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## **QUANTUM COMPUTING'S INTEGRATION INTO SUPPLY CHAIN**

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The development of quantum technologies in today's world opens up new perspectives for various industries, including logistics. The past two years have seen the rapid development of quantum computing, which arouses general interest and hopes for high achievements in the field of logistics. In this context, it is worth exploring the possibilities and prospects of using quantum solutions to optimize global supply chains and overcome various challenges facing these sectors.

The objects under investigation include quantum computing technologies and their applications in logistics. The study employed a combination of literature review, expert interviews, case studies, and analysis of quantum computing principles, optimization algorithms, simulation, modeling, and data security.

Quantum computing, a cutting-edge paradigm leveraging quantum technology, promises unparalleled processing power surpassing traditional supercomputers by millions of times [3]. While its impact on logistics is still moderate due to its nascent stage, growing commercial interest and technological advancements suggest promising prospects for future integration.

Quantum computing stands poised to redefine various facets of logistics, offering solutions to longstanding challenges and unlocking new opportunities for efficiency and innovation, namely:

1. **Fleet & Route Optimization:** Traditional methods of optimizing delivery routes are limited by computational constraints, often taking an impractical amount of time to analyze complex scenarios. Quantum computers, however, excel at handling vast amounts of data and optimizing routes with numerous stops in a fraction of the time. By leveraging quantum computing, logistics companies can streamline last-mile delivery operations, reduce costs, and minimize environmental impact by optimizing fleet routes for maximum efficiency.

2. **Container Optimization:** Maximizing shipment loads in irregularly shaped containers presents a formidable challenge for logistics operators. Quantum computers offer a solution by rapidly calculating the optimal placement of parcels and pallets, regardless of their size or shape. This capability enables logistics companies to fully utilize container capacity, thereby reducing costs per shipment and decreasing the overall number of containers required for transportation.

3. **Rapid Simulation & Digital Twin Support:** Quantum computing accelerates the simulation of complex supply chain scenarios, empowering logistics planners to make informed decisions in real-time. By running advanced simulations more quickly and accurately, logistics companies can anticipate

and mitigate potential disruptions, optimize inventory management, and enhance overall operational resilience. Additionally, quantum computing facilitates molecular-level simulations, driving innovation in materials science and product development for the logistics industry.

4. Quantum Internet & Data Protection: As data security becomes increasingly critical in logistics, quantum computing offers a promising solution to safeguard sensitive information from cyber threats. Quantum encryption techniques provide unparalleled security by leveraging the unique properties of quantum mechanics to create unbreakable encryption keys. By implementing quantum encryption protocols, logistics providers can ensure the confidentiality and integrity of customer data, bolstering trust and confidence in their services [1].

There remain significant hurdles to overcome before quantum computers can be widely adopted for everyday business applications. These challenges include the need for advancements in error correction techniques to enhance the reliability of quantum computing systems [2]. Additionally, accessing and setting up quantum computers for day-to-day use is currently more complex and time-consuming compared to traditional supercomputers, posing practical obstacles for businesses. Moreover, existing cybersecurity measures may prove insufficient against quantum-based attacks, as the exponential speed of quantum computing could potentially render conventional encryption methods vulnerable to brute-force hacking. Addressing these challenges will be essential to realizing the full potential of quantum computing in mainstream business operations.

### **Conclusion**

The integration of quantum computing represents a significant leap forward in the evolution of logistics technology. As quantum technologies continue to advance and overcome existing challenges, they are poised to revolutionize various aspects of the logistics industry, from route optimization to data security. By embracing and harnessing the power of quantum computing, logistics companies can stay ahead of the curve, drive competitive advantage, and deliver greater value to their customers in an increasingly digital and interconnected world.

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