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Fujitsu on Digital Annealer (Quantum-inspired computing)

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Overview

- As competition increases, organizations need to continuously optimize production processes, delivery routing, and many other core aspects of how they operate. However, many complex optimization challenges are hard to solve efficiently on conventional computers.
- Quantum computers promise to be better suited to running the most effective optimization algorithms. As well as developing "true", gate-based quantum computing, Fujitsu is already a world leader in quantum-inspired computing. This applies algorithms developed for quantum computers on purpose-built digital processors and is available commercially today.
- Using quantum-inspired computing, the Fujitsu Digital Annealer paves the way for much faster, more efficient optimization in robotic manufacturing, materials design, drug discovery, investment portfolio management, supply chain, and disaster recovery planning.

Industry Trends in Brief

- Until now, solving complex optimization problems quickly with existing classical approaches to grow business, reduce costs and improve profitability has been challenging in many cases.
- Streamlining processes involves a class of mathematical challenge called 'combinatorial optimization' – finding the optimal solution from a very large but finite set of options. As the finite set of options increases, the search space to find the solution increases exponentially.
- In new drug discovery, for example, there is an almost infinite number of molecules to assess, but which one will bind best with the target protein is like looking for a needle in a haystack. Current mass screening solutions are only capable of reviewing up to a few tens of millions of molecules and the existing process takes at least two years.
- As a result, companies have been waiting for quantum computers with the promise of instant solutions to such complex challenges. Quantum computing remains mainly lab-based at this point. Although, advances are accelerating, more time is needed before quantum computers can tackle industry-relevant challenges.
- Fujitsu's Digital Annealer provides an on-ramp to quantum computing technology. Using a digital circuit design inspired by quantum phenomena, the Digital Annealer focuses on rapidly solving complex combinatorial optimization problems without the added complications and costs typically associated with quantum computers.

Fujitsu and Quantum-Inspired computing

- Fujitsu's Digital Annealer is available as a commercialized optimization service. This uses quantum-inspired technology to solve complex combinatorial optimization problems at high speed. The Digital Annealer employs an extended annealing method (an algorithm

specific to combinatorial optimization problems) implemented on purpose-built hardware based on digital circuit technology (CMOS).
- Fujitsu is already providing Digital Annealer services in a range of sectors, with customers in manufacturing, financial services, pharmaceuticals, mobility and logistics, and government (see **Reference Customers**, below).
- In drug discovery, some molecular matching problems can now be solved in less than a second using the Digital Annealer. The use of Fujitsu's quantum-inspired computing enables the screening of trillions of molecules and reduces the hit molecule search timeline from two years to just eight weeks. This increased speed of analysis means the range of targets can be progressively reduced, leaving just a core of high value candidates, significantly lowering the risk of trial failure.
- In automotive manufacturing, calculating the best possible path for PVC seaming robots speeds up production lines, resulting in higher throughput without the need for investment in additional resources. With Digital Annealer, the automotive OEM can calculate 64 seams per trip, which equals to find the solution within a search space of more than 10^{100} possibilities.
- Cost and skills shortages remain significant obstacles for many companies and organizations aiming to apply advanced computing technologies. To address this issue, the Digital Annealer is provided as an OPEX service offering. This enables users from a wide range of industries to easily tap into the power offered by Fujitsu's advanced computing technologies.

Fujitsu quote – Yoshinami Takahashi, Corporate Executive Officer, Corporate Vice President, COO, Head of Global Solutions

- "Fujitsu's Digital Annealer solves complex optimization challenges that can only be tackled with quantum-inspired technology, making it possible to offer solutions to our customers that not only help to increase productivity, but also reduce environmental impact and energy expenditures."

Reference customers

- Spain's Kutxabank has achieved excellent results with Fujitsu's Digital Annealer in an ambitious project to improve the allocation of assets to its investment portfolios. The algorithm developed in the project allows the number of assets analyzed to be increased to improve the impact on market management. Fujitsu's Digital Annealer has made it possible to calculate the optimal distribution of investments to be made, through a series of extremely complex permutation operations.
- Bayer Crop Science is working to solve the world's food crisis by providing products and services to establish a sustainable agricultural production system. However, it is difficult to predict yields due to external factors like weather, location, and costs. Bayer has been working with Fujitsu's Digital Annealer technology to simulate operations quickly and accurately enough to prioritize complex production scheduling challenges across 1,300 raw materials in 170 production facilities with seven layers in the supply chain network. The Digital Annealer was able to find an optimal solution for material procurement in only 300 seconds.
- Nippon Yusen Kabushiki Kaisha (NYK), a major global shipping company, is leveraging Fujitsu's Digital Annealer technology to significantly streamline complex stowage planning for car carriers. The Digital Annealer will play a role in automating aspects of the stowage planning process for NYK's dedicated car carriers, an enormously complex task involving

a vast number of possible stowage patterns depending on the number of vehicles loaded, models of vehicles, and the number of ports called along the shipping route.

- Toyota Systems Corporation has introduced a new automobile production instruction system at its Tsutsumi plant leveraging Fujitsu's Quantum-Inspired Digital Annealer technology to streamline automobile production operations. The new vehicle production instruction system will enable Toyota Motor Corporation to respond quickly to production fluctuations and also reduce the workload of its employees. Toyota plans to expand the system to Toyota Motor Corporation's other plants in Japan and, in the future, to Toyota Motor Corporation's overseas plants.
- Hamburg Port Authority worked with Fujitsu to cut traffic congestion and speed up journey times by optimizing traffic light sequencing in the port area and on roads into the German city of Hamburg.
- SAP has recently benchmarked Fujitsu's Digital Annealer to solve complex combinatorial optimization problems. The outcomes exceeded expectations, shedding light on the technology's potential. While the Digital Annealer held its ground among other optimization methods for linear challenges, it truly excelled in handling quadratic problems. This proof-of-concept, a significant step toward SAP's appetite for disruptive optimization, is only the beginning; there is much more to come. For ten unconstrained problems, the DAU was on average over seventy times faster. All but one QUBO problem were solved to optimality in the first second. The remaining QUBO problem was solved optimally after four seconds.
- Fujitsu is participating in the "Quantum National Team" of the Taiwan Ministry of Science and Technology, providing Digital Annealer technology on the cloud to the Digital Annealer Quantum Information Center established by Chung Yuan Christian University in Taoyuan City, Taiwan. The Center is undertaking a five-year research project based on three themes: combinatorial optimization problems, financial sector use cases, and applications to materials development in the chemical field.

Further reading

- Fujitsu and METRON collaborate to drive ESG success: slashing energy costs, boosting productivity with new manufacturing industry solutions
  How Hospitals can become Data-Driven Businesses and Optimize Operation Room Planning
- Harvesting the future: the innovation linking a global agricultural supply chain
- Innovating the drug discovery process with co-creation

