DEPARTMENT OF COMPUTER SCIENCE

Quantum Computing

K S Induja Suresh
22cs02indu@pg.cusat.ac.in
January 11, 2023

Daimler

Daimler envisions a new generation of electric vehicles through battery technology designed with quantum computers.

The Mercedes-Benz Group AG (previously named Daimler-Benz, DaimlerChrysler, and Daimler) is a German multinational automotive corporation headquartered in Stuttgart, Baden-Württemberg, Germany. It is one of the world's leading car manufacturers. Here scientists try to understand and master the evolving set of hardware and software with the technology of Quantum computing and they really hope that in the coming few years time, quantum computing will be able to solve the problems that would even take the state-of-the-art supercomputers hundreds or thousands of years to crack. They would become the best way to discover new and more efficient battery technology, simulating aerodynamic shapes for better fuel efficiency.
At Mercedes Benz Research and Development North America (MBRDNA), a team of experts together with their counterparts in Sindelfingen is coordinating the company's effort to get up to speed with this technology. This initiative of Quantum Computing was established in 2015 by Daimler.IBM runs quantum computers in its historic headquarters of Yorktown, New York, while Google's system stands in a lab in Santa Barbara in Southern California and Venice Beach by Los Angeles. While the machines differ in the architectural and operational details these quantum computers rely on superconductivity. That means they have to be chilled down to minus 272.9 degrees Celsius which makes them one of the coldest spots in the known universe. Daimler researchers access those systems remotely over the internet like an employee would access a productivity suite or database in the cloud.
Looking at the case of the progress of batteries a team of scientists at Daimler and IBM looked into whether a quantum machine can compute and accurately simulate the fundamental behavior of lithium battery materials.According to the Daimler scientist. They predict the chemical reaction by running experiments and observing the results or calculating them as best they could. There is a new trend in material science called Material Informatics which combines machine learning and chemical simulation. They hope that this process can save time as well as money. This tool stands to supercharge the standard workflow to improve batteries for electric vehicles. Today's computers are to show to predict the complex chemical reaction. This is where quantum computing would help in the future: speeding up the progress in chemistry and material by replacing experimental work in a lab with simulation in computers to get results much faster at high accuracy.
They also translate into significant energy savings as compared to running calculations in today's server farms.

J P Morgan Chase

JP Morgan Chase is one of the leading global financial services firms with assets of about $3.7 trillion and operations worldwide. They serve millions of consumers in the US and much more prominent corporate has become a member of the Q-NEXT

quantum research center. JP Morgan Chase, by being a part of Q-NEXT tends to advance the use of quantum technologies for the fundamental algorithms and advance the state of quantum information research. They are not focusing on buying and using quantum computers directly instead, they use cloud-based quantum computing as a service offering from the companies like D-Wave, IBM, Google, etc.
The Quantum computing research and engineering team at JP Morgan Chase is exploring the use of quantum computing for risk analysis, option pricing, portfolio optimization, fraud detection, and merger analysis. They believe that by using quantum computing financial institutions they will be able to produce better, more accurate predictions and risk assessments in almost real time.
JP Morgan Chase opened an Applied Research Lab to design and conduct research across multiple frontier technologies and inventions, and inform and develop next-generation solutions for clients and businesses. Among many research areas, the program primarily focuses on advancements across quantum computing and quantum communications. This program includes research in the area of quantum key distribution, a method by which two parties share a secret key to decode the encrypted quantum information. While quantum computing is not yet practical in these applications, the company aims to be fully prepared when it is.
Therefore in the quantum area JPMC has been busily developing quantum algorithms around optimization, machine learning, natural language processing, and publishing the results.

ExxonMobil

ExxonMobil strives to move the world's cleanest-burning fuel across the globe—a puzzle that demands a quantum solution.

ExxonMobil is one of the largest publicly traded international oil and gas company which uses technology and innovation to help meet the world‘s growing energy needs. It holds an industry-leading inventory of resources and is one of the largest refiners and marketers of petroleum products, and its chemical company is one of the largest in the world. According to ExxonMobil, a significant portion of the global population faces daily challenges in accessing energy, impacting public health and preventing many from fully realizing their potential. Energy challenges will become even greater as the global population grows, from 7.5 billion today to a projected 9.2 billion by 2040. ExxonMobil's leaders refer to this as society's "dual challenge," to provide reliable and affordable energy to a growing population, while also reducing environmental impacts and the risks of climate change.
They have become the first energy company to join the IBM Q Network in 2019 and have also expressed a keen interest in using the technology to explore various applications, ranging from the simulation of new materials to solving optimization problems. The theory behind the potential of quantum computing is well-established, but it remains to be found how quantum devices can be used in practice to solve a real-world problem such as the global routing of merchant ships. To answer this, IBM and ExxonMobil's teams started with widely-used mathematical representa-

tions of the problem, which account for factors such as the routes traveled, the potential movements between port locations, and the order in which each location is visited on a particular route. There are many existing ways to formulate the equation, one of which is called the quadratic unconstrained binary optimization (QUBO) technique, which is often used in classical computer science. After running the algorithms on a simulated quantum device, the researchers found that models like QUBO could effectively be solved by quantum algorithms, and that depending on the size of the problem, some solvers showed better results than others.

Goldman Sachs

The Goldman Sachs Group, Inc. is a leading global investment banking, securities, and investment management firm that provides a wide range of financial services to a substantial and diversified client base that includes corporations, financial institutions, governments, and individuals. Founded in 1869, the firm is headquartered in New York and maintains offices in all major financial centers around the world. They introduce quantum algorithms developed by its Research and Development Engineering team that could allow the firm to price financial instruments at quantum speeds. Goldman Sachs and QC Ware researchers introduce new, robust quantum algorithms that outperform state-of-the-art classical algorithms for Monte Carlo simulations and can be used on near-term quantum hardware expected to be available in 5 to 10 years.
For the past year, Goldman Sachs and QC Ware researchers have been working to answer this question: “How can we cut the current timeline in half yet still get a significant speed-up?” By successfully sacrificing some of the speed up from 1000x to 100x, the team was able to produce Shallow Monte Carlo algorithms that can run on near-term quantum computers expected to be available in 5 to 10 years.
According to the research, the Shallow Monte Carlo algorithms show more moderate speed-ups than Quantum Fourier Transformation Free Monte Carlo (QFT-free Monte Carlo) and Standard Monte Carlo algorithms, they have far less onerous hardware requirements, and therefore are anticipated to reduce the timeline to usability in half. They demonstrated that Shallow Monte Carlo algorithms could result in the ability to perform Monte Carlo simulations on quantum hardware that may be available in 5 to 10 years.

Boeing Company

The world’s largest aerospace company and leading manufacturer of commercial jetliners, defense, space, and security systems, has joined as a core partner by funding collaborative research with member institutions. Boeing’s Disruptive Computing and Networks organization works on quantum communications and computing, as well as neuromorphic processing and advanced sensing.
The Boeing Company with the help of IBM works to explore quantum computing’s potential to deliver advanced computation and communications increasingly at the

heart of aerospace innovation. They takes the advantage of IBM's cloud-based Quantum Experience platform to provide researchers with access to quantum computers and other powerful resources that will help determine how best to leverage the technology to solve the aerospace industry's biggest challenges, including materials testing and optimization. Boeing is planning to use quantum computing to help the company perform comprehensive materials evaluations, model a material's reaction to environmental conditions and determine the estimated service life and performance much more efficiently and comprehensively than is possible using classical computers.
Boeing researchers are experimenting with IBM's quantum computing resources to explore multiple optimization applications.

Mitsubishi chemicals

Mitsubishi Chemical Corporation or MCC is a subsidiary of Mitsubishi Chemical Holdings Corporation. It is a Japanese corporation, that merged with Mitsubishi Pharma Corporation in 2005 to create Mitsubishi Chemical Holdings Corporation. They are the largest chemical corporation based in Japan.
For Mitsubishi Chemical's team to model such a complex electrochemical reaction on a classical computer has proven to be incredibly difficult. Scientists from IBM and Mitsubishi Chemical have simulated the initial steps of the reaction mechanism between lithium and oxygen in lithium-air (Li-air) batteries. They are exploring how to use quantum computers to create accurate simulations of what's happening inside a chemical reaction at a molecular level. The research triumvirate of this company, Keio University, and IBM Quantum is working to better understand lithium-oxygen's potential as an energy source by using new algorithms that take advantage of quantum computing. It's the first research of its kind to have been simulated on a quantum computer as outlined in a paper recently published on arXiv,
Running a new breed of algorithms, within quantum's completely new hardware environment and software, has already yielded quantitatively correct computational results of complicated chemical reactions in the discharge process of the lithium-oxygen batteries A functional battery relies on lithium dioxide, but lithium peroxide can form instead. The goal of studying the battery from the electrochemical perspective is to reduce the formation of undesirable lithium peroxide. It may take years to be able to study the entire problem with quantum computing, but ultimately it will help researchers understand how to prevent lithium peroxide formation.

Cleveland clinic

Cleveland Clinic is a nonprofit American academic medical center based in Cleveland, Ohio. Owned and operated by the Cleveland Clinic Foundation, an Ohio nonprofit corporation established in 1921. They are consistently ranked as one of the best hospitals in the United States.
Cleveland Clinic and IBM have announced a planned 10-year partnership to estab-

lish the Discovery Accelerator, a joint Cleveland Clinic - IBM center with the mission of fundamentally advancing the pace of discovery in healthcare and life sciences through the use of high-performance computing on the hybrid cloud, artificial intelligence (AI) and quantum computing technologies. The collaboration is anticipated to build a robust research and clinical infrastructure to empower big data medical research in ethical, privacy-preserving ways, discoveries for patient care, and novel approaches to public health threats. The company also plans to install the first of IBM's next-generation 1,000+ qubit quantum systems at a client facility, also to be located in Cleveland, in the coming years. It will leverage Cleveland Clinic's global enterprise to serve as the foundation of a new quantum ecosystem for life sciences, focused on advancing quantum skills and the mission of the center.
Collaboration with Cleveland Clinic and IBM will combine their world-renowned expertise in healthcare and life sciences with IBM's next-generation technologies to make scientific discovery faster, and the scope of that discovery larger than ever. They will build upon Cleveland Clinic's existing programs and expertise, with newly recruited world leaders in immunology, cancer biology, immune-oncology, and infectious disease research as well as technology development and education. Researchers will expand critical work on studying, preparing and protecting against emerging pathogens and virus-related diseases.