Rashmi Mohan: This is ACM ByteCast, a podcast series from the Association for Computing Machinery, the world's largest educational and scientific computing society. We talk to researchers, practitioners, and innovators who are at the intersection of computing research and practice. They share their experiences, the lessons they've learned, and their own visions for the future of computing. I'm your host, Rashmi Mohan.

On your weekly trip to the farmer's market, do you spend an extra minute thinking about where that juicy strawberry came from, the journey it has had the faint chance that it might never have made it to your table? Well, you don't have to worry too much about that because our next guest has poured his research expertise and computing skills into optimizing the agricultural experience for farmers to ensure high-quality yield and better outcomes. Amongst his numerous roles, Ranveer Chandra is the managing director for research for industry and the CTO of Agri-Food at Microsoft. He also leads the Networking research group at Microsoft and has shipped multiple products over the years. He's a fellow of ACM and IEEE, has authored over 100 papers and patents and won numerous awards including the Microsoft Gold Star Award. He has been recognized by MIT Tech Review's Top Innovators Under 35, and most recently was included in Newsweek Magazine's list of America's 50 Disruptive Innovators. We are so excited to have him on our show. Ranveer, welcome to ACM ByteCast.

Ranveer Chandra: Excited to be here, Rashmi. Thanks for having me here.

Rashmi Mohan: Absolutely. I'd love to lead with a question that I ask all our guests. Ranveer, if you could please introduce yourself and talk about what you currently do as well as give us some insight into how you got into the field of computing.

Ranveer Chandra: Yeah, Rashmi. So I'm currently the managing director of industry research at Microsoft. I also lead networking research at Microsoft Research in Redmond. I also serve as the CTO for agriculture and food at Microsoft. My team works on cutting-edge technologies that define our network experience. That is how do you connect your devices to the internet? How are data centers connected? What is the future of the internet going to look like from earth, from space, in the cloud? And that's one area where my team and I work with amazing set of researchers in the group who are working on cutting-edge technologies all the way from what is 6G going to look like? How do you make a network secure? How do we connect all the GPUs in the cloud to make sure we can drive the next generation of AI experiences? So that's one part of what my team does.

The other team, the industry team looks at, once you get the data in the cloud, in the edge, what kind of experiences could you land for different industries? What is the future of the energy industry? What's the future of finance? What's the future of agriculture and food? And that's where the third title that I have is, my team also works on helping define what's the future of agriculture. We look at coming up with ways in which we can bring the best of technology to the

agricultural ecosystem. How do you get farmers to be more productive, to be more profitable? So that's what my team does, inventing the best of technology and networks and then using all the advances in computer science, from networks to systems, to artificial intelligence to computer vision, to define what the future of different industries are going to be across different industries that we interact in our daily life.

And to your other question, Rashmi, how did I get into computer science? I grew up in India. I grew up in a city called Jamshedpur in India. And growing up I did spend a lot of time with my grandparents in Bihar. This is a state in northern India where every summer and winter vacation I would go spend my time there with my grandparents. As it happens in India, as many of the listeners from India can relate, at least when I was growing up, our parents used to drop us off at our grandparents' place and then disappear during the vacation.

So we were there with my grandparents and back then I did not like anything to do with agriculture. These villages, they did not have electricity, they did not have toilets, but that's where it grew up. And that's what got me into the agriculture space because a lot of friends I meet were in agriculture. Even though I was interested in agriculture, my background is in computer science. I enjoyed math, I enjoyed tinkering with hardware. So I remember when I was small, my dad had gone to Japan and my father, he got a system, it was like a radio, but it could decode signals in the TV bands from TV channels. And I really enjoyed playing with that, playing with walkie talkies. This was even before I was 10 years old, and that got me really interested into the electronic side of things.

And I also really liked math and algorithms. So when we got a computer in school for the first time, I think it was in ninth grade, we had one computer that was shared by many students. We had to take our shoes off when we entered the computer lab. But just the experience of coding, of realizing how you could enhance your creativity with a computer, like even building the first computer game when I was in high school, those were all exhilarating moments and that's what got me into this field. Of course, after that I studied computer science at IIT Kharagpur, came here, did my PhD in computer science. And since after my PhD I've been at Microsoft Research.

Rashmi Mohan: Got it. Thank you so much for walking us through that journey. I mean, two things that stood out, right? I mean, I love the synergy that you have between your two roles because if you were to describe the roles sort of independently, it would be hard to see what the overlap was. But I saw the parallel that you drew there in terms of talking about how the advances that you're making in your networking research group in terms of how are you going to connect people, you're kind of using that to say, okay, now that we have this ability to connect these people who might otherwise not have had this opportunity, what can we do for them and how can we improve their lives? So I really love that

parallel that you drew, I think will make for very interesting conversation as we get along.

And then, yes, I also recall, I think I did computer science also in my eighth grade, but I distinctly remember the removing your shoes to get into the computer lab. So that got me a chuckle. But yeah, no, it's great to see that you had that early exposure and you had the ability to kind of play with some of these things that came in as maybe as games, but you're genuinely interested and it drove your curiosity to get into the field.

I do have to ask though, Ranveer, before we get into more of your early parts of your career, what does it mean to be the MD of research for industry as Microsoft? So what is your role that, is it mostly limited to researching and saying, oh, these are some areas where we could make an impact, or is it also go all the way into deployment and potentially going to market and trying to understand how do we actually get this in the hands of users?

Ranveer Chandra: Yeah, so it is the latter, Rashmi. And you asked a great question. And this is one of the benefits of being in industry and in industry research is that we partner very closely with customers. As part of our group, we come up with the technologies. Oftentimes even the invention of technologies, the problem that we are working on comes from customers. So we talk to customers, we talk to practitioners in this space, we go to industry conferences, and that even drives the development of new research that we do in the group. As we build the research, we then take it all the way.

So in my group, one of the things we follow is what we call technology readiness levels. The way NASA launches a rocket where they have a similar process where all the way from ideation to becoming a product, we have nine different technology readiness levels. The last three are product, the first six we call a different research stages, and we take it through them all the way from ideation, coming up with crazy ideas to even publishing a paper, building a proof of concept to then trying it out with the customer to scaling to the next level with the customer before the product is green lighted. And we want every project to go all the way and not get stuck at one technology readiness level because if it does, then probably we are not doing the right thing.

So I can give an example, of course we'll talk more about agriculture, but one of the recent work that we are very excited about is in the financial services space. So the problem that came to us from by talking to customers was the problem of how do you run a financial exchange? Right now, all the big exchanges, they have the data center on-prem, like they'll have one New Jersey or one in Chicago. And the reason they have everything in one data center is to provide fairness.

Like for example, the exchange needs to send out these updates, which needs to get to every customer, every market participant at exactly the same time. If

you want to host such an exchange in the cloud, it becomes hard because in the cloud your servers could be anywhere and the wires are not exactly the same length. So how will you provide fairness? So in the team, there are some smart researchers who come up with this idea, which we just published in ACM SIGCOMM this year, which was on a new concept of fairness called response time fairness based on the concept called delivery based ordering. The idea builds on a lot of previous research of instead of having precise clocks using virtual synchrony, virtual clocks, and using that, we are able to define a new model of fairness which can get these exchanges to be hosted in the cloud.

So these are the kind of breakthroughs, again, that's an idea, we are now the next stage. We are looking to deploy it with customers, but we want to take it all the way to a product. Similarly, in agriculture, we actually started working with farmers. I went and interviewed several farmers before we started working on the FarmBeats and our FarmVibes and some of the new work. Just this week we published a new result on archive on generative AI for agriculture, for farmers and how that's going to transform their lives. But to answer your question, Rashmi, yeah, we do look at everything from not just coming up with the idea and publishing a paper, but how do you take it all the way to truly drive the adoption of the technology and industry as well.

Rashmi Mohan: Oh gosh. Sounds like you have the best job ever. That is amazing, and I think the right way to do it as well. I like that you have a framework around it as well when you're talking about your technology readiness levels, because that kind of helps. It's some guiding principles to see how do you think about a problem. How do you know you're sort of moving from one stage to the other and tying up the loose ends at each stage. Again, I'm sure we'll talk about this more. It's also fascinating to me that you have such diverse interests within the portfolio of projects and products that you work on. I'm guessing your team also must be equally diverse in terms of domain expertise. I mean, if you have a problem that you're trying to solve in the agricultural space and also in the financial services space, that requires a deep level of expertise. So I don't know if that is an in-house thing or you partner with the domain experts in each of those areas.

Ranveer Chandra: No, and we do partner with domain experts, and these domain experts could be in-house in other groups within Microsoft or they could be in academia. We extensively partner with academia, with experts in academia who provide that domain expertise. We also partner extensively with other customers and partners who build on top of what we do. They provide us feedback. They're our go-to market as well.

And to your point, in some sense, Rashmi, the way I think of what we are doing is just bringing the best of computer science to the industry. We are building tools essentially bringing the best in computer science, I mean best of networking, best of systems, best of AI, best of edge compute, best of robotics to an industry. But we are still, these are all tools. Eventually we need to work

with the right experts who can package it and take it to the right stakeholders. It is complicated, but it is what we need to do as an industry in computer science.

As computer scientists, we need to bring the best of computer science so that others in the industry can use it and help drive that transformation for the industry. And the role of this has to be very interdisciplinary. Like for example, we partner very closely with land-grant institutions across the US with University of Illinois, Purdue, NC State, Cornell with different professors there who bring in a diverse expertise in, for example, agriculture. Similarly in energy, we partner with Georgia Tech, with Stanford. So that's how we are able to do this cross-domain innovation.

Rashmi Mohan: That sounds really incredible. I definitely have more questions around all of those areas as we progress. But dialing back a little bit maybe to the early parts of your career, Ranveer, I know I was doing a little bit of research and I came across this project, which is called virtual Wi-Fi, I think, a research project that you worked on as a part of your PhD. Curious if you'd like to talk a little bit about that in terms of how did you pick that topic? What was interesting in it for you?

Ranveer Chandra: So virtual Wi-Fi, this was my PhD thesis. The idea behind virtual Wi-Fi was very simple. So for example on your phone or your laptop, when you click on your Wi-Fi icon, you see a lot of Wi-Fi networks. You pick one network to connect to, that's the state of the art. Imagine if you could connect to many such networks, that would be cool. You could start thinking of more capacity, different scenarios. And that's what I enabled as part of my PhD thesis. I worked closely with Victor Bahl back then at Microsoft as Pradeep Bahl was there and other people, John Donegan, who were all here at Microsoft, on building that capability of virtual Wi-Fi. And then when I graduated, I was actually going to go into academia, would've become a professor. The only industry place back then I had interviewed in was at Microsoft Research and they ended up coming here and we shipped it as part of a product.

The reason I came here was I was told that if you come here, it could ship as part of a product. And being in industry, being at Microsoft, our products can touch, if it's ships in Windows, it would touch billions of people. So that was the reason I came here at Microsoft and we shipped it in Windows 7, and it's been shipping since Windows 7 and not in the way we had envisioned when I had written my thesis, but it shipped as part of other features where when you have to enable personal hotspot, like for example on your phone, the same thing, it's now shipping as part of Windows on phones as well. On your laptop, for example, if you do wireless mirroring, it's using behind the scenes. That technology, that was part of my PhD thesis.

That was one of the first such research projects that I worked on that had an academic impact that also had a product impact. It's being used by many people. Like for example, you must be using personal hotspot on your device.

And behind the scenes it's using virtual Wi-Fi as well, that technology that we had developed back then.

Rashmi Mohan: It's really amazing you say that Ranveer, because also I don't know how many folks can actually say that their PhD thesis actually made it out to product and is currently used in a commercial way, even though it morphed into maybe a slightly different version of it than what maybe your initial idea was. With your entry into Microsoft and Microsoft Research in particular that brought you into the mobility and networking research group, what were the other sort of key projects that you remember from your early days being a part of that group? I read a little bit about I think your white space project as well and was quite amazed at the innovation and progress that you made at that time. I'm wondering if you could talk more about that too.

Ranveer Chandra: And that's when I joined Microsoft Research in 2005. One of the first projects that I started working on was this use of TV wide spaces. So the idea behind TV wide spaces is it's built on this concept of dynamic spectrum access. And I'll talk a little bit about it, but the problem that we wanted to address was that of rural broadband. That is how do you bring connectivity to every person on the planet? Right now around 40% of the world's population still doesn't have internet access. I think the latest number is 2.6 billion people, which is something we take for granted. We are on Teams calls, we watch videos.

But still there are significant population in the world who are still not connected to the internet. And the problem, the reason they are not connected to the internet is not because they're not in range of connectivity. There's the GSMA reports talk about how over 90% of the world's population are in coverage range of cellular signals. The problem is that the connectivity is not affordable for most of the population, that's around 30% of the world's population don't have affordable internet access.

And you can see why, like the farmers that I work with, a lot of them in say sub-Saharan Africa, or in India, they're making a dollar, $2 and that's a month. They're not going to be spending a significant fraction of that. Or maybe they can't even afford to pay for internet access. So how do you make internet connectivity more affordable? One of the technologies we have been looking at is that of TV wide spaces. The idea of TV wide spaces is imagine if you had a Wi-Fi router that you could access a few miles away. That would be cool. Right now, as soon as you exit your house or office, your Wi-Fi disappears.

So then the question is how do you get internet? So the way we get this long-range internet connectivity is we took a Wi-Fi signal, and we put it in empty TV channels. This is TV you watch using antennas. When you browse TV channels, on certain channels, you get a transmission, on the other channels, all you get is white noise. One of the technologies that we had developed was a way to take a Wi-Fi signal and to put it in empty TV channels. This is the TV you watch using antennas and in a way that doesn't interfere with your TV reception in an

adjacent channel. So you could be watching channel seven at home, on channel eight we could be sending Wi-Fi signals.

And the reason this is so cool is that compared to Wi-Fi at the same power level in UHF TV channels, your signals go four times farther. In BHF, they go 12 times farther, and that's in free space. Once you put in trees, crops, canopies, your signals just keep going through. So this was a technology that we had developed. The concept, the underlying concept behind that was this concept of dynamic spectrum access. That is if certain channels have been allocated for a certain purpose, if that part of the spectrum is not being used, can you reuse that spectrum? Can you share that spectrum for other users?

Like for example, if part of the spectrum has been allocated for TV transmissions, if the TV transmissions are not happening in that spectrum, can you use it for Wi-Fi-like communication? So when we had built it, we had the FCC chairman come to see the demo we had put together at Microsoft. This was in 2010. There was regulations around it. They've been working with different regulators, different governments worldwide to have the regulations around the use of the spectrum, the TV spectrum for unlicensed access.

We have had different deployments in places in sub-Saharan Africa, in India, in Philippines. And we hear different stories of how people's lives have been impacted with internet connectivity. Like there's this person in Kenya, a musician who's now able to be more productive, reach out to the experts. He was just a musician who would play locally in the village. Now that person with the connectivity, suddenly their lifestyle gets amplified. They can do so much more with internet access. It's truly humbling to see how if we bring some of the things we take for granted with respect to technology in the lives of people around us in different parts of the world, the amount of transformation it can bring in their lives.

Rashmi Mohan: Yeah, no, it's truly powerful. I mean, I'm old enough to remember a time where I didn't have internet as freely as I do today, and I can see how it has transformed my life in many of our lives. Right? It's incredibly powerful what you're describing, the ability to be able to bring that, the connectivity, the access to information, the access to even just communication in areas of the world that might otherwise have not anticipated it coming to them. So it's really, really impressive.

What I would love to understand Ranveer is that how does this work? So when you're thinking about this and you're saying, Hey, you know what, in general, I find that internet connectivity is one, not available in remote parts of the world, or is prohibitively expensive, and so let's try and solve that problem. And then once you solve that problem, you're like, oh, what can I use this for now? I'm just trying to understand the path that led you to saying, okay, here is the problem that farmers in some of these areas are having, and one of the big challenges that we've solved with connectivity can be of tremendous help in

terms of applying to this other problem and solving it. So I'm wondering what your thought process is.

Ranveer Chandra: Yeah, no, that's kind of how it was. So on the one hand, as I mentioned, because I grew up in India and I spent a lot of time growing up in farms, I have seen extreme poverty, and that has been something which has stuck in my mind and something which has been bothering me a lot and something that keeps inspiring you to something you want to change. One of the images I have in my mind, which is very vivid, although it's from the time I was a kid, is my mom would do a pooja, prayer and then she would leave the offerings outside the house and there's a mob of people who were coming, and lots of them were kids, so just to grab something because they didn't have anything to eat. And that has stuck in my mind in the sense that how do we do things to really transform the lives of people, the friends, the people who taught me how to bike, the people I played Kabaddi with, how do I change their life?

And that has been one thing, which ever since I joined that led to this rural connectivity problem that I was working on. It also led to the farming problem. I also have seen a lot of very primitive forms of agriculture being used in India, like for example, hand based seeding, a bullock driven tractor. So those are things in my mind, but the rural connectivity work that I started doing with TV white spaces, it got me to travel to lots of rural areas. I went to Malawi in sub Saharan Africa. Even in the US I would drive, even in the Bay Area, I would go driving and once you go past the city of San Jose, you start seeing these garlic farms in Gilroy and other places. And what got me thinking was when I lost my cell signal out there was, well, we have a way to fix this.

And that's what got me thinking into all the things around what we started calling data-driven agriculture. And I started thinking about since about 2009, 2010 is when I started interviewing a lot of farmers and asking them about the problems. I would go to the Starbucks close by. There was a barista. She knew what I wanted. I started asking her questions and she said she was from eastern Washington. I was like, Hey, why are you going to eastern Washington? My granddad is there. I was like, okay, what does he do? He's a farmer. So I then got on a call with him. So I just did so many calls, must have talked to about 40, 50 farmers at that time.

My learnings were that farmers, they know a lot about the farm. They have been farming there for several years, sometimes decades, even generations. Like there was a farmer here, there's a farmer here I work with. He can feel the soil and say, what's going on? There's a farmer in upstate New York I work with, he could taste the soil and say, what's going on? So they know a lot about the farm and farming practices and soils. Yet a lot of decisions they make is based on guesswork, like when to plant, when to harvest, when to irrigate, when to fertilize, where to fertilize. All of these are based on guesswork.

Our vision with what we started doing with data-driven agriculture, this is what was my finding after four or five years of interviews, I was doing my day job. This was my side thing that I kept doing was this concept of data-driven agriculture where what we wanted to enable was not to replace a farmer, but to augment a farmer's knowledge with data and AI, that is, can we replace guesswork in a farmer's life with data and AI-driven insights? And that's what led to this project when I started talking to them saying, Hey, a lot, what if we started giving this information? Because we can connect your farm, we can get the data, we can get the data from other places. We can get connectivity to your device. Then how would it improve your farming practices? And that's how this entire project got started.

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I think I find that to be really, again, moving to think that something as personal as what you observed growing up, many ways fueled where you wanted to really make a difference. And I think that's true for many of us, right? And you see problems that impact you in a very personal way. You want to try and solve that problem and work towards it. And sounds like a lot of your work has also sort of been motivated by that, which is really very heartening.

I would love to hear Ranveer, so you talked about applying data and ML or technology solutions in the field of agriculture. And I know I've heard also some of your other talks, you bring up some pretty staggering statistics around availability of food and just overall the lack of enough food should have for the world population that we don't. And I'm curious as to how did you approach this problem with the farmers? I mean for maybe farmers who are well exposed to technology, it was probably something that they were receptive to or I'm just curious, what was the response like and how did you approach it in terms of saying, Hey, I have a solution to some of the problems that you may not have even thought of?

Ranveer Chandra: That's a great question. On the first part, the world has a big food problem. We need to grow 50% more food compared to today's levels to feed the growing population of the world. But it is not just enough to grow more food. We need to grow good food, nutritious food, and we need to grow this nutritious food without harming the planet. There's climate change. The soils are not getting any richer. The water levels are receding. With all of this, the key question then we ask ourselves is how do we sustainably nourish the world? And that is such a hard problem. And couple this with everything around food waste that is around 30 to 40% of the food we grow is actually wasted. There are 2 billion people who don't have good nutrition. And that said, agriculture is about a quarter of our greenhouse gas emissions.

So there are various reasons because of which we need to make this industry, the agriculture industry more productive, more profitable, and more climate friendly. Because agriculture, if you think of it's one of the biggest emitters of greenhouse gases. It's also one of the most impacted because of climate change. That is because of changing weather, farmers depend on predictable weather to make their decisions, they are the least prepared to handle any variations because of climate change, especially if you start looking at small holder farmers, they're not prepared.

But agriculture could also be a solution to climate change, because of photosynthesis, plants can pull some of the carbon from the air, and if you use the right agricultural practices, you can sequester some of the carbon in the ground. So that's led to this entire concept on data-driven agriculture. And that's one of the tools. We are not saying it's a solution, but it's one of the very powerful enablers to drive this agricultural productivity to help us sustainably nourish the world.

In fact, our vision is that the entire future food ecosystem is going to be data driven, all the way from the scenario that you mentioned in the introduction, Rashmi from strawberry grown in the farm through the supply chain to how it is produced, how much water did it use, to how it was stored, how it was transported, to how it got to the end place, to the retail store. The entire information needs to be stored. You should be able to do track and trace. If something goes wrong, you should be able to recall the right produce.

And you can also come up with new scenarios, like for example, consumers like us would be willing to pay more if we know that there was no child labor involved in the food that we're eating. The amount of water, the farmer was conscious about the environment when they were farming to produce the food that we're eating. It's not just food. When you think of agriculture, we think of four Fs, food, feed, fiber and fuel. All of that come from the farm. There is a huge part role of the farm in all of those. And for all of those, if you could track it from the way it was grown to the way it was harvested, stored, transported, all of the entire information could lead to a much better world.

And so to the other question, we see the power. We are just taking the first steps in the research that we've done. But then the question is, okay, how do you start talking to farmers about this problem? Because in the end, farmers are a business. They need to feed their family. This is what they do. Of course, farmers are also custodians of the planet. The soil is a natural resource and farmers take care of that. Farmers produce food and all the four Fs that I talked about, food, feed, fiber and fuel.

So when we started talking to farmers, interestingly what I found is that farmers are... so I went there trying to learn about the problem. I wasn't there proposing a solution. All I was saying is, what if I could get you connected to the internet? What if you could start predicting some of the things that you try to predict with

guesswork? What if we could start giving you data to do that? And most farmers I found were very receptive. Most of them. In fact, all of them that I talked to, they were skeptical, some of them that we've seen a lot of people come pitch to us, but they all see the value that it could bring. This was across the board in different countries. I saw that willingness to work with us to try to make it work.

The challenge though was also one was skepticism, but that was not much. I think because we were coming from a tech background, there were only a few people who were skeptical. Most of them were more than willing to actually work, say, what can we do to make it work? The challenge though, and most of the people who are skeptical had this is one of the key challenges in the adoption of digital agriculture is that of the tech-savviness of farmers, that is, farmers are not the most tech-savvy population.

Many farmers, they might be immigrants, their hands are soiled. You can't expect them to take a phone out and type things. And that has been one of the key reasons of the tech hasn't been adopted widely, which is why the latest advances in generative AI are so promising. I'm so excited about what they could do to these latest advances in GenAI and helping drive the adoption, especially overcoming the challenge around tech-savviness or the fact that farmers' hands are soiled to actually help them consume the technological insights that we can generate.

Rashmi Mohan: I think you answered my question because I was going to ask you exactly how do you make your solutions viable, both from a cost perspective as well as an education perspective to be allowing the farmers the opportunity to learn not the nitty gritty of how this might work, but just in terms of just what does this adoption do for them.

I'm curious though, Ranveer, when you talk about generative AI, one, I would love to understand how it's being applied to this problem, but also thinking about it from an overall world perspective and the areas that you work with. How are these solutions working across linguistic barriers and also how do you show results or what are the metrics by which the farmers measure you, if you will?

Ranveer Chandra: So I'll start with generative AI and then we'll get to results because results are overall, and we have a few deployments and there's some very interesting results that we haven't yet published, but we would love to talk to you more about it. So with generative AI, it does bridge a big barrier that exists in farmers trying to consume knowledge. And linguistic barriers, for example, has been one of the blockers. But that's again, where large models have been very helpful. Like in India, what the government has done with the Bhashini effort where across different languages the governments have, they've created a big corpus of data, which has been used to train these models, which you can use to translate from one language to another, and regional languages as well. So that's an effort of the Indian government, which several other governments

around the world are looking to replicate, which I think can help us overcome the linguistic barrier.

But in addition to the linguistic barrier, the other problem is around just consuming knowledge. There's so much knowledge that farmers in particular, and broadly many of us, we don't have access to, which generative AI is helping make it more consumable, make it more available for the population. That's one thing which we are starting to use generative AI for, especially large language models, is to help farmers consume more knowledge. There was this work that was done in India by Microsoft Research where we were looking at partnering. We partnered with another organization where farmers in India, the government has a PM Kisan Initiative, through which it creates these documents, these policy subsidies, and the farmers want to know if they're eligible for the subsidies. Right now, parsing those documents is hard. They would typically pay a middleman, and invariably the middleman's answer would be no. Here, what the researchers did was they use generative AI and a WhatsApp plugin through which a farmer could chat and be able to know whether they're eligible for the subsidies or not.

Well, that's just one part of it. Making documents consumable. The new thing we are doing is starting to make insights consumable. Like if you get farm-level data, if you get advisory-level data, can you tell a farmer what they should be doing in the farm? What if they did something else? And helping a farmer converse in natural language with any of these powerful data and AI platforms that we had been building until now. So that has been a huge enabler. Right now with respect to regional languages, GPT-4 does a reasonable job for most languages, but of course, if you get high quality local data, I think you can create even better models for the particular regional languages.

How are farmers using all the technologies that we are building? So we've been working with various farmers across the world, and there's some very interesting use cases. There's a farmer close to Microsoft campus. He talked about how he needed 31% less water, 44% less lime in the farm that he had. He was a small farmer, sub-acre farmer. There is another farmer we've been working with for six years. He's in eastern Washington. He's a fifth generation wheat farmer, Andrew Nelson, who farms these days over 7,500 acres of wheat spread across 45 miles. And he profiled the different stages in a farmer's life all the way from planning to planting to pre-emergence, to post-emergence of the crop, that's production, to harvest, post-harvest. And in all the stages, he profiled the different technologies that he's been using from us, including things like Power BI, the TV white space-based connectivity, edge compute, all of that he's been using. And the amount of benefit that he has seen when he has been using these technologies.

And the numbers are quite impressive. He needed 38% less chemical in his farm. In one part of the farm, he was able to double his yield and they're really significant improvements. And these numbers, if you look at it, they're quite

significant in a farmer's profit and loss statement. So we are very excited that it's been helping a farmer grow more food. It's been helping a farmer reduce costs by using less chemicals, and it's also better for the environment. They're using less chemicals, they're sequestering more carbon. So he's practicing regenerative agriculture techniques, which is helping him put more carbon in soil. So using all of these technologies, we can actually help agriculture be more sustainable and farmers be more profitable.

Rashmi Mohan: I think it's amazing, the example that you just gave of the farmer in eastern Washington. It's like that digitization journey of that farmer from being able to maybe initially just to be able to educate themselves on what data might be available to actually adopt each of the interventions that you're suggesting and see that kind of amazing returns must be very rewarding for you and your team as well.

Ranveer Chandra: It is. And we are just scratching the surface here, Rashmi, and we are so excited that seeing adoption, farmers are getting to use this technology and betting on it and improving their lifestyle. But that said, we still have so much to do and that's keeping us going in this space. But yeah, you're right. It is rewarding. That's what keeps us going too. For students who might be listening to this podcast. One of the things, in Seattle, it rains a lot and to do research in this space as a computer scientist, usually we're sitting in the office and life is comfortable. For this, we had to go to the fields.

At times, I would ask myself, when I'm driving, I was driving to this farm, I would drive there four to five days a week, and then when you step out, you're not going with an umbrella, you're wearing boots and trying to put some stuff. I was asking myself, why am I doing this? Why am I out here when it's raining? It's gloomy. I could have just been in the office. But then what keeps you going through all of this is that even if 1% of what we are doing gets adopted, the impact that it would have on the lives of so many people would be so huge. And that's what keeps you going.

So just having that ultimate goal of bigger than yourself if you can do this. Again, part of it could make it into a product, it could impact the lives of so many people around us. And that's what keeps you going, keeps you trying to do more and keeps giving you the energy to go out in the rain and keep trying hard to make it work. Of course, that said, I did want to caveat it with farmer's work much more than us. And so that makes you also feel the gratitude and thankful the people around us who keep us well-nourished.

Rashmi Mohan: Absolutely. And I think going back to one of the previous points you made about bringing that data and awareness, even to the end consumer like us might in fact, well for one, definitely influence our buying decisions and our consumption patterns. But I think overall, if we're trying to solve these huge problems like climate change, et cetera, I think attacking this problem from all these different dimensions is so critical as well.

So one question I also had Ranveer is, when you think about a product like this and you actually deploy it with one farmer and 10 farmers and so on, what is the life cycle of your team's engagement? So you are a research for industry organization. How far do you go, right? I mean, do you build this out to scale or do you hand this off to another part of your organization to take it further?

Ranveer Chandra: Yeah, and it's very project by project dependent. Like in the agriculture case, when we had started FarmBeats, it was in research, and then I actually moved from research to Azure to help ship it as a product. The first phase, the second phase. And then I came back. But I still am very plugged in to the product team. And right now we partner very, very closely with our engineering teams and our sales team and our business development team, and we work in as one party. The engineering team right now is shipping certain features, but we help guide what's coming next.

So anything we are doing, for example, in the AI space, in the tech space, we keep them involved and we are involved in the planning of what's coming in the next semester of planning. And as things mature on research, sometimes we transfer the technology. Sometimes people go along with the technology to help make it a product. So yeah, we are very fluid within the company to take things from ideation to product to adoption as well.

Rashmi Mohan: That's absolutely, I would say probably the right model to guarantee success, right? Because there is a lot of knowledge both in terms of how decisions were made, why certain decisions were made, or just engagement with your early adopting customers and having that knowledge transfer over as you're building out the product for a much larger scale is also extremely valuable.

Ranveer Chandra: Valuable learning for us as well because it helps guide the research. Otherwise, I think we operate in vacuum. If we try to do something just in research and say, Hey, it's someone else's job to productize it. I think the philosophy of research that I follow, and I know many people in my team follow, is if we come up with something, the onus is on us to get it all the way to product. And in the process we need to learn how engineering works. Engineering is a science in itself. The way you have to take something and make it a product, ship a product that is reliable, that will be usable, that has all the right metrics built in. So I think having this combination of a team of people working together to solve a bigger problem is key to make significant impact, especially if you're talking of some of these hard problems, which will take really, really long to solve around food, around sustainability and so on.

Rashmi Mohan: Very fascinating conversation, Ranveer. For our final bite, I would love to hear from you, what are you most excited about either in the field of machine learning and using of data in the field of agriculture and farming or what you might pivot to next within your research for industry group?

Ranveer Chandra: Yeah. I'm very excited about the role of all the AI advancements and how it is going to help us make the next big improvement in the agriculture and food ecosystem. That's one thing that is keeping me up at night. I'm coding, I'm working with team members on just coming up with those breakthroughs. And the thing is this technology, the AI technology, it's not just about the AI models. It includes being able to get data from remote sites because in some sense, the goodness of the AI models depends on the data, and that is a networking problem. It also depends on various places where you might want to run it on the edge. But agriculture, the kind of questions we also ask is, if you're running on the edge, would you be running smaller models? And then how would such a multimodal system looks like? It's not just a multimodal as well in the sense it's not just text, it's computer vision. What if you take images? How can you combine that with text to sounds, is an interesting one as well.

So I'm really, really excited about both the things, being able to capture new data right now that data around us is not being used or captured, but once you get the data, how do you translate it to something actionable that can make a huge impact. In this case, the one scenario that drives me a lot is agriculture and food. So how do you get farmers to be more productive? How do you get them to be more profitable and how do you get them to practice more sustainable agriculture techniques while staying profitable? And I think data and AI will play a huge role and I'm very excited the role that a generative AI systems, that is the systems that drive generative AI, will play in helping make that transformation.

Rashmi Mohan: I'm super excited about what you just described as well, Ranveer, I'll be closely following what you and your group does because I think it's absolutely amazing the mission that you've set for yourself and what you could potentially do with it. Thank you so much for speaking to us at ACM Bytecast.

Ranveer Chandra: Thank you, Rashmi.

Rashmi Mohan: ACM Bytecast is a production of the Association for Computing Machinery's Practitioners Board. To learn more about ACM and its activities, visit acm.org. For more information about this and other episodes, please visit our website at learning.acm.org/bytecast. That's learning.acm.org/bytecast.