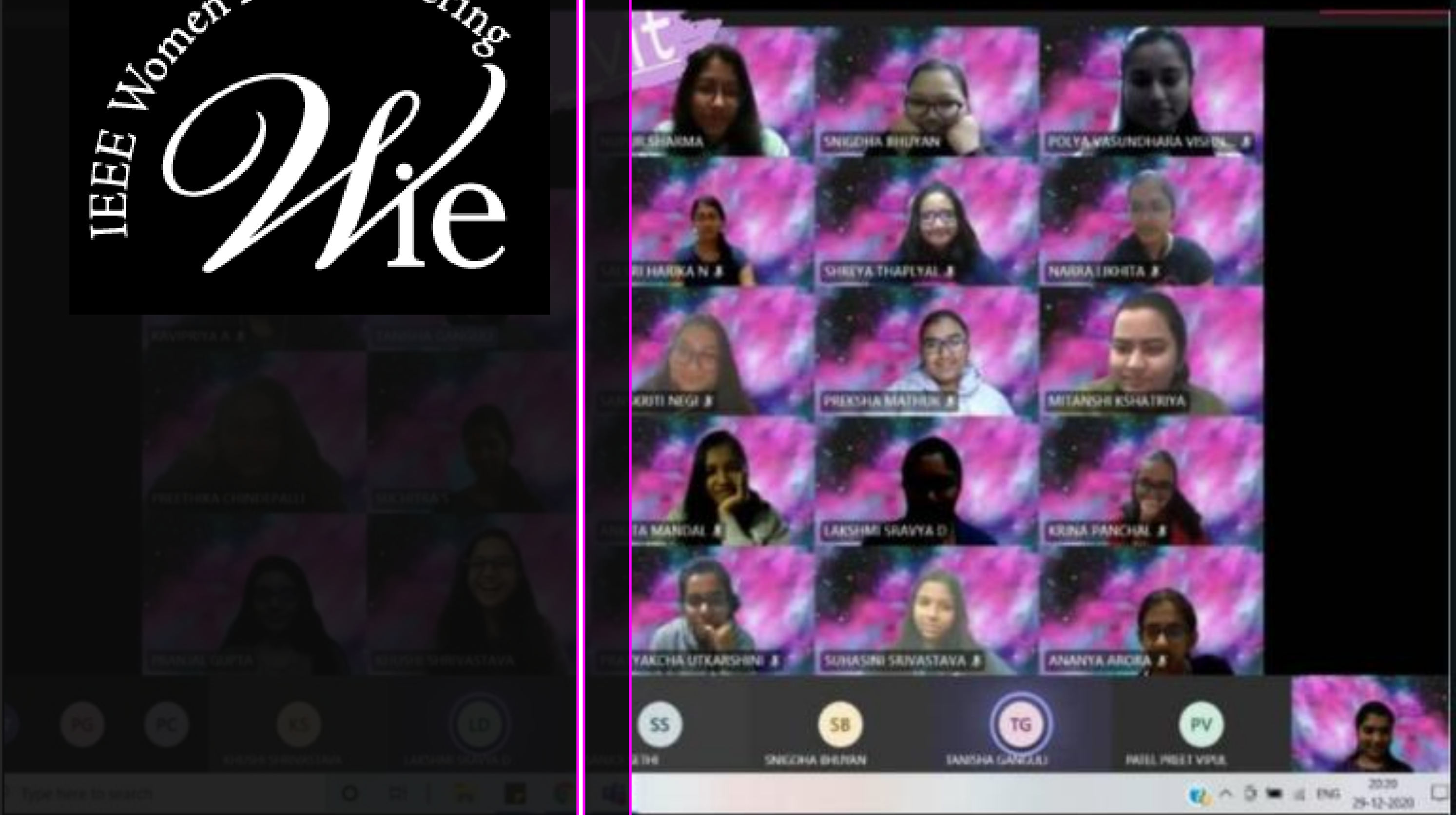
WIE GAZETTE

WOMEN · TECHNOLOGY · INSPIRATION · EMPOWERMENT



VOL-V

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THEME- QUANTUM COMPUTING

Quantum computing harnesses the phenomena of quantum mechanics to deliver a huge leap forward in computation to solve certain problems. Quantum computing is the exploitation of collective properties of quantum states, such as superposition and entanglement, to perform computation.

GLOSSARY

1. **Bloch Sphere**
   Bloch Sphere is the geometrical representation of the pure state space of a two-level quantum mechanical system.

2. **Cryostat**
   A cryostat is a device which is used to maintain low cryogenic temperatures of samples or devices which the cryostat mounts.

3. **Decoherence**
   Quantum decoherence is the degradation of a state over time which thus reduces the quality of a system, leading to errors in quantum computation.

4. **Entanglement**
   It is the property where two or more quantum objects in a system are correlated, or intrinsically linked, such that measurement of one changes the possible measurement outcomes for another.

5. **Quantum Contextuality**
   It is a phenomenon necessary for the working behind universal quantum computation. What you measure in terms of quantum necessarily depends on the 'context' of the experiment.

6. **Quantum annealer**
   It is an analog quantum computer that operates through coherent manipulation of qubits by changing the analog values of the system's Hamiltonian, rather than by using quantum gates.

7. **Quantum Memory State**
   Quantum Memory State is the state in which qubits must retain themselves in order to be of value in quantum computing.

8. **Qubit**
   It is defined as a quantum bit that operates widely in quantum mechanics. Additionally qubits can be added by a process called entanglement.

9. **Quantum cryptography**
   A subfield of quantum communication where quantum properties are used to design communication systems that may not be intruded upon by an observer.

10. **Quantum Register**
    A collection of n qubits is called a quantum register of size n.

HEADLINES

Driven by the guarantee of new applied sciences that will convey benefits for society overall, global areas throughout the planet are putting intently in the field of quantum computing. When it comes to quantum computing, no one wishes to omit out – and that wish is triggering a sort of global arms race. Now is the ideal time — quantum computing is going from something hypothetical to reasonable. Furthermore, it's headed to having a genuine effect. Quantum computing will disrupt current strategies and take care of already significant issues, generating notable answers for the industry.

Let's take a look at a couple of significant patterns in quantum computing that are digging in for the long haul.

Quantum Computers using silicon chips: The qubit is the elementary unit of quantum computing, practically equivalent to the bit in traditional PCs. To perform blunder-free estimations, quantum computers are probably going to require no less than a million qubits. The most recent examination, distributed in the journal PRX Quantum, recommends that these computers could be alternatively made with industrial-grade silicon chips utilizing existing assembling measures, rather than embracing new assembling measures or even newfound particles. While the uses of quantum computers vary from customary computers, they will empower us to be more precise and quicker in immensely testing regions, for example, drug advancement and handling environmental change.

Compact Quantum Computers: Quantum computers created to date have been exceptional gadgets that fill whole research facilities. Presently, physicists at the University of Innsbruck have assembled a model of an ion trap quantum computer that can be utilized in industry. The minimized, self-supported gadget shows how this innovation will before long be more accessible. The smaller quantum computer can be self-ruling and will before long be programmable on the web. A specific test was to guarantee the stability of quantum computers. Quantum gadgets are extremely delicate and, in the research centre, they are shielded from outer unsettling influences with the assistance of intricate measures.

There are several industry-specific applications of quantum computing in the future.

TIMELINE

- 1968: Conjugate Coding is invented by Stephen Wiesner.
- 1973: Alexander Holevo researched that *n* qubits can carry more than *n* classical bits of information, but at most *n* classical bits are accessible. This result is referred to as "Holevo's bound".
- 1981: At the First Conference on the Physics of Computation, held at MIT in May, Paul Benioff and Richard Feynman give the potential advantages of computing with quantum systems. One of the primary applications is a simulation of the physical properties of matter, which creates a new path toward developing novel materials and pharmaceuticals.
- 1985: British physicist David Deutsch publishes the idea of a "universal quantum computer".The universal quantum computer can simulate any other quantum computer with at most a polynomial slowdown.
- 1988: Yoshihisa Yamamoto and K. Igeta used the approach that photons transmit qubits and atoms perform two-qubit operations to realize the first physical quantum computer.
- 1992: David Deutsch and Richard Jozsa proposed to use the Deutsch–Jozsa algorithm on a quantum computer. This was perhaps the earliest outcome in the computational complexity of quantum computers.
- 1994:Peter Shor, at AT&T's Bell Labs in New Jersey, presents an algorithm that can efficiently find the factors of large numbers, in theory significantly outperforming the best classical algorithm.
- 1995:The first-ever United States Department of Defense workshop on quantum computing was organized by United States Army physicists Charles M. Bowden, Jonathan P. Dowling, and Henry O. Everitt.
- 1996:Lov Grover, at Bell Labs, invents the quantum database search algorithm that would offer a significant quantum advantage in searching unstructured databases.
- 1997:Bruce Kane proposes a silicon-based nuclear spin quantum computer and the first execution of Grover's algorithm on an NMR computer takes place.
- 2001: A collaboration between IBM and Stanford University publishes the implementation of Shor's algorithm. Their implementation is based on factoring 15 into its prime factors on a 7-qubit processor.
- 2006: Vlatko Vedral, at the universities of Porto and Vienna, found that the photons in ordinary laser light can be quantum mechanically entangled with the vibrations of a macroscopic mirror.
- 2012: A novel theory of Bell-based randomness expansion with a reduced assumption of measurement independence is discovered.
- 2019: A paper by Google's quantum computer research team was available in September 2019, claiming quantum supremacy.

Dr. Alex Moylett :
Being a woman and working in computer science, a male dominated sector is difficult as there is comparatively an alarmingly low representation. Being from the LGBTQ+ community increases the difficulties faced. One such admirable woman has fought through it all and now stands a very strong place in the specialised branch.
Dr. Alex Moylett is a quantum scientist at *Riverlane*, a Cambridge-based company that works on developing quantum software. She completed her PhD in Quantum Engineering at the University of Bristol, where she conducted her research on imperfections in photonic quantum computers. Her work on quantum computing and data structures has been published in journals such as *Quantum Science and Technology*, *Quantum Views* and *Physical Review A*. She made it clear that we must be time-efficient, and should think of the multiple goals we can presently come to and not just the process of building large scale quantum computers in the future. This inspired her to take up short-term linear optical quantum computing.

As a child, she was always fascinated by the capabilities of computers. She says that her parents and her love for video games played a significant role in steering her towards a career in the STEM field. Apart from her parents, she was also heavily influenced by Shafi Goldwasser (winner of the Turing Award in 2012) during her undergraduate studies. It was Shafi Goldwasser's work on cryptography and complexity theory (specifically zero-knowledge proofs) that inspired her to pursue her PhD in Quantum Engineering. One of the biggest achievements of her career was when she presented her research before members of parliament for the STEM for Britain event at the age of just 26. This allowed her to get into touch with numerous academic societies and funding bodies like the EPSRC, Institute of Physics and the Royal society of Chemistry.

She currently works with her team at Riverlane on the Deltaflow operating system, authorizing full advantage of the quantum computing stack to be taken, including all kinds of resources for the benefit of the chemical, pharmaceutical and materials industries.

Dr. Moylett has mentioned that the lack of female representation in the computer science field is definitely perceptible and that out of her cohort of around 60 students, the number of women could be counted on one hand. Dr. Moylett enunciates upon the necessity of inspiring more young women and girls to change their attitudes about the STEM fields and engaging them in more technical subjects to close the gender gap.

She says that “lack of women means that there often aren’t people you can relate to in a professional space; at worst it makes it harder to push back against actual sexism and misogyny when it does happen.”

Dr. Moylett is also a proud member of the LGBTQ+ community. It was during the second year of her PhD that she came out as transgender and non-binary. Her preferred pronouns are she/her and they/them. Various hardships were faced like being unable to change her name on publications and being commonly misgendered. She steers towards events that endeavour to build a more diverse scientific community, as everyone should. A step towards progression is the availability of a code of conduct, where individuals can be punished or held accountable for specific behaviour. She speaks up about being a minority in the field of quantum computing, and how incredibly vital it is to be an ally and to convince senior positioned people to change policies. Dr. Moylett is a firm advocate for supporting the minorities, women and people from the LGBTQIA community in computer science and other STEM fields.

LEARNING GUIDE

The discipline of quantum computation has made speedy development within the past few years. In 2016, IBM placed the f quantum computer in the cloud, increasing the reach of technology. The industry has started experimenting with quantum computing systems to assist optimize transaction settlements, use machine learning to tease out new insights, and boast scie discoveries. Learn more about quantum computing through these resources:

Video Tutorials

1. A beginner's guide to quantum computing | Shohini Ghose
2. Quantum Computers, Explained With Quantum Physics
3. Quantum Computers Explained – Limits of Human Technology
4. Quantum Computing Expert Explains One Concept in 5 Levels of Difficulty | WIRED
5. Quantum Computing for Computer Scientists

Playlists:

1. https://www.youtube.com/playlist?list=PL74Rel4IAsETUwZS_Se_P-fSEyEVQwni7
2. https://www.youtube.com/playlist?list=PLOFEBzvs-VvrXTMy5Y2IqmSaUjfnhvBHR
3. https://www.youtube.com/playlist?list=PLD7HFcN7LXRcKEiyRxdTDVRaMZQDhojhb
4. https://www.youtube.com/playlist?list=PLay4zC7VCXV4gWb0ucSUQiGcRJFYMzROT

Books:

1. **Quantum Computing for Everyone (The MIT Press) 2019**
2. **Dancing with Qubits: How quantum computing works and how it can change the world (Packt Publishing) 2**
3. **Quantum Computing: An Applied Approach (Springer) 2019**
4. **Quantum Computing since Democritus (Cambridge University Press) 2013**
5. **Quantum Computing for Babies (Baby University) 2018**
6. **Quantum Computing for beginners: A Complete beginner's guide to Explain in Easy Way, History, Features Developments and Applications of New Quantum Computers that will Revolutionize the World (self-publish**
7. **Programming Quantum Computers: Essential Algorithms and Code (O′Reilly) 2019**

Certification Courses:

1. https://www.coursera.org/learn/quantum-computing-algorithms
2. https://www.coursera.org/learn/quantum-computing-lfmu
3. https://www.coursera.org/projects/getting-started-quantum-machine-learning
4. https://www.edx.org/professional-certificate/delftx-quantum-computing-and-quantum-internet
5. https://www.edx.org/micromasters/purduex-quantum-technology-detectors-and-networking
6. https://www.edx.org/micromasters/purduex-quantum-technology-computing

MYTH BUSTER

1. Quantum Computing will completely replace classical computing.
Though Google claimed to have achieved 'Quantum supremacy' with their quantum computer Sycamore, the truth is that quantum computers like Sycamore can perform only specific tasks. Furthermore, quantum computers require special conditions like low temperature to prevent overheating. It is practically impossible to provide such conditions for a large number of quantum computers. Hence, tremendous development will have to be achieved for classical computing to be replaced by quantum computing.

2. Quantum computing can run programs similar to its classical counterpart.
Quantum and classical computing work on distinct principles. Hence, the way they function is drastically different. This simply implies that both computing systems work on different algorithms. As algorithms are different, there is no way that this myth could be true.

3. Quantum computing is better than classical computing for solving all problems.
Though quantum computing is extremely fast, it is unsuitable for solving every type of problem. Currently, the problems which it can analyze fall into two categories: problems designed exclusively for a quantum computer like simulating quantum systems(e.g. Systems like cells) or problems relevant to our daily life like optimization. Moreover, the present-day quantum computers have only around fifty-qubits free at any instant even though it contains more qubits. This means we currently lack fault-tolerant quantum computers. The algorithms designed for the problems demand a fault-tolerant system and quantum computers have not reached this stage to be capable enough to solve all types of existing problems.

4. Quantum-safe cryptography can provide complete data security.
Quantum computers are capable of breaking the PKC algorithms used to protect classical computers from data breaches. Though quantum-safe cryptography has been proposed as one of the solutions, it is only in theory. Hence, as of now, there is no foolproof method to overcome the quantum attack and safeguard data.

Quantum computing uses quantum mechanics to provide a massive leap forward in computation to solve specific issues. Quantum computers are data storage and processing machines that make use of quantum physics features. This can be beneficial for some tasks where they can outperform even our most powerful supercomputers. Traditional computers, such as smartphones and laptops, store data in "bits," which can be either 0s or 1s.

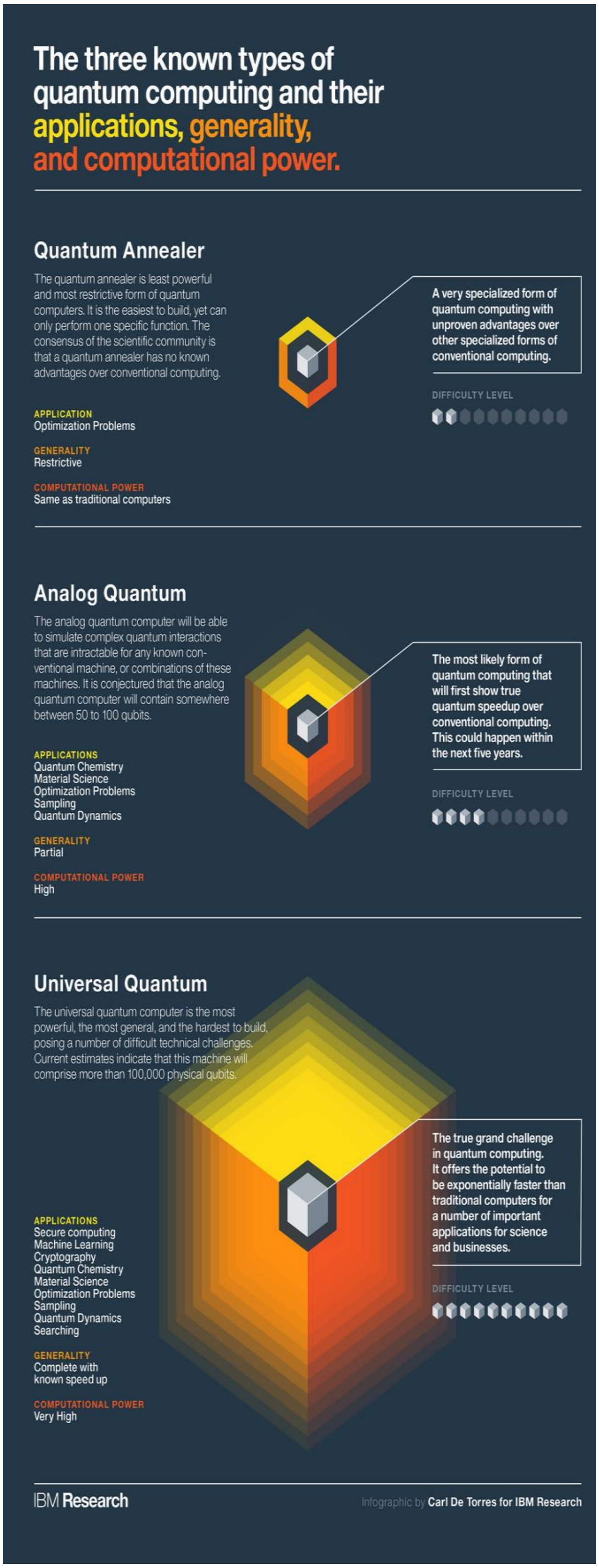
A quantum bit, or qubit, is the basic memory unit in a quantum computer. Physical systems, such as the spin of an electron or the direction of a photon, are used to create qubits. Quantum superposition is a characteristic that allows these systems to be in several configurations at the same time. Quantum entanglement is a phenomenon that allows qubits to be inextricably linked. As a result, a set of qubits can represent multiple things at the same time.

We've relied on supercomputers to tackle most problems up until now. These are extremely powerful traditional computers with thousands of CPU and GPU cores. Supercomputers, on the other hand, aren't very adept at tackling certain types of problems that appear simple at first appearance. This is why quantum computers are required. They can represent these enormous issues in massive multidimensional spaces created by quantum computers. This is something that traditional supercomputers are incapable of.

Quantum wave interference algorithms are then utilised to locate solutions in this realm and translate them back into usable and understandable forms.

Simulating the behaviour of matter down to the molecular level is one of the most potential applications for quantum computers. Volkswagen, for example, is utilising quantum computers to mimic the chemical composition of electric car batteries in order to identify new methods to improve their performance. Pharmaceutical firms are using them to compare and evaluate substances that may lead to the development of new medicines.

Quantum computers might take several years to fully realise their promise. However, if these strange new computing devices live up to their hype, they have the potential to revolutionise whole sectors and accelerate global innovation.



SUMMARY

Quantifying Quantum Computing

Quantum computing holds the power to revolutionize traditional medical, communication, and encryption systems.

Today, companies like IBM, Microsoft, and Google are racing to build perfect quantum computers and achieve quantum supremacy. Countries like China have invested billions for innovation in this field.

Fig: Quantum computer

So, what exactly is quantum computing?

Quantum computing can be defined as the exploitation of collective properties of quantum states, such as superposition and entanglement, to perform computation.

First, let's take a look at how our traditional computers work. Data in our computer systems are represented in 1s and 0s which can be interpreted as either switched on or switched off. Every app you use, the game you play, and the photograph you take is ultimately made up of millions of these bits in combinations of ones and zeroes.

However, this way of representing data does not reflect the universe very well. In a real-world scenario, things are far apart from just on and off. We encounter a lot of uncertainty and that is where the problem arises. Even the best of supercomputers struggle to deal with uncertainty.

It has been proved that when we go down to a really tiny scale, classical mechanics does not seem to be much effective. This is the reason why physicists discovered a whole new field in physics, quantum mechanics. Quantum mechanics forms the basis of quantum computing

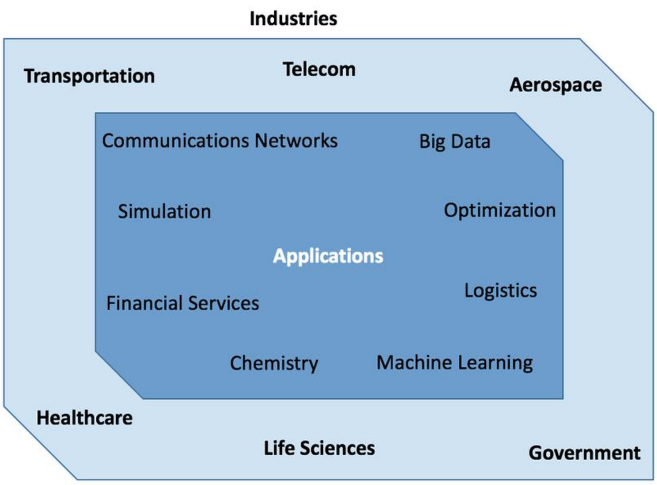
How does Quantum computing solve this problem?

A quantum computer works differently. Rather than storing information using bits represented by 0s or 1s as conventional digital computers do, quantum computers use quantum bits, known as qubits, to encode information as 0s, 1s, or both at the same time. This superposition of states along with the other quantum mechanical phenomena of entanglement and tunneling is what enables quantum computers to manipulate enormous combinations of states at once.

SUMMARY

Let's take an example. If you flip a coin, there can be two outcomes, heads or tails. But, if you spin a coin it can land on both heads and tails. You can only be sure of the outcome when you stop that coin. Superposition behaves in a similar fashion as spinning a coin and that is what makes quantum computing so powerful.
The other thing that qubits are capable of doing is called entanglement. Normally, if you flip two coins, the result of one coin toss has no bearing on the result of the other one or their results are independent. In entanglement, two particles are linked together, even if they're physically separate. If one comes up tails, the other one will also be tails.
The catch here is that quantum computers can string together multiple qubits which can tackle extremely complex problems that would otherwise take millions of years for normal computers to perform.

Where are Quantum Computers used?



Apart from enabling faster and more efficient solutions to our problems, quantum computers have made it possible for us to do things that we could not even imagine years ago. Quantum computers are used in a multitude of areas including:

1. Artificial Intelligence and machine learning: Artificial intelligence and machine learning are some of the prominent areas right now, as the emerging technologies have penetrated almost every aspect of humans' lives. However, with the increasing number of applications, traditional computers cannot keep up with the pace. This is where quantum computing can help process complex problems in a short amount of time.
2. Computational Chemistry: According to IBM, one of the most promising quantum computing applications will be in the field of computational chemistry. It is believed that the number of quantum states, even in a tiniest of a molecule, is extremely vast, and therefore difficult for conventional computing memory to process The ability for quantum computers to focus on the existence of both 1 and 0 simultaneously could provide immense power to the machine to successfully map the molecules. This can revolutionize pharmaceutical research.
3. Cybersecurity: The online security space is vulnerable and the number of cyberattacks has also seen rapid growth. Quantum computing paired with machine learning can help in developing various techniques to combat these cybersecurity threats. Quantum cryptography can also be used to create safer and better encryption algorithms.

So, is quantum computing the future?
Despite several perks that quantum computing provides, it is highly unlikely that our laptops or smartphones will be equipped with a quantum chip anytime soon. Apple will not release an iPhone Q . Even though Quantum computers have been theorized and talked about for decades, the reason why it's taken so long for them to arrive is that they're incredibly sensitive to interference.

SUMMARY

Almost anything can knock a qubit out of the delicate state of superposition. As a result, quantum computers have to be kept isolated from all forms of electrical interference and chilled down to close to absolute zero.

Hence, quantum computers will mostly be used by academicians and businesses to improve their efficiency. Right now, even the most powerful quantum computers only have 50 qubits. This field is still in its infancy and all we can do is wait to see what the future holds

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6. https://analyticsindiamag.com/top-applications-of-quantum-computing-everyone-should-know-about/

FAQs

1) What is quantum computing?
The use of accumulated properties of quantum states (superposition and entanglement) to perform computation is quantum computing. The device which performs these computations are quantum computers.

2) What is the difference between quantum computing and traditional digital computing?
Traditional digital/conventional computing use binary codes(1 and/or 0) to crunch through operations. However, quantum computers use quantum bits or qubits. They do use 0 and 1 but have a third state, 'superposition.'

3) How does a bit differ from a qubit?
A bit is the basic unit of information representing a logical state with one of the two possible values: 0 or 1; A qubit is a basic unit of quantum information that can hold more information (For example: up to two bits using superdense coding).

4) Who invented the quantum computer?
In 1998, Isaac Chuang, Neil Gershenfeld, and Mark Kubinec created the first quantum computer.

5) Do quantum computers exist?
Most quantum computers work with less than 100 qubits. However, major tech companies are progressively working on building a more efficient and meaningful quantum computer.

6) Is machine language used in quantum computing?
While machine learning algorithms are effectively utilized in data computation, quantum machine learning uses qubits and quantum operations to improve computational speed and data storage efficiency.

7) What are the mathematical concepts related to quantum computing?
Linear Algebra is an important mathematical concept. Furthermore, matrice multiplication, inner products, and tensor products are crucial components for mathematical computation.

8) What is the relation between quantum computing and Quantum cellular automata technology?
A quantum cellular automaton is an abstract model of quantum computation. It is limited to the conventional cellular automata models introduced by John von Neumann.

9)Do nanotechnology and quantum computation share any relatability?
Quantum technologies operate through the exploitation of properties of quantum states at a small scale. They are dependent and underpinned by advances in the field of nanotechnology

10) Why is it hard to build quantum computers?
Quantum computers are difficult to engineer and build. Some of the most common difficulties which creep in are decoherence, state preparation, error correction, and implementation of gates. In fact, programming quantum computers is a hard task as well.

SPOTLIGHT

Domain: Finance & Sponsorships Head
IEEE-WIE is a technical chapter that is divided into 4 major departments namely technical, design, management, and editorial department.
For any chapter to run accordingly it requires a bond and sync between the members. Managing finances is one of the most important parts of any organisation. Being a finance head is not an easy task, there’s so many responsibilities in line. From collecting sponsorships and maintaining the numbers right. I’ve got the opportunity to talk to our Finance and Sponsorship Head of IEEE-WIE from the management domain, **Pranjal Gupta**. She is one of the most hardworking and dedicated members in our club. She has shared some of her experiences and views about her position in the management domain.

Q1)Could you give me an overview of the duties and responsibilities you hold as the Finance and Sponsorship head?
Pranjal:
- There are various factors that come into play when it comes to the working of the club, especially in the Management Domain, one of them being the financial management. As a Finance head, the duty of maintaining the financial branch of the Management domain falls under me.
When it comes to bigger events, Sponsorship plays a very key role for the success of the event. As a Sponsorship Head also, my duty resides in managing the Sponsorship responsibilities for the event and making sure of the easy on-boarding of the sponsors in the event.

Q2)What parts of the job do you find most challenging?
Pranjal: The role itself is a huge responsibility yet an amazing experience. It requires an extra careful and yet creative approach for every new situation that comes up while in the job. Constant working and keeping a record of the work done, not done or yet to be done is very important for efficient working and thus one of the big challenges that needs to be avoided at any costs.

Q3)How does this department encourage personal as well as professional growth?
Pranjal: I have always been good with numbers and loved to be the backstage spotlight of any event. Finance is something that has recently fascinated me a lot and I would like to pursue this interest further someday, hence this role gives me a chance to experience real world kind of roles in the domain.
Being a Sponsorship head, contacting and keeping in touch with sponsors for the events helps in making good networking, thus giving me a chance to branch out further more and open up good opportunity chances.

Q4)Considering all the people you’ve met in WIE, what are some of the important things you’ve learned?
Pranjal: There are various things that I have learnt while being in WIE for almost 2 years now. I had amazing chances to meet amazing and talented women working together to grow as a one group along with helping each other to grow also. One of the most important things that I have learnt from WIE is to never hesitate from trying new things that fascinate you and never to back down from any opportunity that is being offered. You never know what amazing experiences and opportunities are there in store for you.

Q5)Have you faced any kind of setback dealing with this department? If so could you give a brief explanation about that.
Pranjal: I have absolutely no complaints as such from the Department apart from an amazing experience for me. I am very proud of the Management domain of WIE and I couldn't have asked for a better team to help me out in the workings under my role for the chapter.

STAR PERFORMERS

1. **Design:**
Ishita, an extremely creative and artistic designer from the Design Domain, truly bedazzled everyone with her phenomenal work this month. From her boundless enthusiasm to her magical posters for events, Ishita put forth her best in making significant contributions to each and every activity there was. Her posters are the very embodiment of creativity, as she exquisitely combined the essence of the theme for each poster with a mystical blend of intricate art and scintillating aesthetic to produce a visual masterpiece. Keep dazzling everyone with your sparkle Ishita! You're crossing new horizons every day!

2. **Editorial:**
Vasundhara, a versatile and highly skilled writer from the Editorial Domain, blew everyone away with her awe-inspiring dynamism, literary talent, and her immaculate articulation. Her energy in every meeting paired with her eagerness to take initiative inspired us all! Her quick thinking and ingenuity bring out a charm in every piece she works on. Vasundhara has an extraordinary way with words, as she weaves together an ethereal composition that'll take anyone reading it on a thrilling intellectual adventure, in the technical universe. Hats off to you, Vasundhara! You are our writing queen!

3. **Management:**
Shruti, a multitalented and charismatic member of the Management Domain, took the club by storm with her flawless leadership and resourceful ideas. From coordinating events to immaculately leading a team, she was on top of it all and made sure every venture was a full-blown success. She acted as the central core link in every event she participated in, bringing about a synergic balance among all the participants. Her systematization and organization skills are beyond comparison and she has time and time again proved to be a much-valued member of the club. A big standing ovation to you Shruti! You've blown us all away!

4. **Technical:**
Sadhana, a budding professional from the Technical domain displayed an insane level of dynamism, technical adroitness, and finesse this month. Using her extensive expertise, she navigated through every technical aspect of each event conducted and facilitated it all with an extraordinary level of dexterity. She put her best in every project, and incorporated a curated set of well-thought-out details, making sure the end result is nothing short of pure perfection in every aspect. Continue to shine Sadhana! You're always making us proud!

EDITORS

Vrushali Deshmukh- Editor-in-Chief

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