

Yes. So, so this is, this is a thing, is that you are always playing this game of trying to. Make things interact in the way you want them to interact, but the equal as well, trying to prevent them interacting with everything else that you don't want them to interact with. Yeah. So it's essentially the, the finite control.

Mm-hmm. Is, and the mastery of that will be the, how we unlock this new style of processing on scale and doing this on scale so we can do it with, and so this is what we can do at the moment. We can do it with a small number of. Bits, but then scaling up to thousands of qubits, that's where real, real challenges and engineering comes in.

What's the largest that's been built successfully then? So the largest device, which has been reported is the I B M device at 433 qubits. Right. [00:09:00] Um, which is. Which is getting to a decent size, but there's two, there's always two issues here. One is the number of qubits, but also the quality of the qubits. So people can, in theory, make a thousand qubits, but they have terrible quality.

Yeah. So they're completely useless. So there's, so the number of qubits is not always a good measure. For how capable we are at doing this and, and what do you think the timeframe is between today and a point in the future where you think there will be a stable, usable machine with a high enough number of qubits to actually do something remarkable.

So what we're saying is there's sort of a Moores law starting to come up in quantum computing here. So we're seeing a Moores Law on a doubling of quantum capability on the average of 18 months. Hmm. So it's important to note that a doubling quantum capability is actually a double exponential in classical, the equivalent classical capability here.

So [00:10:00] every single qubit I add to my system doubles the. Classical equivalent needed. So a doubling of a system is a, is a four times better. Right? Classically. So we see this in only 18 month scale. Mm-hmm. And so the number of sort of iterations to get to us, the point where we can't simulate it anymore, that's on the order of two or three years.

We're about two to three scalings away from that, right? That's not where we'll see commercial value. That's where we'll see the ability to not simulate anymore. So most of the problems that we would tackle with a quantum computer can be tackled in other ways classically. And so again, we need to see another two or three doublings again beyond that to we'll see commercial value coming in.

So we're talking sort of six or seven years for real change driven by these devices. So it's within two or three, you know, three year strategy cycles of, of, of most organizations at this point. Eg. Relatively imminent. Yeah. Yeah. [00:11:00] It's starting to get to a point where we really need to think about it and how to deal with this.

And actually how to use it and how to get more commercial value outta it. Hmm. It won't be general purpose, commercial value, but it's about those particular use cases which will change the world. And I've heard a number of. Use cases, it could be used for like communication instantaneous and things like this.

But what in your minds I, is it gonna be something like cracking encryption where people are gonna focus down on and use it to, to break defense? Or is it, do you think there'll be a better application or a more altruistic application of it first? So I think if it was just for cryptographic use cases, we might as well give up and go home, right?

'cause who's going to care? Governments will care. Everybody else will move to post quantum, cryptographic schemes will be go away. It'll all be fine. We shouldn't care about those. It's much more interesting. The other use cases, so one of the big one is chemistry and the ability to simulate chemicals. So, [00:12:00] Classical computing completely changed fluid dynamics and wind tunnels.

So pre classical computing, whenever you wanted to test a new error flow, you had to go and build, physically build it, and go and put it in a wind tunnel to see how it behaved. Classical computing changed that 'cause it allowed us to simulate that in silica. So you could tweak a design quickly. You could quickly test out a new idea if you had a crazy new thought on how you could design something.

Quickly shove it on a computer, see how it behaves. In chemistry, we can't do that at the moment. Everything we have to do has to be in a lab. If we want to test a new chemical, a new battery material, we have to make it and test it in the lab. Quantum computers give us a promise of totally changing that workflow of allowing us to simulate chemical reactions using shredding as equation on a quantum computer, and actually be able to.

Chemistry in silica in a computer and test things out. So new drug designs, [00:13:00] new battery materials, all of that opens up in a way that we couldn't do before. One of the things that you touched on as you were going through the earlier description is that classical computers and quantum computers, the quantum are sort of, you know, infinitely faster in a lot of ways.

There are some jobs that a, a traditional computer might do. At least as well, if not better. Could you just draw that distinction out for us a little bit? And why is that? So there's two or three big issues with quantum computing. Fundamentally, they are physics, physics driven, and physics control, what we can do with them.

And so this puts certain limits on what we can do with them. So firstly, they are really very slow. So a quantum computer, even at the best, even at the best estimates, will be a thousand times slower than your G P U. So just for clock rate is slow. So if you're doing something which is just classical in nature, You should never let a quantum computer do it.

Mm mm So for example, there's a [00:14:00] joke, which is if you have a quantum computer and he wants to add one plus one, the quick way to do it is to ask a classical computer to do it. That's an, by the way, that's an excellent quantum scientist joke right there. You know?

So it's slow. So if you're just doing classical computation, if you're not making use of this different way of doing computation, then give up. That's not right for your quantum computer. Equally as well. Loading information onto a quantum computer is slow and hard. So when we do sort of, when we think about loading information classically, we just flip bits.

Flipping bits is quick and easy. Hmm. Doing that quantumly and loading a quantum state into a quantum computer is a long and tires and process. So big data problems. Not going to help you with data deluge. Don't use a quantum computer for it in general. Hmm. There might be particular tasks you can should do with it, but in general, the day-to-day use problem, quantum computing is not gonna solve you.

So when you look at the way something like generative AI [00:15:00] works at the moment, how do those two worlds come together given that generative AI is effectively data-driven? So what you, what you'll need to do in this, and this is actually really what you need to do in general when you're thinking about quantum computing and actually heterogeneous computing in general, is to say, what are the computational tasks I have?

How do I find the right place to use the right compute for the right computational task? So for example, in taking sort of generative ai, so something that we worked on as a project recently is looking at using a large language model to give a really rich and deep embedding. For your data. And actually that shrinks your data down drastically in terms of size, and then using a quantum computer at the backend to enable machine learning in a way, which we can't with a classical machine.

So using a sort of large language model for the embedding. Hmm. And then using a quantum computer for the bit it's good at, which is the highly expressible model. At the backside of this michel of framework. [00:16:00] So you envisage in a future, as quantum becomes commercially viable and starting to get used in more kind of industrialized ways.

Are you envisaging a world then where there'll be hybrid environments effectively? Yeah, so I, I, I very much view a world where we will never get rid of a classical computer. So we'll view a, we'll have a quantum processing unit, a quantum accelerator. So in the same way a computer as A G P U, we'll imagine a cloud infrastructure where there's a bank of GPUs, A Q P U, and a bank of CPUs, and they're all interacting in a way building workflows, which.

Push information across those divides and really leverage out the power of each piece individually, and this is how we're going to make best value outta these machines. We shouldn't try and put everything on one. We will then, if we do that, we'll kill the advantage. We'll remove any value in that sort of case.

Gotcha. So you think that if I'm a cloud consumer in, you know, five to [00:17:00] 10 years, let's say probably won't be six, will it, it might be towards the end of a decade or so that I will get quantum offered up. There's a different processing device within a cloud infrastructure. Mm-hmm. That I would then create an application architecture across the.

Exactly, and exactly we're already seeing this, the first steps along this, um, road coming along. So we've already started to see cloud providers exploring how they can co-locate their Q P U within data centers to provide low latency interfaces between the GPUs and the CPUs and the quantum processing units to really accelerate that sort of thing.

So it's really much a horses for courses. It's another tool in your kit bag of, uh, being able to solve a problem. You just use it, right, use case right time. I think for a lot of people, they don't appreciate that it's, it's got its place, but it will have to be alongside as opposed to fundamentally replacing what we understand the modern.

Yeah, I agree. I'd [00:18:00] sort of, I'd sort of had the, that the perceived wisdom was it would supersede the classical computer. Yeah, me too. I think a. So it might do, but not in my lifetime. Yeah, yeah, yeah, yeah. I, I, in theory, it is a general purpose computer, so it can do everything but. You wouldn't want it to in general, in the same way that A G P U is a no-no purpose computer, but it's good for certain things and A C P U again is good for certain things.

We are seeing this real move to hybridization, a heterogeneous compute environment where the different pieces of hardware used for the right tasks to get maximum value. Are there any specific challenges that you are looking at at the moment or that you can see going on in the world of quantum that need to be overcome?

Either by, you know, you guys who are developing in this space at the moment, or indeed the consumers ultimately of Quantum, what are the challenges that we sort of jointly need to overcome to begin drive business value? [00:19:00] So at the moment, the quantum ecosystem has a sort of bad trick and bad habit of, of saying, here is a quantum algorithm to solve a problem.

This problem is relevant to this industry, therefore, quantum computing is relevant to this industry. One of the things I think is really important, and we should be really doing now, is actually really going down to the nitty gritty and saying, how do we get value outta this? So again, going back to that chemistry example, we know quantum computing is good for finding, for example, the energy of a molecule that doesn't get you a drug.

How do we actually use this to get, as a drug, how do we use it to actually understand for problem and change the commercial value here? Rather than just playing with as toys. I see, I see. In your mind the horizon for that is five to six years before it's doing that level of application. Yeah, but if we don't start already, start thinking about that now.

I. It will come along and we'll then have another five or six years before we can start [00:20:00] using it properly. It's a bit like the graphene thing where you go, we've invented something, it's got ACE properties, but now we've gotta find an application for it. And then there was that rush to go, we want to use it for something.

And it's that, get that problem out before, um, the capability arises. Yeah. Yeah. I think people still feel like that about big data technologies. The technology arrived before the problem. Yeah. Still trying to rush around trying to fix for fix for something that's like seven or eight years old at this point.

Yeah. So we don't want to be in that situation. We want to really, I. Get to the ground running here and really push it. But also we want to build quantum computers for the first devices, which are useful. So part of that is actually understanding what the resource requirements are going to be for these problems.

Mm-hmm. To say what are the properties of the quantum computer, which will be really valuable for us. And then, Feed that back to the hardware manufacturers to help them understand how were they going to get the value sooner. Because in the same way that sort of classical computing, the first classical computers were quite specialist devices [00:21:00] for specialist tasks.

Colossus, for example, was designed for cracking codes. That's what it did well, and it was built for that purpose. Yes, it was a sort of general purpose computer, but it was designed for that purpose. In the same way the first quantum computers will be designed for their purpose to get their real value there.

What you been looking at this week? So each week I will do some research on what's trending in tech, and this week I want to focus on how businesses can use quantum computing. So like we already mentioned, quantum computing promises to revolutionize the way we live from offering better products and services to increasing overall efficiency in the business.

So it can help businesses to overcome large amounts of data, but it [00:22:00] can also overcome complex technical issues that have been time consuming at the moment, or even unsolvable. So there are a couple of areas that can benefit the most of quantum computing, and we already mentioned artificial intelligence and quantum cryptography and cybersecurity, but there is also quick data analysis.

And the drug development and the chemistry that you already mentioned, uh, James. Uh, more efficient manufacturing processes and traffic optimization. So quantum computers can make traffic jams a thing of the past. I'm really looking forward to that one. That sounds like an excellent usage. Yeah. We should take the M 25 start on that one.

Yeah, exactly. I don't care about the rest. Yeah, the M 25 is just sitting there waiting for you, mate. It's just down the road from where you are. I've just heard a cheer go up from the world. Yeah. So, James, question for you. What do you think of these areas? Do you really think that this can bring businesses the most benefits outta quantum computing?[00:23:00]

Or are there things missing here or not right at all? So I, I think that you pick up some of really early use cases, which we really think are going to really change the world. And it's important note that getting even just one or two of these right will be hugely valuable and worth the investment we're putting in.

So as you say, for example, if we solve the own 25 problem, that would be London sorted and, and happy. It'd be lovely, but some of a drug discovery, for example, or chemistry problems. So fertilizers, for example, understanding how the pea plant in your garden. Fixes nitrates to enable fertilizers. That's a hugely multi-billion pound industry, which could be completely changed overnight if we went there.

Hmm. Looking at the optimization sort of problems over traffic and the logistics problem, there are many, many optimization problems at the moment, which we do offline. We do them offline because they're too slow to do. Online, but doing it on online would allow us to be much more efficient, to [00:24:00] make the changes much more quickly to explore what those are.

So for example, in power systems, understanding how we integrate renewable energy is something which is very dynamic in nature. So doing absolutely those sort of optimizations in a power system online would change that industry as well. There's a lot in the, how it actually does it and how you apply it, and there's probably a whole other podcast on how you would take it and apply a sequence of lifecycle controls to be able to get to an answer.

But, uh, in classic software development, we have mastered the application lifecycle management, or I should say we know what good application lifecycle management is. Not everybody applies it, but. In quantum computing are people starting to think about the mechanics of the how and the practical natures of about how we develop those processes and approaches and ways of working that allow us to integrate it with the other domains that you talk about.

So we're starting to think about this and it's, it's still very early days in this, but it's very clear that we [00:25:00] need to build better systems, better infrastructure to do this and develop sort of software here. Um, we are still in very early days, so when we talk about quantum computing and writing and quantum computing program, we talk about a circuit.

So this is just like your sort of traditional logic circuits from, from days gone by. And that's really the level we're at at the moment. There is still a sort of, Need to build abstractions here to actually get us to do useful and things in future. So it'll take a while before those traffic gems are really Yeah.

A thing of the past. Yeah. Okay. Disappointing. Yeah, so, so this podcast is going so well until that point and we're sort of time timescale of problems. We sort of think that chemistry and the chemistry problems are the nearest in terms of accessibility for quantum computing with the sort of, Optimization being a few years behind that, so, right.

I feel chemistry is sort of nearer term and then optimization. [00:26:00] I just think about that the mastery of implementation will be a key point. It's great that the technology exists, but how do you scale capability? I. How do you then scale the, the tools you need to be able to apply it effectively? There's a whole other part of it that will have to start to rise to, to, to make the impact that we suggest it can, or that I should say We know it can.

Yeah. It's just the, um, developing mastery of the capability and there are a whole load of engineering challenges for us just still solving this space. So there's a whole load of. Challenges around error collection, for example. So as I said before, qubits are noisy, they're bad quality. But again, as we did in classical systems, we built bad systems, which we then corrected with errors.

Similarly, we expect similar technologies to be useful in quantum computing as well, and that's a whole challenge in the zone, right? So to round us up, then you are placing your bet on one of the chemistry. Applications being the sort first big breakthrough moment, is that gonna be the fertilizer one you [00:27:00] mentioned earlier?

Do you think? I've, I've, I've read about the impacts that could have on things like greenhouse gases and various other life on the planet, changing aspects. So I think that small drugs are likely to be the first place. Yeah, because they're, they're smaller molecules, so it's, it's a molecule size issue. So the smaller your molecule, the more likely we are to see impact sooner.

So, so small drugs, Molecules are likely to be first cases. Also battery technologies might also be, 'cause they're very highly structured systems. Right. So they're relatively, um, small number of things which have repeated many, many times. Hmm. So there's potential there in those sort of use cases. But the fertilizer won't be long behind that, I think.

Right. Great. I mean, what a amazing conversation. I feel like I've learned a huge amount, James. Yeah. No, no, no. That was, uh, what I loved about that was the clarification on the points and the helps bring structure around the thinking. Yeah. Yeah. For me, it was [00:28:00] really unclear what the. It can be a one and a zero at the same time.

And now I get it. Yeah. We'll, uh, ask you to explain that to us again over a glass of wine one day Shall here? Yeah. Okay. Good. Look at that. So anyway, here's your test. Yeah. So James, thank you so much for joining us and helping us with a great conversation and educating us all this afternoon. And we like to end the show by asking our guests what they are excited about doing next.

And that could be anything from, you know, I've got a great restaurant booked at the weekend all the way through to something that you're doing in your professional life. So James, what are you excited about doing next? Um, so one of the really exciting things that we're trying to do as a project at the moment is to lean into the noisy and the sort of statistical nature of quantum computing and really leverage some of my, I used to do statistics and probability in the past to really leverage those to bring that value sooner and deal with those errors in fun and interesting ways.

[00:29:00] Fantastic. We wish you all the very best with that, and thanks again for joining us this afternoon. So a huge thanks to our guest this week. James. Thank you so much for being on the show. Thanks to our producer Marcel, our sound and editing wizards, Ben and Louis, and of course, to all of our listeners.

We're on LinkedIn and X, Dave Chapman, Rob Kernahan, and Sjoukje Zaal. Feel free to follow or connect with us and please get in touch if you have any comments or ideas for the show. And of course, if you haven't already done that, rate and subscribe to our podcast.

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