TECH
mahindra

Quantum Computing Unlocking New Opportunities for Supply Chain Management

WHITEPAPER

Abstract

In recent years, the global quantum industry has advanced dramatically with significant investments made by both public and private sectors.

Tech Mahindra holistic SCM offering

The major driving factor is the enterprise adoption quantum computing , the improved cooling technologies, fabrication, verification, and architecture support the enhancement of quantum computers along with:

- Improved quantum algorithms
- Accelerated investments in quantum tech
- Increasing growth of community-led quantum contributions

Quantum algorithms are becoming a key part of modern computing. These kinds of algorithms work on the principle that if you know something about the environment, it will give you an answer closer to the real thing than anything else that could possibly operate on that same subject. As a result, quantum computers will become an essential part of our future computing architectures.

Key Takeaways

The key areas covered in this whitepaper are as follows:

Introduction

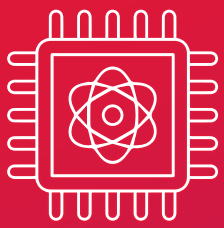
Quantum computing (QC) is an emerging technology that has the potential to transform various industries, including supply chain management (SCM). QC utilizes the principles of quantum mechanics to perform complex calculations and solve problems that are beyond the capabilities of classical computers. In the context of SCM, quantum computing can bring several benefits.

As we continue exploring the potential of QC, we will be seeing new applications – and old use cases being reimagined. We will see new ways for computers to answer questions about themselves and their surroundings with unprecedented accuracy, transparency, and reliability. And we will also see the power of algorithms rise above their creators as ever-more-capable devices detect patterns and make more informed decisions.

The main appeal of QC is that it solves complex problems faster with limited resource consumption, making it a perfect solution for big data processing e.g., aerospace logistics.

The platform has been set for next phase of use cases to scale up on quantum on such as

- Supply chain optimization
- Asset portfolio optimization
- Fraud detection with graphs
- Targeted customized advertising
- Agri-predictions
  Weather and natural calamity prediction.



Fundamentals and Real-World Applications of Quantum Computing

There is duality in nature to an extent that a particle exists as both wave and a particle but how does it affect computing would be the next big question.

Silicon chips as we see it in computers today work on the principle of voltages. A +5 voltage (any positive) is deemed as "1" and a lack of voltage or "0" is considered to be a 0. These bits as we call it defines the entire logical structure and architecture of how computers compute today, but these are mathematical and classical jargons (Silicon chips being very real in the classical world we live in)

The quantum world on the other hand is more probabilistic, a bit can be "0" or "1" at the same time. It is only when we observe the bit can the real nature be found out. In other words, a quantum system continues to be in a state of quantumness unless measured classically. It is only when a quantum system is measured, does it leave the quantum richness and collapses into a classical state.

This phenomenon described above gives the essence of speed. Where 1 bit in the classical world, allows a user to either use it as 0 or 1, a quantum bit (also referred to as Qubit) allows a superposition of both states at the same time unless measured so it allows 2 combinations. Let us increase the bits to 3 or n. A classical bit allows one out of the 2n combinations, a Qubit allows all the 2n combinations simultaneously which is a massively parallel approach to computing. Imagine a 32-qubit computer, where we can do 232 parallel computations simultaneously to get an output. This number corresponds to the number of stars in our galaxy.

A qubit is referred to as **|0>** or a **|1>**, rather than just **"0"** or **"1"** . **This is called a "Ket" notation. And these states are called Computational Basis States. Before I go ahead and explain this, let me go into the business facet of it and why does it make me excited about quantum computing**

Basic Quantum Principles

It is important to understand the basic quantum principles that are available which enables the reader to understand the power of quantum

Superposition

Since a particle at a sub-atomic level exists as both a particle and a wave it lends itself to being both on and off at the same time. This is analogous to a switch or a modern-day computer bit which can be either 0 or 1. However at a subatomic level , a particle can be both 0 and 1 at the same time. What it is , is not known until it is classically measured because of the Heisenberg's uncertainty principle. Once you measure the particle using classical techniques, the particle leaves its quantum state and with a certain probability exhibits as a "0" or "1". What this gives you is the hint of the quantum speed.

Let us assume we have two particles (bits) as a computer parlance would allow us and if we had to measure them, we know that these two bits can take one of the 4 forms “00”, “01”, “10” or “11”. In the subatomic world all of these exist together as a state and so the power of computation becomes 2^n

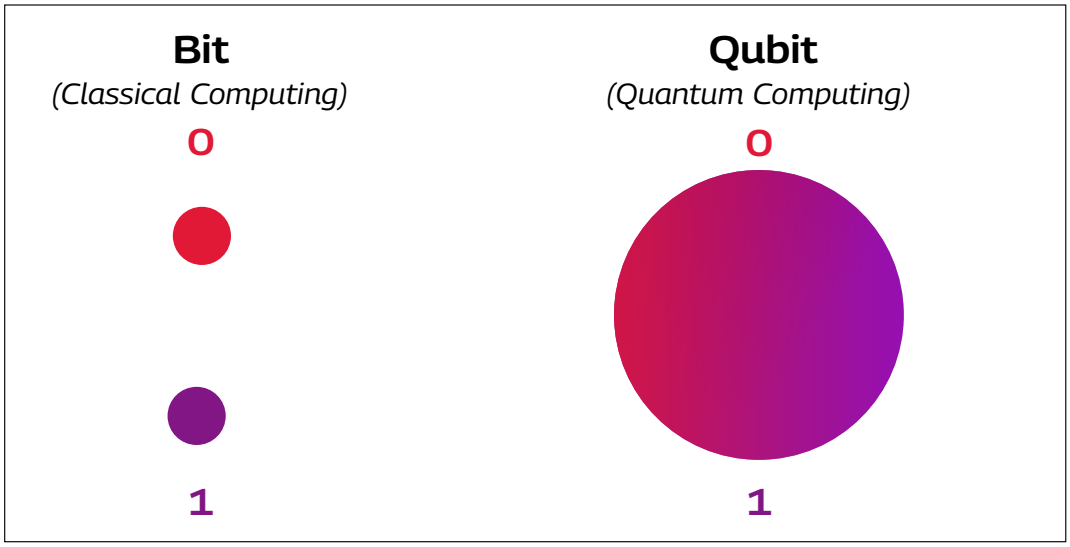


Figure1: Super position depiction

Entanglement

Entanglement is yet another “spooky” principle that has baffled scientists over a century now , a concept that occurs only at the quantum level with no real explanation. Normally particles in this universe are created as pairs. The pairs are distinguishable by a property within the particle be it spin, charge etc. The entanglement principle as seen states that if you keep on the particle within the pair with you and send the other one to a far-off distance, as far as the end of the universe, and you put data on the particle close to you, the particle at the far corner of the universe would also have a mirror of the data. Now this , defies the principle of space and time and also the basic laws of the universe

What this does allow us to achieve is quantum encryption fantastically. Imagine two keys which are created as a pair and a hacker manages to just spoof at one of the keys. The hacker has not yet decrypted the key but manage to locate it. This is good enough to send a message to the entangled key that some change has happened, and the keys can be changed, and system protected from a hack. Entanglement is so spooky that even Einstein could not wrap his head around it

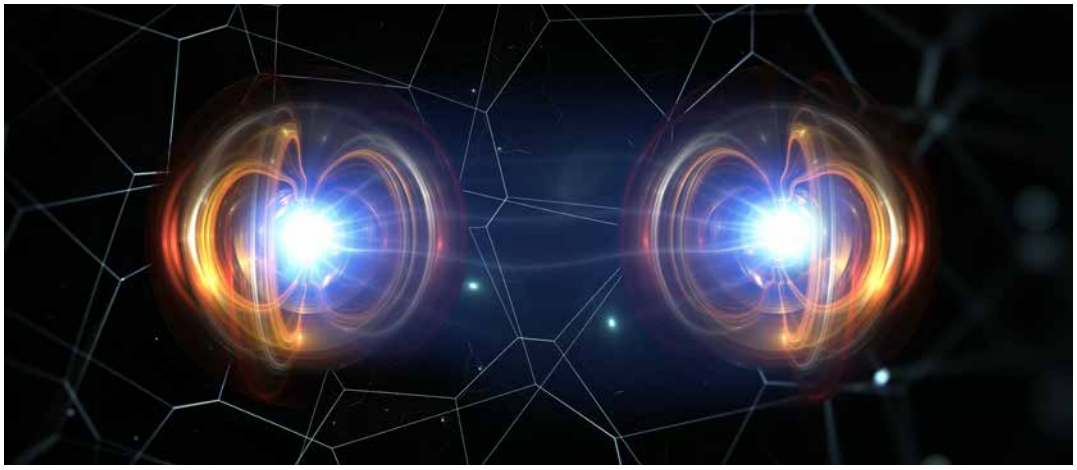


Figure2: Quantum entanglement depiction

Quantum Tunneling/Annealing

Quantum tunneling is yet another feature of a quantum system which lends itself beautifully for modern day AI applications and another principle which is counter intuitive.

Let us imagine we are rolling a ball towards a hill. We all know classically that the amount of kinetic energy available within the ball would enable it to roll up the hill. If the ball does not have requisite force of kinetic energy , it would roll down and not go over the hill. Well, in quantum world since the particles exist as wave and particles both, there is a small probability that this particle without the requisite kinetic energy can appear on the other side of the hill. This effect is like a tunnel drawn by the particle to reach the other side .

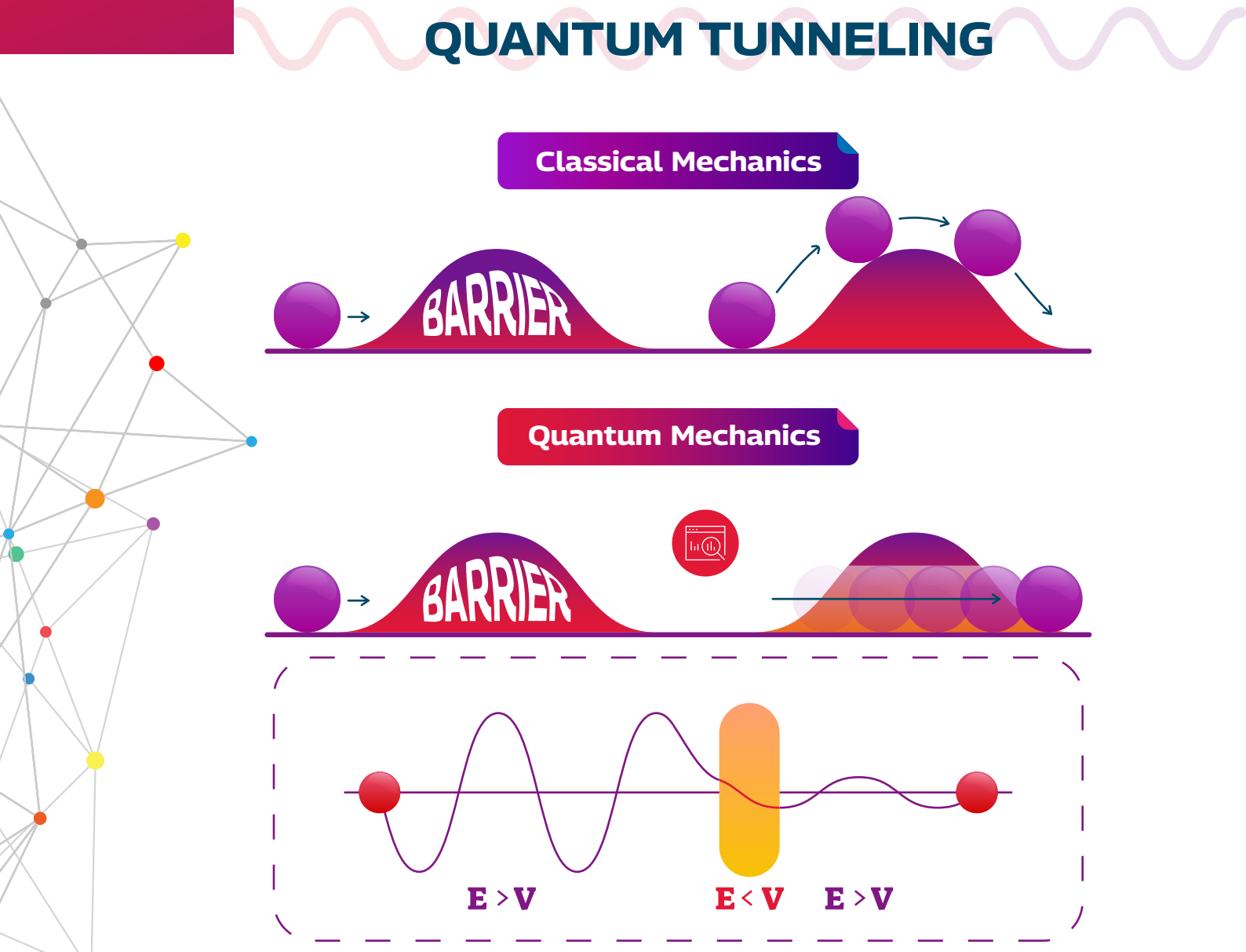


Figure3: Illustration of Quantum Tunneling

Why is this important? Well, we have seen that the AI and machine learning applications rely on the gradient descent method to find a global optimum. This is like a drone sent to the bottom of the hill to get a local optimum faster than the gradient descent. This technique can also help us determine global optimum and not get caught in local optimas.

Practical Applications

We finally reach the point where we can explain the different practical applications that a quantum computer can have today and put specific focus on some military applications, but before we do that, we also want to spend some time on some of the applications being used in the world today.

A simplistic application grab is shown in the figure below

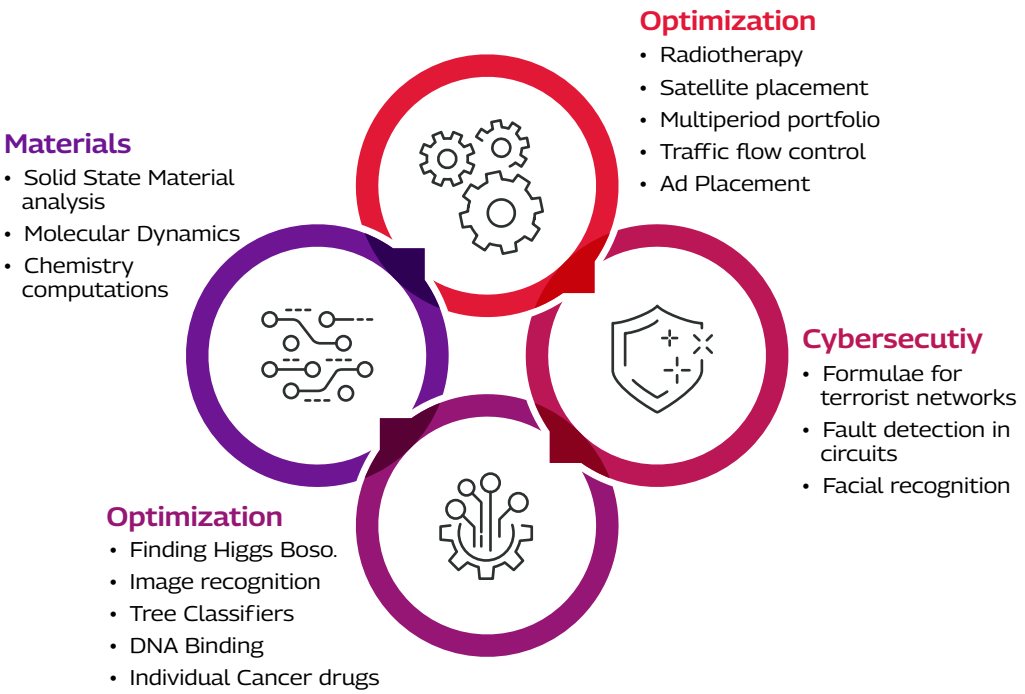


Figure6: Practical applications of quantum computing

Exploring the Potential Applications of Quantum Computing in SCM

Some of the use cases of quantum computing that can be applied in supply chain management(SCM) include:

1. **Optimization:** Quantum computing can help optimize supply chain networks by solving complex optimization problems that classical computers cannot handle. For example, *it can aid in optimizing supply chain routing, inventory management,* and production planning.

2. **Demand Forecasting:** Quantum computing can help improve the accuracy of demand forecasting by analyzing complex patterns and processing large amounts of data. This can help supply chain managers make *better decisions about inventory planning, production scheduling, and distribution.*
3. **Simulation:** Quantum computing can be used to simulate supply chain scenarios and test different strategies. This can help supply chain managers *evaluate the impact of different decisions and identify the best course of action.*
4. **Risk Management:** Quantum computing can help identify and mitigate supply chain risks by analyzing large amounts of data and predicting potential disruptions. This can help supply chain managers take *proactive measures to minimize the impact of potential risks.*
5. **Cryptography:** Quantum computing can also enhance supply chain security by improving encryption techniques. Quantum cryptography uses the principles of quantum mechanics to create unbreakable encryption methods, which can help protect *supply chain data and ensure secure transactions.*

Quantum computing has the potential to revolutionize supply chain management by providing faster and more accurate analysis of complex data sets, solving complex optimization problems, and improving supply chain security. As quantum computing technology continues to evolve, it is expected to bring significant benefits to supply chain operations in the future

Tech Mahindra holistic SCM NXT.NOW offering

Tech Mahindra has a holistic offering that covers areas spanning planning and execution, sourcing, contract management, delivery, aftermarket, and control.

Figure7: TechM SCM NXT.NOW framework

With our unique expertise in quantum computing, we can transform SCM for our customers by unlocking new opportunities.

Authors

"We are reminded of the limitless-ness of human curiosity, when we see man and machine create marvels for the future together" is the quote Nikhil Malhotra lives by

Nikhil Malhotra

Nikhil Malhotra is the chief innovation officer and creator of Maker's Lab, a unique Thin-q-bator space within Tec Mahindra with over 20+ years of experience in a variety of technology domains.

The lab focuses on artificial intelligence, neuroscience based AI, robotics and quantum computing along with extended reality and applying old science to modern problems. Nikhil's area of personal research has been natural language processing, enabling machines to talk the way humans do. Nikhil has also designed an indigenous robot in his lab, as a personal assistant.

He lives by a dream of creating smart machines that would wed human emotions with artificial intelligence to make lives better. He is also a leading speaker on digital transformation, practical use of AI and the future AI and in the UK list of mavericks and mavens of AI. He holds a Masters degree in computing with specialization in distributed computing from Royal Melbourne Institute of Technology, Melbourne.Nikhil currently resides in Pune with his wife Shalini and sons Angad and Rudra.

Vishwas Bunyan

Vishwas Bunyan is an SCM expert of the Digital Transformation Office. Vishwas has around 22 years of Professional exposure in the IT Industry with experience spanning digital transformation, supply chain and various presales roles he has done his MBA from Indian Institute of Management, (IIM), Trichy and had done his BE(ECE)