

# How Volkswagen is Using Practical Quantum Computing to Explore Traffic Optimization and More

## A Case Story

*"I believe in exponential technology. We feel sure that the know-how we build today will give us a competitive edge...We can use quantum computing to improve the life of people and their mobility - in any city in the world."*

Martin Hofmann  
CIO - Volkswagen

### A Simple Question with a Complex Answer

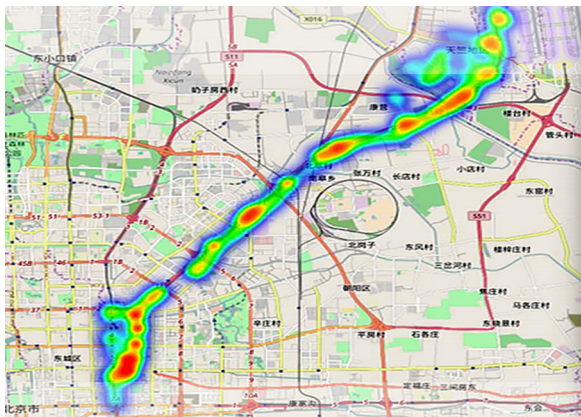
In 2016, Volkswagen Group CIO Martin Hofmann asked his team a deceptively simple question: what if traffic congestion could be prevented before it became a problem?

Finding out the answer would prove to be much more complicated. The number of factors involved—millions of vehicles and passengers, billions of routes and destinations—was enough to overwhelm most conventional computers. It would take a system capable of dealing in probabilities rather than absolutes to make Hofmann's idea a reality.

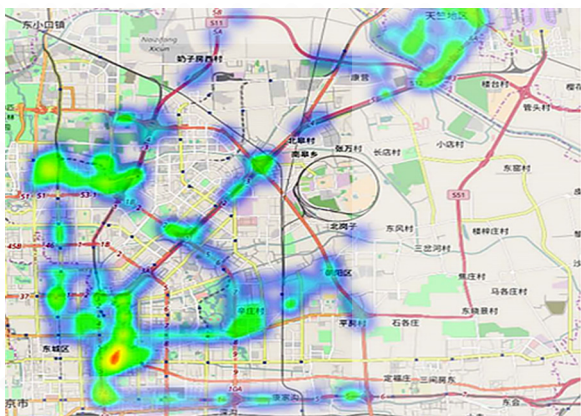
Under the leadership of data scientist Florian Neukart, five Volkswagen software engineers set out to determine if this problem could be tackled using a D-Wave 2000Q™ quantum computer. Using movement data collected from 418 taxi cabs in one of the busiest cities in the world—Beijing—the team sought to optimize traffic flow between the city center and the Beijing airport. The result of the proof-of-concept successfully demonstrated that the D-Wave system could be used for traffic flow optimization.

"What makes the now developed solution so special is the possibility to scale it to any city," says Neukart, Principal Scientist at Volkswagen's CODE Lab in San Francisco. "Size, infrastructure, traffic volume—quantum computers enable us to adapt our solution to all conceivable conditions."

Before: Congestion to the airport



After: Optimized traffic flow



### The First Production Quantum Application

Based on the proof-of-concept, Volkswagen developed a mobile app which predicts the best route to any given destination, and unveiled it to attendees of the 2019 WebSummit in Lisbon. Nine buses running on three lines commuted the half hour between the city center and the conference. To calculate the optimal routes, VW used traffic data from Here Maps, providing updates to bus drivers every two minutes. They are in talks to offer their new state-of-the-art traffic management system to cities around the globe, enabling public transportation organizations, taxi companies, and transport service providers to deploy their fleets more efficiently while minimizing waiting times for passengers and reducing air pollution and accidents.





## A Quantum Launchpad

The success of their initial quantum computing project served as a launchpad for Volkswagen to explore a wide range of potential applications. “We have to manage resources, we have to come up with ways to optimize either schedules or production logistics, and quantum annealing lends itself naturally to doing these kinds of problems,” explained Sheir Yarkoni, a quantum computing researcher at Volkswagen’s Data:Lab Munich.

Projects currently underway at Volkswagen include the optimization of assembly lines at vehicle plants and addressing packing and distribution logistics. On the factory floor, a continuous stream of data generated in ever-changing conditions by the production process must be optimized to allow objectives to change in real time, minimize delays and wait times, and listen and respond on-demand to sporadic, irregular requests and responses.

To find ideal solutions, Volkswagen is developing a hybrid algorithm that relies on both classical and quantum approaches to problem solving. A similar hybridized approach has been assigned to machine learning problems. Using non-negative/binary matrix factorization, software engineers have designed a recommendation system that understands customer biases, preferences, and behaviors, then helps them select and customize their ideal vehicle.

Another area of exploration is quantum chemistry. Molecules are so complex that classical computers are incapable of simulating the full dynamics. At the 2019 NetSys conference Neukart and his team presented a paper on how a D-Wave system solved basic electronic structure problems, an important quantum chemistry problem. They also suggested potential alternatives for addressing more complex quantum chemistry problems on quantum annealers in the future.

With growing quantum application expertise, Volkswagen’s team is now exploring areas as diverse as financial market prediction, cybersecurity threat detection, vehicle price predictions and weight minimizations, and the continued development of self-driving cars.

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