FUTURE SIGHT PODCAST

Ep. 28: The Future of Computing

Future Sight Podcast by Capgemini Invent

As business and technology move forward at a rapid rate, it has become increasingly important to explore new ways to adapt and grow for the future. This podcast is your guide to that future journey.

Join us as we explore a new topic in business, technology, and transformation. Find out more about the challenges businesses are facing today and what they can expect in the future. Listen to leading industry experts as they break down need-to-know, actionable approaches with strategic insights and provide tangible takeaways.

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Episode Transcript

Ollie Judge: This is Future Sight – a show from Capgemini Invent. I'm Ollie Judge. On this show, we explore new ways for you to adapt and grow for the future in business.

As 2021 comes to a close, on this week's episode, we're looking into the future of computing in 2022 and beyond.

We're going to be discussing three areas of technology that are likely to be game changers in the years to come. We'll be covering AI and Machine Learning, Blockchain and the Metaverse; and finally, Quantum Computing.

Joining me today from Capgemini Invent are three experts in their respective fields. Firstly…

Kary Bheemaiah: Hi, I am Kary Bheemaiah. I'm Chief Technology and Innovation officer for Capgemini Invent. My job over here is to work with emerging technology and figure out new products and solutions for our clients and potential new clients.

Ollie Judge: And…

Moez Draief: Hello, I'm Moez Draief, Chief Scientist at Capgemini Invent. My role is investments and collaboration with partners in academia, and also an industry focus on innovation covering AI, but also other topics.

Ollie Judge: And…

Julian van Velzen: Hi! My name is Julian van Velzen. I'm CTO and head of the Capgemini's Quantum Lab. And my role is to both prepare ourselves and start learning about quantum technologies as well as start experiments with our clients.

Ollie Judge: This is a very special episode of Future Sight because we're actually going to be talking about the future, which is something that we don't get to do all that often. And, what we're going to be talking today about is the future of computing.

And, between us, we've got people that can represent the software side of things, the hardware side of things, and the interconnectivity between all of that. But what I do want to start off with is a bit of an open question and that's: what the state of computing is right now?

Julian van Velzen: There has been talks about the end of Moore's law: basically, that classical compute systems won't develop any further, for quite some time already. I think I heard this first 20 years ago. And it is still going on. It will probably go on for a little while longer. Like the current hardware innovation is still progressing. There's still all kinds of tricks they can do with the lithography to make it even smaller.

But at some point, it is going to stop. And I think at some point, there will be challenges and the kind of things that we want to do that, even if we improve our systems by 10, 20 or 50%, it won't be enough. So, we really have to start thinking about other types of hardware architectures to think about how we can address some of the big challenges of the future.

Ollie Judge: Kary, you've been quite opinionated about this stuff and the limitations of how certain industries can use their computers. Let's talk more about computation power of how far we can really push the current systems that we've got? Are the other systems that we've got at the moment fit for purpose, for what we're trying to do, or are we trying to design new ways of doing things without a problem to actually solve?

Kary Bheemaiah: No, I think that it is not that rigid. It's a cat and mouse kind of a game to a certain extent, in which you have an increasing amount of need for computation as we move forward. And some of the solutions are mostly hardware-based like what Julian was talking about. But then, there's other solutions in terms of just the software.

And what we're realizing today is that, when you start thinking about how the software needs to be looked at, then everything comes into play in terms of where is the compute actually happening at a chip level? So, it turns out that the distance that the data needs to travel from where it's stored to where it's computed, has a big impact on the amount of energy that is consumed in terms of being able to do the computation.

And so, today, we are seeing a lot of research that's happening in terms of doing on-storage compute. So you need to be able to reduce that distance of where you store the data. Can you actually do the computation directly with that?

More importantly, when you're doing a lot of computation, this comes to Moez's field of work, which is all about AI. And over there, when you start looking at a lot of these extremely large neural nets are heavily computation-necessary as well. And what we're seeing today is new techniques which come inside over there in terms of being able to groom these models a bit better, use new kinds of tech approaches and being able to figure out how do we get the same kind of predictability, the same kind of quality result without being so intensive?

And then, there's more information in terms of just being able to be using the data in a lot smarter kind of a way. So there's many different avenues which can be explored when it comes to that. But the key thing which I'm looking at today is also the fact that we are now used to seeing more and more of decentralized compute.

So do we need to do the computation in the way that we do today building structures? Or are there places in which we can actually have decentralized storage, which is an area where we're seeing a lot of work coming on in the blockchain space, decentralized computation? There is even a de-centralized DPM that's coming out right now.

So, I don't think there's a kind of "here's the solution that you require for this kind of an application", that is something that will become much more defined as we move forward. But at the same time, what we do have is more and more optionality in terms of being able to look and see: how do we actually kind of figure it out smart ways to do this? Because it's not just a hardware or a software problem. It's everything.

Ollie Judge: So, I'm going to dig into that software angle a little bit. And, I suppose, tell us a little bit about what software 2.0 is, and where we need to move to, to enable some of this more decentralized structure. And we're not just talking about blockchains, we're also talking about like machine learning on your device that you carry with you every day.

Can you give us a bit of background on where we're moving to at the moment and some of the sort of big trends that are coming?

Moez Draief: Sure. So, the trends in terms of hardware, in terms of data collection, architecture is really progressing. But to bring all these together, you have to have standardized ways of writing software and sharing software that people could use. That are traceable and easy to exploit. And previously, when you wanted to do software in software 1.0 era, people had to sit down carefully think about what to write down, ensure that this is interoperable with the rest of what's happening in the ecosystem. And then ensure that this works.

In the software 2.0, it's actually the machines that write the algorithm, the machines that design the algorithm. And this is easy as a definition, but this means that you have to have all the components that come together nicely.

And I think this is where we are now: in this space where you have data that it's reliable, that it's well documented. You have a streamlined processes of building those algorithms and you have the oversight that ensures that the algorithm is performing as anticipated, that is not using too much energy, that it's respectful of ethical considerations, et cetera.

And I think, within an organization, internally, this is something that could be done successfully. If you want to do this at a global scale and make the most of data collected at all parts of the world and shared between organizations and insights also shared between them, I think we are at the very beginning of that journey. And hopefully, like the next 3 to 5 years will enable us to crack some of the exciting problems that hopefully we'll be discussing later in this episode.

Kary Bheemaiah: I think one way to look at it is: if you are someone who's got increasing amounts of computational burden that's affecting the way that you work and what you do, then in that case, there is a what, where, and how with computation. So, you need to first ask yourself, where are you computing?

Because the place where you're getting your energy source from is very important because this is still a physical infrastructure. And then you have to think about how to compute? So that of course is in terms of the computing hardware and what kind of algorithms and what kind of like processing systems you'll be putting in place?

And then finally, it's what are you computing? What to compute? And that's the computational demands. And that's where you can use a lot of these new kinds of flex solutions, which are coming out there. The reason that you want to do it from this where, how, and what perspective is because it affects the bottom line.

It affects a lot of the power usage. It affects a lot of the carbon emissions that get created from implementing systems. Something which I think Moez and I have been looking at more and more importantly is also all these different systems, how they are connected together, because there is a whole operations and processes pipeline that gets created. And there's efficiencies that you can get inside over there as well.

Moez Draief: There is actually a huge bottleneck when it comes to producing useful insights from the data that's out there. I think, we will need armies of developers to be able to do this. And I think, by moving that, by removing the human aspect bottleneck and by creating automated generation of codes where it's supposed to be consumed and shared between different organizations in a reliable way, this really fosters a lot of innovation.

And I'm just going to give an example. For example, if you look at what happened during COVID, there's been a lot of data, a lot of papers, and a lot of insights. But nothing that can bring all this together from where they are being produced to come up with a solution that enabled us to raise to the challenge. And this is… We have the components; we just don't know how to bring them together.

Ollie Judge: Oh, off the back of this, we've got a lot of potential and that we've got a lot of, let's say, new toys to play with. But as we've spoken about on the show before, the key to any good machine learning initiative is clarity of data or essentially having your house in order before you can do all of this stuff.

Are we now at the point where people have got their data in shape as much as they should? Or are we still somewhat limited by, how people have: number one, taken their data in? But also, how they're able to expose that to newer systems?

Moez Draief: I think that is some of the mundane data quality, I want to get my data, nice and reliable, et cetera. I think there's a lot of efforts and a lot of technology that it's going into that. I think we are going to solve that problem. And then I need the data that I can extract insights from. And for the time being, the success is around… This is called supervised learning. So, good labels that you could use to learn to label data that you have not seen in the past.

And this is, I think for the time being, a bad avenue. I think it was great to show potential, but it is limited again by the human factor: how to label things, how reliable… We are not great, actually, as individuals, at labeling thing. There's a lot of subjectivity often.

And so, the area is moving into what's called more and more "self-supervised learning" now, where give the machine data and it would figure it out for itself, what's interesting, what's relevant, what are the relationships, and then learns from that. This is very early days. There are a lot of research papers in that space, but no groundbreaking tools that could be deployed in an enterprise environment. But I think this is something that is going to completely change the nature of how we use AI.

Ollie Judge: Okay. And off the back of that, we've say for the last few years, people mainly understand AI as being able to surface a picture of a cat from their photo albums or mostly tagging things up so that you can organize the data and have a little bit of prediction in there. And this is open to the group, but probably primarily Moez.

Where do you think people are going to be seeing the newer developments in AI in maybe the next year or next couple of years that goes beyond just that?

Moez Draief: I think there's been an application domain that's been looming for a number of years, but I think this year there's been a major breakthrough, which is biology. I think in biology we make a major step change with AlphaFold, but it's not just AlphaFold. There are many exciting developments where we are using AI to understand a scientific area where we don't have an app. I hope the biologist is not going to dislike what I'm going to say, but a pretty simple way of explaining things like we don't have the maths like we have in physics, et cetera.

It's still an area that relies a lot on experimentation, the experiment design, the data, and people's intuition. And now that AI is getting more and more involved in that space, we are going to uncover patterns and we're going to create consistencies in the way we understand biology, diseases, and drug discovery, that has never been done before.

And I feel like this is really a great area, computational biology. And I think we had an episode earlier in the month about synthetic biology, which is how to create new living. Not just understand what's out there. But how to beat evolution in some sense. And I think there's a lot of hope that AI could crack that.

It is still the beginning. A lot of challenges ahead. But I feel like this is…we're going to move away from cats to get them the drug that's going to be personalized to you, to your disease, and that will improve your life quality.

Ollie Judge: So, what's quite interesting there is: you've got something as complex as biology that has infinite variables. Most of which we still don't understand either. All of this is, is going to require an awful lot of computation power. So I want to think about the scalability of these models, and which is where I'm going to tick over to quantum computing in a minute, because I want to talk about the limitations of the current infrastructure that we have.

In the last year, we've experienced anything from chip shortages for GPUs that people might not be able to get hold of. We also know that using that kind of computer is resource-heavy. It's not well power managed. So, what are the limitations here in, in terms of hardware to actually power all of this stuff?

And I think Julian touched on it a little bit earlier there with Moore's law is now slowing down. So, what does the future of this look like? Are we actually being limited by the computers that we're running on there?

Kary Bheemaiah: So, when it comes to hardware, transistors are not really getting more and more efficient, especially current ones or contemporary ones. But what is also important to understand that, when you're using hardware, the energy that's consumed and that affects the computation, it's actually determined by the data movement.

So as a result of this, as we realize that some of the solutions that we're coming up with, which are not contemplated, I'll let Julian talk about those. How do we increase the hardware efficiency? So, one method which people are looking at today is how do you do data reuse on deep neural networks via low-cost memories?

This is like the data that's accessed once from the memory, it can be reused multiple times for different operations. This leads to the kind of stuff which we call like "future map reuse" or "filter reuse". What they're essentially doing is making low-cost memories. You just making sure that if you're accessing the information from the memory part of the hardware, that this new kind of architecture affects the data flow and how you're going to be reusing it.

MIT actually did some work on this. They actually created a new kind of chip, which is based on what they call the "Eyeriss architecture." And they were able to exploit enough reuse of data to reduce the amount of memory access by around a hundred. Some of the other tests showed that they could reduce the amount of off chip memory access which is more expensive by close to 1000 X.

So that's just in terms of the hardware. But we're also seeing new advances in what we call "in-memory computing" which is where, you're moving the computation into the memory itself. So, that's another hack which they're trying to do. And I think there is some work that's coming out in computing with light, but that kind of sounds like it's Julian's territory. So, I'll let him answer.

Julian van Velzen: So, there are all kinds of advancements in many different sections in hardware. I think for example, if you take the example that Moez provides about personalized drugs, there is things like AlphaFold that is able to predict that a protein folding with deep learning approaches, it will have its purpose. Then, there are kinds of in-memory, or maybe even neuro morphic type of computer systems that will have its own purpose.

And I think what's really important here is that there will be many of these different compute systems both in terms of hardware and software living together in a heterogenic compute landscape. And quantum computing will be one part of that landscape. There are definitely some things that, you know, even if you improve those systems by a lot more calculating the full electronic interaction for some of the molecules, it won't work even if you have compute systems that have the power, a thousand times more power than those today, and it runs for thousands of years.

So, it's really nearly impossible with some of the current hardware. And our quantum computers of course can be one of those things that open up new possibilities. What I really liked was what Kary mentioned before, is that we really have to think about what we want to compute, where we want to compute and how we want to compute.

So, it'd really be a question of: what kind of server or hardware can I use for this? Then, how do I let this work with some of the other servers that I use? How do I decompose my problem into machine learning parts, and then sending one part to a quantum computer for the most toughest?

And this won't be easy, right? Because it's two pieces of a Lego block that don't fit very well together. So, you have to think about like: how, where do I put my data to make sure that these will work together? For example, for some of these calculations, you need the quantum data, the quantum computer, and some of the classical data to be extremely close, like in the order of nanoseconds in order to work efficiently. And some other data that can be filtered apart from each other and still work.

So, it will be really a question of what do I use, where do I use it and how do I make this work together?

Moez Draief: And the success actually, I will focus especially on the eye space, have been any kind of high data need and high computation needs application is bringing the two together. That there is the software and the hardware that work in sync to solve the problems.

However, the industries and their production cycles are different. So hardware is not produced until there is a great software that shows potential that hardware would work. And then software solutions don't get widely exploited because they cannot benefit from hardware acceleration. And I think, there are more and more players, especially in the tech world that are realizing, that are investing internally and bringing hardware that will be beneficial to software that it's down the line, be it, that the GPUs and the IPUs and all kind of these software, and these hardware that we talk about.

But also, I think there is, as Kary and Julian mentioned, there is all of the aspects of photonics and using other types of approaches that have a nice application when it comes to AI. Because not only they do compute, but they also do compression. So, that means that they extract the best of the data, the essence of it, that would reduce the compute down the line.

So, you can if you have a double benefit from having very powerful compute, but this is also little data. And so, from an energy perspective, this is actually super powerful. And we see in the photonics space, a lot of applications using sketch shake, and we partnered with a company called LightOn that does this and is actually bringing this to market. There is a lot of exciting things down the line in this.

Kary Bheemaiah: Yeah, it's always the case, right? That when you've got something in abundance, you tend to overuse it or not have enough respect for it. And because Moore's law was working so well, and it was so consistent, people just got complacent with the way that they were using a lot of the computational resources.

And so, we just went for these massive brute force methods. So, you were mentioning about these large models out there, like GPT-3 or of these third models, which are out there. And it turns out if you actually look at them, they always report on there, they have these leaderboards where they always talk about like hope evolvement it is.

And there's no doubt. You cannot argue with the actual capabilities of these things. But then you realize that you've done it in a very Bruce Fort kind of a method. It just dumped a lot of data and you find that computer that come up with these results. Now that we're hitting certain kinds of limits and we're realizing, this kind of abundance that we thought we were immersed in isn't really a reality.

We need to be a lot smarter. So, just moving from the hardware side to the software side for a second. One of the things we've realized recently is that a lot of these large models are often over parametrized, right? They've got too many parameters. You don't really need that much.

So, one thing that we're starting to see is something which is known as "knowledge distillation", which essentially entails making the model smaller by taking a large model that works very well. And then you distill it into a smaller model, which are then creating the larger models' predictions. And we're like, what are the key activations within these models that actually can help you come up with a similar kind of result?

This has also led to an increasing amount of GAN. So that's generative adversarial network. And it's basically, to utilize fight each other you could say. And over that as well, you're finding like smarter ways to do, so they're trying to use a lot of synthetic data over there in order to create the data set and augment the training data set, which you have, like the data that you've got inside over there. It's also leading to what we mentioned a little bit before, which is "pruning." And pruning is essentially the process or the approach of taking a pre-trained model and removing or pruning unnecessarily model parameters.

So, you can prune different parts of the model, or you can propose different kinds of metrics for what makes, what are the small way which are inside these models, which won't really have a big impact. Maybe we can get rid of them and make this a little bit lighter. And yeah, this happens not just in the level of the model, but also at the level of the net.

And that's something which really helps in being able to reduce the amount of energy consumption, the amount of computation that is required to get to a similar end.

Julian van Velzen: One other example that I want to give to what Kary mentioned that regarding that we got spoiled by the abundance of compute power before, right? Every year, transistors have doubled. So, we didn't really have to be smart in the way we use our software is something that we see now with the developments of quantum algorithms as well.

Because, in this process of trying to figure out new quantum algorithms while we're being extremely limited with the quantum hardware that's available, we can only do these toy models. In the process, we figured out a lot of classical algorithms that are actually much better than we ever thought.

So, it's really that the scarcity you'll have to quantum hardware that drives us to verify new classical algorithms that are much better than we've ever thought. And yeah, it already showed to have a lot of value.

Ollie Judge: I'm going to pause that slightly. We've crossed over into the realm of quantum computing. So, I think it'd be good to get just a brief explainer from Julian on what quantum computing is, what it means, and also what it's potentially going to be good at.

Julian van Velzen: So quantum computers are a fundamentally different types of computers whereas classical computers are built on these transistors and they have a specific way for computing. Quantum computers are used to the phenomena of quantum physics to build a new type of computer. And they are extremely fast for a very specific type of applications.

One way to think about them is as if they are like super specialized GPU's that are good in certain things. So, for example, think about like simulating fluid dynamics, computations that take classical computers thousands of years, if you want to simulate this in a large extent. That could potentially be sped up by millions of times, in two seconds. Or think about large computational problems, electronic structure and simulating how drugs work or figure out new materials.

So, all kinds of things that are really computationally challenging and that are not possible for classical systems and could potentially be sped up with what's going on.

Ollie Judge: Cool. Last time I checked in on quantum computing, it was like the original computers, that they were the size of rooms and stuff like that. Is that still the status of quantum computing or are we beginning to get to a point where it's feasible for people to think about it as part of that sort of like ongoing industry strategy?

Julian van Velzen: So, it's very early, right? These machines are in complete development. I think in past 10 years, we have proven that it could work. And it has been proven that there, you have very small computers that can run some algorithms. But it's now really in a time where we tried to scale these things up to be able to do serious problems.

So, at this point, nothing has been done with these machines for any practical advantage. But nonetheless, you can already build your algorithms, test them on actual hardware, figure out what use cases work and what doesn't work and make sure that you're ready, because the development is going pretty quick.

It might still take 5 years or 10 years, no one really knows. But if the potential is that big, if you could really speed up some things, thousands, or millions of times, it's probably worth starting to.

Ollie Judge: Sure. So, with this completely different paradigm, I know that my technical animator screams at me every time I ask for water in something that I do because of all of the fluid dynamics and how that works. So, we're going to be talking about blockchains a little bit later and the metaverse. But with the sort of introduction of quantum computing and the way that it can tear through modern computing patterns at a potentially much faster rate, could that potentially be the undoing of modern cryptography? Could it fell an entire industry just based on its speed?

Julian van Velzen: Yeah. So, one of the things quantum computers are particularly good at is to find patterns in large sequences of numbers. And this is exactly what cryptography is based on. So, many of our current cryptography will be broken with quantum computers whenever they're matured. So, it's definitely not today. And then nothing in the next five years either.

But after that, it becomes pretty tricky, and no one knows when it will happen, and you better be prepared. So, the thing is that, even though it may still take 10 years before quantum computers are big enough to run these types of algorithms to break cryptography, it means that by then, you have to be completely migrated to newer type of encryption.

You have to completely readjust your whole aerial, whole network, or your cryptographic assets. And this is extremely complex and time consuming. If you want to give yourself some time to learn, to make mistakes and to migrate, it's a good idea to start today.

Kary Bheemaiah: And this is actually a really important point because Julian kind of educated me a lot about quantum cryptography and QKD[1] and BQC[2] systems and everything else. And, because there's so much going on over there, I think one of the issues why a lot of our clients, or even a lot of people who are looking at quantum computing, they look at it as a curiosity and they're like, “wow, this sounds like really interesting, but it doesn't really affect what I'm doing today.” Or “I don't see how I can actually move from what I'm doing today to what's going on over there.”

And I think a good mental model that people need to have is that every technology is always like a phase of transition, right? So, it's not like you have one system that you work on today and tomorrow you're going to move to a completely different system.

You do so in certain kind of progressive ways, and you need to have some kind of reason to start using a specific quantum technology. It's not just in terms of computation. One of the things that when we started thinking about the Q-lab, which Julian runs right now, it wasn't just to focus on quantum computation.

There was also that “let's look at quantum sensors, let's look at quantum communication systems.” And the reason for doing that is not just because we have an extremely wide client base who have different kinds of needs. It's also because of the fact that there are a lot of these technologies, which are already at the product stage, meaning that every technology goes from being completely new, it's called “genesis phase.”

And then it becomes used for very specific things. And then it becomes used for different things. And that's when it becomes like a product offering till the point it becomes a total commodity and everyone kind of uses it. And right now, we've already got certain kinds of quantum technologies which are in the product phase.

So, a good example for this is quantum sensors. And at Capgemini, one of the labs that we have at Cambridge Consultants, they've done work with quantum magnetometers. And quantum magnetometers are used for detecting very small variations or levels of magnetism with a very high spatial accuracy.

And this can be used in places like navigation or mine exploration if you need to use it in mine quarriers. Or orientation of drones and autonomous vehicles or in places where GPS doesn't work right up to like sonar and detection of moving metal objects and vehicles and stuff like that. Also, a lot of applications for it in cell imaging and pharma.

And so, if you're thinking, how do I start this quantum journey? How do I start moving to this new realm of computation and all these technologies? That's when you select something specific, which already has a physical, tangible thing that you can use right now.

Then once you get into that, and you see the quantum advantage, no pun intended, then it helps you open up and see that “okay, fine, now I can see what's the additional system that I can transfer into.” And that even five years down the line, when we come to this impasse, “oh my God, all the all the encryption systems are just going to get totally pulverized right now.” You're already in a state of mind and it's not going to be like a big emotional shock.

Julian van Velzen: Yeah. Maybe one thing to add to that is that it's not a coincidence that there is so much going on in quantum technology worlds, right? There's has been 50 years of developments, engineering developments

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[1] Quantum Key Distribution
[2] Blind Quantum Computation

and scientific developments in all kinds of building blocks that are used for sensors and for computers and things like single photon detectors lasers and all kinds of cryo-genetic tools, and many things more.

And because that has been up to a maturity level, that it's so extremely good. It's the reason why we can build quantum computers and it's exploding from research facilities into many of our clients are starting to explore. And similarly, for sensors and they are a little bit easier to produce.

So that's why we think there is more commercial value in the next couple of years? Yeah, but there's this whole building block that made this happen.

Moez Draief: And I think that there is also a lot of progress that happened on the algorithmic side. We lacked algorithms. Before we had some Toy problems or interesting problems, but that, that we had algorithms for sure, the Shor's algorithm, the Grover's algorithm. But now there's like tons of algorithms available there that look at linear algebra, that look at differential equations.

And now, if we are obviously not that the level of the classical type of algorithms, but we are cracking multiple problems. People need to be aware that writing a quantum algorithm before even deploying it on their quantum computer is an art in itself. It's like their concepts are different, the way you think about gates is different, the way you write algorithms.

There is copying data, for example is challenging because there are limitations in copying it actually cannot. There is the "no cloning" kind of principle that stops you from doing certain things. So, really the design itself changes. And I think it is interesting.

And hopefully, there'll be tons of quantum algorithms when there are quantum computers. But it's also, as Julian was saying, this is a great way of building a new algorithms in the classical world, because we have new tools now to think about problems and new approaches. And I think there's a lot of potential there as well.

Kary Bheemaiah: And there's that side-by-side existence, which is already happening right now. You hear about quantum machine learning which is a term that's been thrown around for the past couple of years. And what's interesting about it is… it is actually more of an interplay as in which… where does classical computing actually stop and where does the quantum computing like take over after that? Do you need to use all the computation that you need to do? Does it have to be on a quantum computer? Or can you offload it in a certain kind of way?

Julian van Velzen: Actually, we did participate in the BMW problem challenge. But to reply to what you said, or add to you both, is quantum computing would definitely not take over classical systems, right? It will be a specialized type of compute system that similarly like a GPU does a certain type of things.

I think in, let's say for example, a weather prediction, it's been mentioned as a use case for quantum computing. But at its current stage, it's way of a complex problem, it involves thousands of things from measuring data to understanding fluid dynamics to predicting larger flows. And I think there will be its first, it will be a quantum algorithm that does, you know, some very specific things. For example, determining how some droplets of water interact with other materials, to understand how clouds behave. And there will still be a lot of AI that predicts other parts of the weather.

And in the future that will continue to evolve where quantum technology will have more of a larger role and more advantage. But it will always be a heterogenic landscape where there will be decomposition of this problem into many different computer architectures.

Ollie Judge: I think what has been interesting through our conversation so far is trying to figure out the interoperability between all of this stuff. Like how do we send things off to a quantum computer for that to work on it? How are we choosing the right processes to go to the right bits of hardware and software as we move through everything? We've recently talked about metaverses on a different episode, but in the sense of entertainment and connectivity and all that kind of stuff. But I'd actually quite like to think about the metaverse on this episode as more of a new internet, a new way of all of our systems communicating with each other that is maybe a bit more modern than the current transfer protocols that we have at the moment.

And also, how do we facilitate the right highways between all of these new things that are coming through, especially when some of them may not have a centralized place that they're working through? We've talked a little bit about decentralization and all that kind of stuff. I'm going to ask a question to Kary first, which is going to be are blockchains the right application for all of this stuff to be built on, or is it just the rudimentary thing that comes before the next thing?

Kary Bheemaiah: No, you got to boil it down to just one specific deck, all right? That's cheating and you can't do it with my favorite tech as well.

So, it is like a big conversation that Moez and I have been instigating with a lot of our people who work in engineering because the real conversation over here is actually about MLOps.

And Moez came up to me, sometime back and he was just like, "Hey man, no one's cracked this. It's so strange that everyone's going completely crazy and gaga over IoT and new kinds of devices and on-device intelligence, and we can do this, and we can do that." And he's like "all this information is coming in over here."

You've already got like computational challenges that we need to take into consideration and a big part about it is if you have these kinds of value chains of data flowing in and out and, being computed upon, then it creates bottlenecks. So how do you address these issues?

And this is like the reason that we actually reached out to Tim Scarfe. So, Tim Scarfe runs a podcast called "Machine Learning Street Talk". And on Machine Learning Street Talk, he gets really premium people to come down over there and have these amazing interviews with them.

And so, we reached out to him and we were like what do you think? Because you talk to all the experts. We'd rather speak to you rather than speaking to 10 different experts. And he told us essentially the same thing, he's not been able to crack this. So, I think if we're going to be talking about this, we first need to think about it from conventional processes. Like, how does this actually work over here?

Blockchain has got technically a role to play in all of this because the world between off chain and blockchain is like getting more and more porous, right? So you've got a lot of information, which is not on a blockchain, now being transmitted to it. But never forget that a blockchain is made for a very specific reason.

It's a value transfer protocol. And what we're talking about over here is communication protocols intermingling with the value chain protocol. And value chain protocol has got a very specific purpose. I's supposed to be able to do the transferability of an economic value in a very decentralized way and therefore make it cheaper.

But it's in a very specific context. And what we're talking about over here is computation in general, which is a big, much bigger umbrella term. That's why I would now handover to Moez because he's the guy that I go to when I need to talk about communication.

Moez Draief: I think Kary is right. There's not a technology that it's going to solve this. But I think that the ideas behind the blockchain, of being able to trace actions and be able to be confident on who did what and how, and this is approved in a decentralized way, will be part of the solution.

To go back to what I was saying earlier about software 2.0, this is an ecosystem of people developing code based one, actually machines developing code on data collected somehow in the metaverse or in the real world or through sensors or whatever.

And then this is transformed into insights, into areas where most people have no clue how to go from the data, to the insights. So they have to trust what's going on, and then people have to create a certain interoperability between all these, to be able to stitch all these solutions together, to enable you to solve a problem.

I gave the COVID problem earlier. They required people who do statistics. You require biochemists, you require companies that do drug discovery. You have to trust the clinical trials, et cetera, et cetera. In an era of mistrust and distrust of science and innovation, I think if you have these amazing tools that are put out there and there is no oversight, and there is no way of checking why the machine is recommending this, why this drug is the right drug, how it's been discovered, who interfered with the data collection, with the algorithm design, et cetera, then clearly, we're going to have even less trust in this innovation, because now it's not going to be, MIT and Harvard and Cambridge deploying these solutions or a company.

It is going to be everybody you and I can sit down and develop something, put it on the market, stitch it to existing solution. And it's a new product. And I think, we call it the MLOps. You can call it DataOps. It's the X-ops world of being confident in how things have been designed, how things are working, what are the limitations of the things who fixed them and how they got fixed?

And I think this a way of thinking about products that again, could work in a company and a small company on a software. But if you're starting to have these "everything as a service" type approaches to selling products, then we need something like blockchain for value exchange, about insight exchange and code exchange and data exchange.

This is the thing that's going to be, for the next 10 years, if we want to crack what AI brings to the table and what new hardware advances enable us to do, we need to get this confidence in what we are building from all dimensions.

Kary Bheemaiah: Yeah, because there's so much complexity, that gets involved in that. So that lets us use, you used the word metaverse, which everyone seems to throw around, but this really highlights the differences in the protocols you could say. Okay. We know that more and more of this metaverse stuff is going to be web-based, it's already happening. The new cultural zeitgeist is being written as we speak.

But think about the actual user. You always have to start with the user. So, let's say they're using either a traditional medium which could be a computer, or it could be a smartphone. Because it's got a lot of AR functionality over there. Or they are using like an AR/VR headset.

So they put that on, they get into some kind of metaverse on a platform. They start walking around. They're doing different things. They're communicating with their tribes that they meet over there, or they are talking to creators, they're looking at their artefacts, about what they are producing over there.

And at some point, during this phase, they say, "oh, I want to make an economic decision. I want to buy this NFT. Because I can now get a physical representation of it and wear it in the real world. And I can also get a virtual representation of it, which I can dress up my avatar with it."

Up to this point, blockchain is not really involved. Up to this point, it's just like traditional platforms. Okay, fine there's new gadgetry that's involved in it. It's only at the point when they make that economic decision and make the decision to connect their wallet and make a payment that we have the conversation that moves to the blockchain.

And what we've been talking about over here is there are complexities and efficiencies which need to be addressed in the communication protocols by itself, especially because we're getting more and more novelty that's getting created more and more new novel experiences, and a customer mindset that is spending, between six to eight hours for most millennials. Every day they're spending it online today.

So that by itself has got its own computation kind of challenges with needs to be solved. And of course, if you move into the blockchain, then over there again, there are a lot of computational problems. It's the reason why we had generation 1 blockchains, generation 2, and now we are in the era of generation 3 blockchains.

And what are they all doing? They're all fighting because of efficiency. Whether it's in terms of transaction throughput, whether it's in terms of energy consumption, that's what they're going about. They trying to make sure that they can have the most efficient blockchain, which cannot just match whatever visa, transaction group it is, but go orders of magnitude beyond that, because they know that this is where the demand is coming.

So, you can't have a one-size-fits-all kind of solution, a very nice, simplistic way to go about it. Because essentially, you're dealing with massive amounts of complexity. And so, your approach needs to have a way to respect that complexity, to understand it, and have a lot of granular solutions which are linked up together and make sense of that they're interoperable. They flow into each other.

And hence, the reason that we started talking about MLOps, whatever Ops, XOps, as you want as much as Moez said, because if you don't understand the bottlenecks, you're not going to get the kind of efficiency requirements that you are looking for.

Julian van Velzen: Maybe one thing to add here. I think one important thing is that there is this growing demand for transparency in the way we compute things, and we'll compute what. And the reason for it is that I think one thing is that everything becomes computable in this metaverse picture, right? Where the boundary between the real world and the digital world is fading.

And secondly, because it's becoming very difficult to see who's doing what and what type of compute systems are.

And one thing that I would like to add that there is that there is also an increasing inequality in compute capabilities. We see that with the chip shortage now, with the growing international tensions. And we see that also with quantum technologies where US has recently put very strict export control to China for quantum technologies.

And there is a lot of talk in Europe as well about bolstering agreements that EU uses for protection for these types of technologies, as well as travel and exports restrictions.

So it becomes even more important to have more transparency in the way we compute things and to really make sure that we will be able to distribute the computes capabilities equally and fairly.

Ollie Judge: I think that's an important note to take forward and also somewhere where I wanted to go around metaverses and all this kind of stuff. The argument against metaverse right now is that we're inventing all of this technology for somewhere that people don't actually want to be quite yet.

Because there's no motivation for them to be there. We're not at "ready, player one," we've just got Facebook or Meta putting literally your desk in a 3D environment. That's not super exciting. So, have we got a bit of a chicken before the egg problem right now? We're expecting people to show up and use all of these new value transfer mechanisms without necessarily understanding what the people are going to be doing in these environments.

And then, as an add-on to that: what's going to be better in these environments? If we can use all of these new technologies, where are people going to see things be not just more efficient, but as we've seen, leaps with smart phones and all that kind of stuff, what actually brings the leap forward rather than just replicating how I use a credit card, but I'm now in a different environment?

Kary Bheemaiah: Yeah. I'll take a first stab at this. I'm a big fan of Gresham's law, which in economic theory is just "bad money drives out good" right? So, you might have different currencies, but the one that everyone wants to use for whatever reason, that's what they kind of gravitate towards.

And this is something in which like technology has got this feature that once it's out there, the cat's out of the bag, so it's not going to go back inside again over there. So, this metaverse conversation has started. It's been going on for a while, by the way. It's come into the public limelight just because of the fact that, Facebook has done its rebranding and made it a verb that everyone's throwing around over here.

But it's ultimately up to the person to make that choice. It's the user's need for it. And even before the metaverse became such a normalized term, there were people already doing it. If you're working in blockchain, or if you're looking at what's going on in crypto, the NFTs came out in 2017 with Crypto Kitties. And after that, it's like, it had its evolutionary path, to the point that people are using it for different things.

They first started by making board apes and profile pics with it. And today what you've got is people are using these NFTs to go ahead and actually make completely virtual fashion houses. So, these are only virtual dresses, right? They're only virtual clothes. They're not physical things, but you've got designers who are actually doing like fabric which is only for digital applications.

And the reason that they're doing it is because there's a market for it. One of these dresses, these virtual dresses sold for $10,000 recently. And you might be asking the question: why would someone pay money like that? If you're spending six hours a day online you want to be able to represent yourself in a certain way, in the same way that when you leave your house in the morning, you make an effort, you kind of dress up a little bit. You make sure that you are perceived in a certain way when you walk and do a public situation. If you're doing that in a virtual space, why not have the same kind of thinking over there in which you want to be able to be presentable in a certain way?

And this is a choice. There are certain kinds of people who get inside over there and maybe it becomes a trend; right now it seems more like a fad. And there's like a difference between those two things, but it's really up to the person to make that choice. And some people will take it, maybe the younger generation. We all have smartphones today. No one's telling you that you need to use a smartphone. You can perfectly go back to using like a flip phone, just like a simplistic phone.

But when you make that decision, you're also giving up the access to the world's information in your pocket. So that's like the thing over here. It's the fact that we have the choice to make it. And if people want to make that decision, then as long as there are people who are creating demand, there will be people who could provide supply.

Moez Draief: If we take a utilitarian view as well about it, I think it's a huge opportunity to collect data on people behavior, and a lot of environment and control of the experiments. But they're all things where it's very difficult to remove the contexts and understand why a person is reacting like this.

This could be social behavior, but it could be for a disease. It could be for all sorts of things. So with Kary, we are engaged in a big umbrella project that we call "Human Machine Understanding". And to be able to build the right interfaces, but also the right experiments and kind of design experiment that get you to understand when someone is in pain or someone is under stress or someone is confused.

I think being able to build between a virtual world and a real world and be able to capture that information and disentangle the elements that are in there. I think it's really a very rich set of experimental designs that we could do. And this has nothing to do with building by in fashion or NFTs or anything.

Kary Bheemaiah: Yeah. And you'd like to build on what Moez is just mentioned right now. Like today, if you look at the whole area of pain management, what have we done over there? We've pretty much outsourced it to the pharma companies.

Now you've got to ask yourself the question: with all this newfangled technology out there, how come we haven't been able to crack this problem? And it turns out that there's a massive level of distrust between the person who is paying or the care receiver and the healthcare provider.

It's very hard for us, even though we can empathize to be able to actually gauge the depth of pain and what this person is actually feeling. Today, what we're doing with human machine understanding is trying to figure out that aspect. How do we use bio signals? How do we use different kinds of data points that can actually help a caregiver understand the depth, the intensity of the pain? And then based on that, be able to make a much better decision? And it gives a much more pragmatic kind of treatment to these people.

And you might say that this sounds like they're using a lot of data in trying to figure out what the persona of a person is. That's essentially what they're doing with this metaverse technology as well. It's always context relevant. It's always going to be the case that once they use it, they might not want to go back to how things were.

And that's a decision that needs to be made both by the person who's getting access to the technology and the people who are behind it or creating it, that would be a reasoning view.

Ollie Judge: Oh, wow. Covered a lot of ground there. So, my next question, we're going to move on to a couple of, wrap up questions. But at the moment where we've been talking about new technologies and new ways of doing things and all that kind of stuff, but new stuff comes out all of the time.

Instead of looking into the future, we're actually going to look into the past a little bit. What over the last year, have you seen people waste time on or get a little bit too stuck on the hype of, and it result in little to nothing or be completely scrapped? It'd be quite nice to potentially get an example from all three of our little pillars here.

Kary Bheemaiah: When we started thinking about AI and ethics, we said, no, this is an engineering problem. And we had to like really to help them understand that this is an AI. It's got a lot of capability, but at the end of the day, it's looking at variables and data.

So, if you want to really have a serious conversation about resolving ethical constraints and ethical issues, then the way you need to go about it as from an engineering perspective, like what are the actual variables of ethics? How we like able to quantify that so that it can be understood by a computer?

And unfortunately, this, there are people who work on this and then they do really good work. But most of the noise that you hear about AI and ethics, it's overly dramatized to the point that we are losing real focus on the issue. And the issue is it's should be looked at from an engineering perspective, rather than this weird way that it's being talked about.

Moez Draief: Yes. To pick up on this, actually, we had a long conversation with Kary about this topic. I think clearly, we want to make sure that machines don't discriminate, but we don't build machines to discriminate or not discriminate. We give them a problem to solve. And if in the process of the data or the end user that interacts with it, there is discrimination, the machine is not going to fix that.

And this is why we need the oversight that I was talking about earlier. We need to put in place things that guarantee that things don't go out of whack. But if we start by saying, "we should not do AI because of ethical issues", then there are many things I think in the past we would not have done.

And I think to be more specific on that, on an area where I think we lost a lot of energy is the transparency of algorithms. There are tons of papers and tons of, I think, interesting academic work in this space. I've done work with one of our clients, a bank about analyzing the impact of existing transparency algorithm.

And we showed that how unreliable they are and how noisy they are to all sorts of things from the feature engineering of a data scientist, to the quality of the data, to how it's read. And so, this is an area where we should make a lot of progress. There are some great academic things out there to learn from.

But it's not an area that we cracked. And it's actually a fundamental problem of machine learning, which is how you make machine learning that generalizes and that learns from things that it has not seen. So, the problem is actually a fundamental problem with machine learning, not just an ethical problem.

But I think, without going into controversy, this is I think a problem where we should probably refocus especially in the industries that are most sensitive to data and data kind of breaches and ethical aspects. They focus on the value, put in place things that limit the risk and be transparent when things go wrong, rather than trying to come up with fancy ethical considerations that are not necessarily useful.

Ollie Judge: Julian. You've been very quiet. What has been over-hyped in the quantum space in the past year?

Julian van Velzen: I think there's a lot of hype around quantum technologies. The most common thing is that people think about these machines as if they will solve everything. And it's just a super-fast computer.

But the reality is that it's super difficult to get an advantage, especially in the near term. And for many of the applications, you would need like machines that are very far away soon. So, I think what some people, some companies have wasted some of their time on is to really try to squeeze value out as soon as possible instead of building sustainably along the road, instead of trying to get a proper quantum advantage.

And I think that corresponds to how you set up your team, how you set expectations, what kind of problems you try to work. And it's much better to have a longer-term vision. It's really a marathon and not a race. So that's something that I would really recommend to everyone.

Ollie Judge: I think. The useful thing for everyone to be thinking about, especially with quantum stuff. So, my last question another, maybe a little bit pointy one, but we'll see how it goes. All of the stuff that we've been talking about at the moment and a big highlight of this year in every regard has been sustainability and understanding the impact of everything and how that works with our planet.

Quantum computing right now has not really reached the stage of optimization for any kind of like power consumption. Blockchains in a lot of contexts are not good for the environment at all, until they moved to a proof of stake way of working. And there is an awful lot of e-waste in the traditional Moore's law way of us building things, that we want faster computers all the time to build faster software on that we just get rid of.

Are some of the technologies that we've been talking about today, going to enable essentially through the computation of everything that we're doing. And Moez, you touched on this a little bit earlier of how we make things more efficient, potentially through compression or less computational impact through optimization. Are the technologies going to be able to get to that point where they can almost self-optimize to be more sustainable before we run out of time on the amount of time that we're actually developing these technologies through?

Moez Draief: I can start if you don't mind. So, I think on the of AI in sustainability, and then I can talk about sustainability more broadly; but I think there is more and more of a kind of focus in AI now to understanding the impact of the algorithms, the data that is collected and how to do this in a more efficient way.

And I've been working with a good friend at Imperial college, London, about how to take this as a dimension in addition to accuracy of the algorithm and its energy consumption; and how much you're gaining by running a more powerful algorithm, compared to something that it's maybe less powerful, but have better energy efficiency.

And we actually published an open-source tool that enabled people to do these trade-offs with colleagues from France, from the data science team in France. So, in the AI space, that is clearly because people believe that this is going to be a general-purpose computing paradigm that will be used.

People are thinking more and more about it. I think now, if we talk about sustainability more broadly, I think it's like talking about AI as an umbrella. This is a big topic. There are many levers, and there are many things to think about. And there's been a lot about the carbon impact and the fossil fuels, but there are new ingredients we use, there is our way of interacting, consuming, moving.

And I think this is something that if we are able to measure and play back to people, how they are impacting the planet, this could also be a great call to them to understand their impact.

But also industries. I think data could help a lot in doing this. But I think we need to break this problem into many smaller problems that we can solve rather than just an umbrella problem that we were going to struggle to solve if taken this way.

Kary Bheemaiah: I think a lot of the reason why people have got that understanding that crypto, blockchain, and Bitcoin especially use a lot of energies because it traces back to this article that was published by Nature.

And this article, which was published in 2018, I think, or something like that, made a lot of assumptions that were wrong. They thought that the amount of energy that was going to be useful but validating each and every transaction is the same as it used to validate a block, which is not at all true.

And secondly, they thought that was during the tail end of the ICO craze, where we just saw like a huge spike in adoption. They thought that kind of adoption rate would continue. And in reality, it didn't happen that way. It went down, there is ups and downs, and it happened over there.

So that's like the reason why this got circulated and since no news makes as much impact as sensational news, this kind of entered a lot of people's minds. The truth of the matter is: if you are running a proof of work protocol and you're a validator on it, you are incentivized to reduce your energy consumption. Because otherwise, you will be spending a lot of what you gained directly in being the energy cost.

And this is the reason why, especially after the crackdown in China (which I think was good for the overall Bitcoin economy), you had more and more of these mining rakes which are actually farms, which were set up in places where there's access to cheap, renewable energy. And the fact of the matter is today, 70%, or even up to 75% of the energy that's used just for Bitcoin actually comes from renewable energy, right?

You might say: why aren't we using this energy for something else? We spend more than the total amount of energy that the Bitcoin network actually consumes just by using the electrical devices that we just keep on, but we don't use every day. And so, if you're going to be talking about this topic seriously, you need to have a much more holistic vision, just like in any system. But people are doing and more of it with renewable energy today.

And if you've transitioned from Bitcoin to third-generation blockchains and or if it's Cardano or if it's Solana, these have been designed from the get-go to be as carbon-neutral as possible. I think Algorand, that's one of the main reasons we partnered with them. It is because we looked at how they were operating the stuff and they're able to say that “fine, we prefer partnering with these people because they do have a net-zero ambition, which they are achieving, in a very advanced way.”

Ollie Judge: To flip over to Julian, are we going to reach that like correct tipping point where the technology can be optimized so that it doesn't waste a bunch of stuff? I think this is the most interesting question for quantum because it is still in its early years. Is there much thought going into that right now or is it still a little bit up in the air?

Julian van Velzen: No, absolutely. So, I think one perspective is to see how polluting the technology itself is, right? Like how many data centers we have for AI running NLP models or how much minus we have to sustain the blockchain? And I think that's a valid reasoning for quantum technologies as well.

Those machines operate at absolute zero temperature and are quite bulky and take a lot of energy. But it is like comparing apples and pears. These machines are so extremely powerful that if they will be big enough, they may be able to do safe things that the biggest supercomputer clusters wouldn't be able to do in thousands of years.

So then, the energy consumption becomes irrelevant. I think what is maybe… what I find more interesting than to look at just the energy consumption of these technologies is to see what you can do with it. I think we have a lot of challenges in the race to move to a net zero society.

I think we are making some progress these days with solar panels and other types of sustainables, and some progress in moving to electrical vehicles. Although it's really, I think at this point, 1% of all the cars are electric. So, it's really just a very small step.

And we'll have many more challenges in the future moving from the steel industry to a more sustainable one or cement or the way we use air conditioning in our homes or heating and many other things. And I think we will need all the new technologies that we can get.

So, we need the more advanced AI to build new materials. We'll need quantum technologies to develop new batteries that will make electric vehicles more attractive. We need to go beyond the solar panels of today and make them more efficient and more applicable in different circumstances.

So, there are many of these challenges ahead, and I think that's both new types of AI and quantum machine, quantum computing will definitely play a big role there.

Ollie Judge: From today's episode, it's easy to see that there are some seismic technological shifts on the horizon as we go into 2022 and beyond. Technologies like the ones we've discussed here today are only going to become increasingly relevant to businesses in all industries. And as tech, like quantum computing and innovative AI algorithms become a reality in how we operate our businesses, it's even more important that we keep our sights firmly set on the future.

A big thank you to today's guests, Kary, Moez, and Julian for sharing their insights and expertise. If you enjoyed this episode, don't forget to subscribe on Apple Podcasts, Spotify, or wherever you get your podcasts. This has been Future Sight, a show from Capgemini Invent. We wish you all the best for the new year.

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