Section 2: Week 6: Presentation Transcript

Nate Bachmeier

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North Central University

Quantum Data Management

Good evening, I’m Nate Bachmeier, and today we will be covering database quantum supremacy.

# Section 1

Identify the new technology and provide a comprehensive discussion of the new technology’s functionality.

## How’d we get here

If we asked experts to predict the future, in 2000 they would have said the world would be full of relational stores. In 2010 there would have been rumblings of NoSQL databases that focused on IoT, Cloud, Big data, and Mobile. Now as we enter 2020s there is a huge transition across the industry into NoSQL and NewSQL systems. Looking further into the future we can see that data will continue to grow exponentially, however our data management systems are growing linearly. This will eventually lead to a point where our horizontally scaled systems are insufficient, and a new paradigm shift needs to take place. Many believe that will come from quantum supremacy of data management systems.

## What is quantum

If a quantum database can perform a task better than a mainstream database at a task, it has reached supremacy. There are specific aspects that QDB will likely gain supremacy such as optimizations and matrix operations, versus other aspects that are less likely to outperform its predecessors (e.g. binary search index). This would suggest that hybrid quantum databases will arrive as the first step in this next evolutionary chain.

## How does quantum computing differ

Unlike traditional computers, a quantum device uses Qubits to hold a superposition that is both on and off. These qubits can become entangled with other qubits, such that the value of one cascade into the computation of another.

An analogy exists where Alice might pay Bob and Bob will only go to the movie with Charlie if he’s paid. In this scenario, Bob attending the movie with Charlie is entangled with the decisions of Alice.

Transaction management encounters a similar scenario, where values are conditionally written into the store and based on the commit flag either applied or rolled back. Instead, of managing the complex I/O operations, we could encode the problem as a quantum operation, and force the entanglement to align with the commit flag.

## Grover’s Algorithm

Grover’s algorithm proposes a model that can find a value from an unordered set in exactly square root of N steps. This has a huge improvement over classical systems that have an average time of N/2. One way to think about this is to imagine there are ten identical boxes and a ball inside one of them. Through three iterations, you apply an oracle by shaking the box and listening for noise. Some of the boxes make sounds that could be a ball, so you increase the likelihood those are the ones to pick. After completing this sqrt(10) times you open box 7 and there’s the ball (or a dead cat).

This has enormous implications to data management systems for any scenario where we need to find e.g. the row id of an unindexed value or determine which node contains a given record without any previous information. Others have expanded this concept to introduce more efficient data operation primitives.

# Section II

Discuss the new technology’s advantages and disadvantages.

## Advantages

The primary strength of this technology comes with its ability to solve interconnected matrix propagation problems. In this regard its very much like a neural network or similar technology. Another critical benefit is that it can reduce the gaps between ACID and BASE technologies to emulate missing functionality like joins.

## Disadvantages

The biggest disadvantage to QDB is that it only exists in mathematical proofs. There are practical limitations due to the qubit noise and the simulation systems grow exponentially (e.g. 50qb is 16pb of potential data). There are mainstream Quantum as a service solution though these systems target academic research scenarios. Another problem is that the technology needs to prove its supreme and at this point in the data management story, we can more economically handle the data with traditional systems.

# Section III

Discuss the evolution of the technology. Contrast its current functionality with the functionality of its predecessors.

## Evolution

The road from relational to quantum is fairly involved, with the company first needing to get into the cloud and transition into NoSQL or NewSQL platforms. These platforms provide the first level of improvements. Next the organization will likely go through a multi-tool built for purpose phase that addresses their use cases but at high operational costs. The final step involves introducing quantum as a mechanism to replace several of these purpose-built tools with something faster and more versatile.

# Section IV

Evaluate the new technology in terms of the business solutions that it would potentially address.

## Business Challenges Addressed

Quantum allows the organization to process more ideas in parallel and extract greater insights from larger data sets. These insights come from the capabilities to address optimization problems, machine learning, fuzzy logic, and accelerate matrix computations. As the company can test every competing idea simultaneously, they will come to more agile decisions and be able to maneuver through dynamically changing market conditions with greater ease.