Cover Story: Quantum Computing: Triangle's next high-tech cluster?

Patrick Dreher (lower left), Frank Mueller (lower right), Daniel Stancil (upper left) and Dennis Kekas (upper right) of N.C. State University.

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Tucked into a nondescript building at N.C. State University's Centennial Campus is – at least according to a trio of N.C. State professors – a glimpse of the future.

It's an IBM-fueled hub for quantum computing, the application of super computers to do – well, they're not entirely sure.

"That's like going back to the 1950s and asking Alan Turing, 'What's a computer going to look like in the year 2000?'" says Patrick Dreher, theoretical physicist and professor of computer science at N.C. State, referencing the famous British scientist.

What they are sure of is the multi-billion dollar opportunity quantum holds to solve problems in numerous industries – and it's an opportunity the region can't afford to miss.

Dreher, along with Daniel Stancil, professor and head of N.C. State's Electrical and Computer Engineering Department; and Frank Mueller, professor of computer science, are leading the effort at the university.

And they're not alone.

"It's going to bring a lot of jobs … potentially new industries and billions and billions of dollars," says William Hurley, aka "whurley," the serial entrepreneur from Austin, Texas, who was behind the book, "Quantum Computing for Babies."

For the Triangle, hub status for quantum computing research and development with assistance from local universities could catapult a variety of industries to levels not imagined in the current environment.

Today's supercomputers will look like an abacus, scientists say. Companies could create chemical catalysts at a faster rate, the financial services industry could create algorithms of risks and rewards of portfolios quicker with more accuracy, and logistics and supply chain analysis could make highways and airways more efficient.

That's why companies would want to relocate and expand in an area with a high concentration of quantum computing companies, consultants and researchers.

And that's why folks at N.C. State and Duke University believe public and private money is needed to develop the quantum computing ecosystem in the Raleigh-Durham area — fast.

"There's a lot of buzz right now in the air of possible applications for quantum computing, and I think two things are happening," says Kenneth Brown, associate professor of electrical and computer engineering, chemistry and physics at Duke. "It's getting closer to reality, so people want to make sure they can take advantage of it once it comes online. But I think the second thing is companies are realizing … how challenging the problem is."

Money and goal comes together

According to Deloitte, venture capital investors have invested $147 million into quantum – basically super computers that can solve problems in minutes that would take traditional computers years, or even decades.

The technology has secured $2.2 billion in recent research support from governments around the globe. And analysts predict that could be just the tip of a profitable iceberg.

Others are paying attention as well. China is investing more than $10 billion in a new quantum computing campus that could be operating by 2020, according to The South China Morning Post.

In the United States, Dreher says, there is “no reason” the Quantum Valley can’t be in the Triangle thanks to the confluence of projects – and dollars – the region has seen over the past year.

Shortly after IBM picked N.C. State for its first stateside university quantum computing lab, Duke researchers scored a coveted research project to work on quantum computing hardware, a $15 million, seven-university collaboration dubbed the Software-Tailored Architecture for Quantum co-design project.

The goal is to demonstrate a quantum advantage of traditional computers within five years. It’s being led by Duke’s Brown. “The idea was to get together a group of people who would try to make a device at the scale where you could actually solve problems that are hard to solve with the largest computers available,” he says. “We think of the problem being a problem of code design in that these initial devices, they are limited in their size and they are limited in the number of operations they can do.”

Brown’s team seeks to change that – and he says success would be a big deal for the Triangle. He says quantum computing is one of the only things Congress agreed on this year, when it invested $1.5 billion into quantum computing. “I do think our work on this project is helping set up Duke to be a place that can really grow in this area,” Brown says.

That, in turn, translates to the rest of the region. He notes the school’s history of collaboration with Microsoft and IBM – something that will continue as the technology advances. “These companies need more people with some quantum training,” Brown says.

The talent Duke is creating through its quantum hardware projects could work alongside the workforce coming out of N.C. State’s software-oriented initiatives. “We really need to start training students to be these bridges,” he says.

The demand for talent is growing, says Dennis Kekas, associate vice chancellor at N.C. State. “It’s really hard to find the talent that has this background,” he says.

No one can accuse the Triangle of waiting. As universities bulk up their resources to get ready for new pools of federal money coming online in 2019, private industry is eyeing what's happening in the Triangle – and not just IBM.

A review of LinkedIn profiles shows Microsoft is stealthily building its quantum computing footprint in the Triangle. It's not alone.

"Several companies from several industries have reached out," Kekas says.

Brown notes his students often find internships at Microsoft and IBM. And just "the other day" he met with someone from a large accounting and consulting firm "who just called up, wanted to see what's going on at Duke with quantum," he says.

If all goes well, the Duke project could have a prototype in a year, which could leverage even more attention, he says.

Education's role

Chirag Dekate, an analyst with research firm Gartner, says there's a space race of sorts between companies such as IBM, Google and Microsoft to create the technology that will capture the opportunity.

"These are companies that are investing billions of dollars," he says.

And they're trying to solve problems that haven't even been realized yet, Dekate explains.

"Quantum computing is never going to replace the laptop you're working on," he says. "Quantum computing is a very specialized computer that can address problems that, currently, computers cannot even imagine addressing. ... It will never be used for web-browsing."

Instead, it will solve problems that would take laptops generations to solve.

"There's an entire world to explore in terms of tackling physics problems that are unattainable or unsolvable with the standard computer," N.C. State's Dreher says, calling the idea of a quantum computer "seductive" for a researcher.

But it's valuable to the country's future competitiveness, too, he says, using the financial sector as an example. One problem the computers might one day "solve" deals with the cryptographic encryptions used globally in financial transactions and classified communications.

"The original people thought the algorithm was unbreakable," Dreher says.

“If you take all of the computing power in the world today and try to crack the codes it will take to the end of life to go about cracking these,” Dekate says. “But using quantum computers, you can almost instantaneously crack current encryption.”

At least some day, says Dreher. That potential has obvious national defense implications, which is why the U.S. wants to stay ahead of the technology.

It’s a use-case driving investments in the technology by companies such as Barclays and J.P. Morgan.

The pharma space, too, could drive the technology – particularly relevant as the Triangle is home to firms such as GlaxoSmithKline and G1 Therapeutics.

“Imagine being able to simulate molecules, drugs essentially, any biological phenomena on a quantum accuracy,” Dekate says.

Unlimited potential

While the quantum computers that exist today can’t meet those challenges, N.C. State’s Stancil notes “the industry is growing very quickly.”

“I don’t think it’s going to be that long – a single-digital number of years – before the machines are at the point where some significant problems can be solved. And we’ll need the talent that has the background,” he says. “If you wait until the machines can solve real problems to start learning about it, you’ll be significantly behind.”

The differences between what he’s discussing and your laptop can’t be understated.

“The typewriters still had the same keyboard as a laptop,” he says. “Think of this as a totally different machine. A completely alien keyboard you don’t even know how to type letters in. ... You have to completely relearn it.”

Kekas says that’s why what N.C. State is doing is so important.

“It’s a chicken and egg, right?” he says. “You need the knowledge workers, but you have to train them and the technology is still evolving. What better way to get that transfer of knowledge than to do research projects?”

As a method of training that future workforce, the unit is looking for more problems for its researchers to tackle.

“We’re wanting companies to contact us and we will pair them up with a Ph.D. student,” Mueller says.

Stancil sees the talent pool universities are building in the Triangle as having more of a draw than just academics.

“When companies are thinking about locating major facilities here, one of their considerations is, what is the talent pool going to look like?” he says. “Ensuring that we are leaders in this area and providers of significant talent will help to grow the quantum activities in the region.”

Hurley, whose companies include quantum computing startup Strangeworks, says quantum computing promises to bring a bigger shift in technology than anything seen over the past few decades – but that the Triangle isn’t the only region going after the new sector.

Others in the game

Hurley points to places like the Institute of Quantum Computing at the University of Waterloo in Ontario, Canada, as competitors, where research has been ongoing for years. “There are a lot of places that have been in quantum for a long time and they see this as their moment to shine,” he says.

And the competition is global.

“[Quantum computing] will be in countries where the government has strong programs,” Hurley says, pointing to China. “It will also be in a state or province that has that support – but is also tied to a key industry.”

He says it’s going to take several components to create the quantum “hub” of the future – from government support to ties to key industries to universities.

Dekate says the key to securing the title will be the talent pool, and that, with initiatives like what’s happening at N.C. State and Duke, the Triangle region is a clear contender.

“The Research Triangle seems to be a core area where there are synergies happening,” he says. Companies such as IBM investing in university programs are proof that they believe it too, he adds. “What many of these companies are trying to do is, they’re trying to invest in early talent, early skillsets so they can create the Quantum Valley of tomorrow.”

He says the Triangle has three elements that work in its favor: interest from corporations, well-known research universities and graduates coming out of those institutions “entering the workforce ready.” Hurley predicts aerospace,

pharma, energy and finance as the sectors first in line to take advantage of the new technology.

Cities such as Houston, with its strong energy sector and proximity to universities, will have an advantage, he says. But the research-savvy Triangle, with its proximity to Duke, N.C. State and UNC-Chapel Hill, is on the list, too.

“Then you have to have a startup scene that’s well-funded,” he says.

But with all industries touted as disruptors, there are risks.

“The market is so formative,” warns Dekate. “Things are so elementary that there are around 100 or 150 people who actually understand the quantum mechanics behind the quantum computers. … Not many people even have access to quantum systems. … This could very well go the other way.”

He says what N.C. State is doing with IBM minimizes its own risk.

“You’re not paying tens of millions of dollars to buy the system. … You are accessing the system when you need it,” Dekate says.

Universities, companies and regions not exploring quantum face the big risks too, he says. Without a workforce trained in the new technology, “you go in blind.”

“When you have access to university students and university resources, then you suddenly do not just have a means of utilizing these systems, you also have access – and that’s the key to enabling high-level utilization of these resources,” he says.

While estimates online for the market range to the billions, Dekate says any numbers are premature.

But if technologies line up, he says, “this market in the next 10 to 15 years could easily be a multibillion dollar market.”