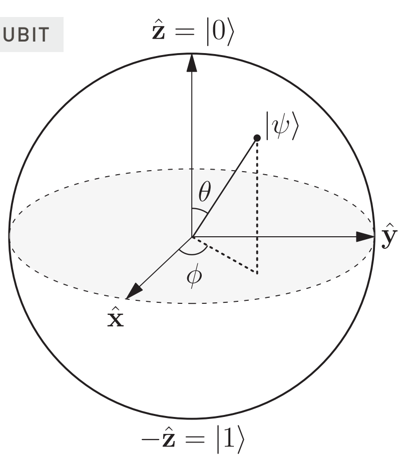
AN OVERVIEW OF QUANTUM COMPUTING

BY: 84.51° SCIENCE TEAM

AN OVERVIEW OF QUANTUM COMPUTING

Quantum computers exploit fundamental properties of quantum physics to offer potentially exponentially faster computing. While traditional machines use sequences of binary bits in either on or off configurations (1 or 0) to communicate how to operate on data, quantum computers use subatomic particles called qubits capable of assuming both values 1 and 0 simultaneously. By harnessing the uncertainty of the qubit, quantum computers offer a promise of radically faster computations for solving some of the most critically important problems today, provided that problem-specific structures exist and can be uncovered.

QUBIT



RELEVANCE TO 84.51° AND KROGER

Virtually every privacy and e-commerce application would be impacted dramatically by the development of practical quantum computing. Essentially all private communications and secure transactions rely on a form of cryptography known as public key encryption, which while nearly impossible to solve using traditional computing, could be cracked in a reasonably short amount of time using a quantum algorithm.

While an ethical company like Kroger is not interested in cracking public key encryption systems, what would we do to safeguard our customers' privacy and transaction security against quantum computing? One solution is itself based on quantum computing, as there are now quantum-based encryption algorithms which could not be broken by quantum computing.

Besides security, the increased speed provided by quantum computing could also offer better approximate solutions for many problems faced by technical teams across the Kroger enterprise. A few examples of these applications include price and promotion optimization, forecasting of sales and revenue, supply chain distribution optimization, recommender systems, general data analytics and machine learning, and natural language processing and search technologies.

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USE CASE FOR 84.51° AND KROGER

We have developed a science for performing P&P optimization, parsing an enormous number of promotion plan combinations to identify better-and-better versions to achieve the financial goals while respecting various business rules. While this science is state-of-the-art, it cannot guarantee finding the absolute optimal plan (e.g., the one yielding the highest possible sales, while respecting the business rules) in a feasible amount of time. In fact, no algorithm can possibly find the absolute optimal in less time than the age of the universe (literally!).

An operational quantum computer could far better address the huge search space by using qubits to assume both binary values 1 and 0 simultaneously, thus "quantumizing" the optimization techniques to allow searching of both a much larger solution space, and looking well beyond the traditional scope (e.g., Looking at many more cross category interactions such as "How does reducing specific soft drink brand prices impact/increase the sales of various types of chips?"). Quantum computing would not only unlock better solutions, closer to the absolute optimum, but would be able to address larger and richer problems that we have no path of addressing with classical computing technologies today.

OBSTACLES

Generating and managing qubits is a formidable scientific and engineering challenge. Qubits must be isolated in a controlled, stable, quantum state to avoid interaction with their environment and decay of their superposition before their job has been properly done (uncontrolled decoherence). Some manufacturers of experimental quantum systems achieve this by using superconducting circuits cooled to temperatures colder than deep space, while others trap individual atoms in electromagnetic fields on a silicon chip in ultra-high-vacuum chambers. Despite these efforts, noise from various sources will always cause errors in calculations. Building a practical quantum computer depends on detecting and correcting these errors. While there are some practices that, in theory, can compensate for these "hardware" problems, finding a feasible solution to this problem appears to be a long way off.

While many serious theoretical physicists doubt that quantum computing can ever be more than an intellectual exercise, it is fair to say that many times when an engineering feat seemed impossible, it was solved in a decade or two.

Even if successfully built-to-scale, quantum computing will never be an all-purpose mechanism capable of automatically solving any problem. Brilliance is required to find structure specific to the particular problem at hand and then to design the algorithm accordingly.

SUMMARY

Quantum computing holds the potential to radically speed up computations for solving some of the most critical problems of the day. Currently, there are not application-ready, true quantum computers, but these could be a little more than a decade away. If practical quantum computing becomes available, it is imperative that Kroger is at the forefront of this technology for data security reasons. There would also be benefits in increased problem-solving speed and capacity for Kroger's technical teams.