Become (and remain) the disruptor

with FUJITSU Quantum-Inspired Computing Digital Annealer

FUJITSU

shaping tomorrow with you

Are you ready to launch the next wave of digital disruption?

If you thought digital disruption was a one-off process to be completed (or resisted), unlocking a new, better world driven by technology, then think again.

Whatever digital transformation you have encountered so far is just the beginning. As computing continues to advance, new waves of disruption are coming – and will continue to arrive with increasing frequency.

The question for anyone with influence over organizational strategy is how to ensure, from now on, you become and remain the disruptor – the agenda-setter.

Fujitsu is co-creating exactly this capability with its customers – today – working with global banks, the world's most successful manufacturers, pharmaceutical companies and many others. Fujitsu has been deploying a revolutionary new way of optimizing intractable problems in real time – one that scales as the size of the problem increases. We call the underlying technology FUJITSU Quantum-Inspired Computing Digital Annealer.

Quantum-inspired computing is the new disruption

The key to business success is all about optimization of value, risk, product, and process. FUJITSU Quantum-Inspired Computing Digital Annealer is that key – and is available to solve real world problems today.

Using the Fujitsu Digital Annealer Solution, innovators now have the ability to calculate – instantly – the optimum sequence of steps for service and production processes from quintillions of possible alternatives. This can be in robot optimization in automotive and manufacturing set-ups, congestion-free traffic route optimization for logistics companies, portfolio investment decisions for banks to minimize risk during financial crises, and accelerated drug discovery with faster molecular similarity identification for pharmaceuticals companies. The Digital Annealer solution, which includes an end-to-end consulting, service and delivery offering not only enables organizations to massively optimize their businesses but also to create new disruptive market opportunities in their sectors.

For a manufacturer, this means reaching new levels of efficiency that can avoid the cost of a new factory. For infrastructure intensive industries it means much greater certainty of return on investment. For governments, it means a far greater probability of meeting climate change commitments or creating workable solutions to improve urban mobility. For medical science, it means revolutionizing medicine through faster drug discovery.

Imagine near-instant, continuous calculations on this scale and complexity, making possible what was only fantasy until now. And it can all be integrated into existing infrastructure environments and hence to existing processes – saving time, reducing risk and minimizing investment.

You can now create the next wave of disruption in your sector, today.

What could optimization of intractable problems mean to your organization?

The next wave of disruption is here, and it's based on optimizing problems that are intractable today.

These are called 'combinatorial optimization' problems and can easily scale out of control as the size of the calculation increases.

Whenever an organization does something – anything – there are variables. Should you do *a* or *b* first? What if factor *x* came into play in one scenario but not another? The more variables you add to the model, the more accurate the result becomes. From working out the most efficient way to deliver the optimum amount of cash to ATMs in a single town, to planning an entire global manufacturing schedule, **identifying the optimum solution is the way you make profit and ensure you are ahead of the market.**

The difficulty is that any reasonably complex optimization calculation will have quintillions of possible solutions, making it very hard to obtain an outcome.

For example, traffic route optimization with five pairs of start and destination points involves 10^{100} possible routes to avoid overlaps between vehicles and minimize traffic delays. This is a use case that has been investigated by numerous global automotive vendors for mobility platforms and by and governments to reduce carbon emissions and for the betterment of society.

FUJITSU Quantum-Inspired Computing Digital Annealer is transforming capabilities today

Financial services – optimization for portfolio agility, lower credit risk and operational efficiency

Real-time optimization with FUJITSU Quantum-Inspired Computing Digital Annealer has many applications for banks and insurance companies. In credit risk assessment of individuals and companies, it reduces risk by increasing the correlation of credit evaluation items while improving efficiency by reducing the number of credit characteristics to evaluate. Real time interest rate swap optimization in derivatives trading is another high gain option.

Other possibilities for digital annealing in financial services include calculating the optimum amount of cash and the most efficient route for ATM replenishment. Cash replenishment accounts for up to 60 percent of ATM network operating costs and optimization would improve profitability significantly. Optimizing where the cash is in the network at any one time can also result in gains from interest from the Bank of England that is paid on cash within a 'bonded store' – highly secure locations from which cash is distributed to ATMs and banks - but not in an ATM. The mathematical problem is how to keep just enough cash in ATMs and banks to provide the service

customers expect, while moving cash as little as possible in the network and keeping as much as possible in the bonded stores.

Using the FUJITSU Quantum-Inspired Computing Digital Annealer, NatWest bank has completed a highly complex portfolio risk optimization calculation that needs to be undertaken regularly by the bank, at 300 times the speed of a traditional computer while providing an even higher degree of accuracy. The calculation helps portfolio managers optimize the composition of the bank's £120 billion high-quality liquid assets (HQLAs) portfolio. HQLAs are assets such as cash and bonds that every UK bank must hold as a buffer in case it runs into financial trouble.

Given this early success, the bank is now looking at what other portfolios can be calculated using the same technology. For instance, adjusting the allocation of assets following a surprise movement in the market, in a much shorter space of time than normal.
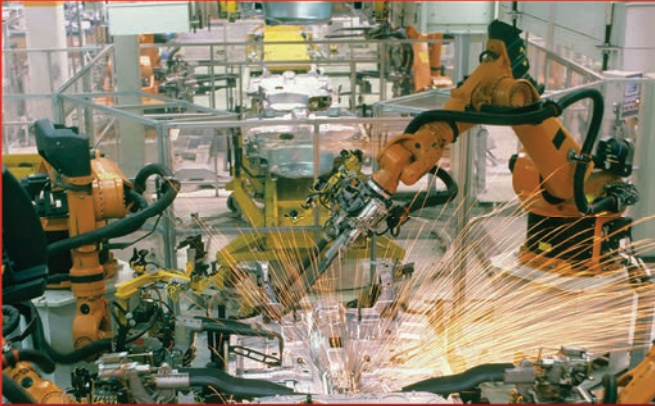
Automotive manufacturing – optimization for total flexibility, maximum efficiency

World-leading car manufacturers have engaged with Fujitsu for a range of optimizations using the Digital Annealer, including job-shop scheduling, engineering design optimization, vehicle route optimization and robotic welding positioning. Digital Annealer is currently calculating the perfect path for robot welders setting out from and returning to their base positions, resulting in higher car output but with the same resources and within the same time.

Currently, prototype quantum computing solutions addressing this challenge can compute optimized routes for seven welded seams. Working with FUJITSU Quantum-Inspired Computing Digital Annealer, a major automotive OEM has already tested and optimized 22 seams, cost effectively increasing the number of cars produced using the same resources, and this is about to be raised to 64 seams (with 8,192-bit scale) making a disruptive change.

Public sector – optimization to meet public policy challenges of the future

Cities and national governments are urgently addressing the issue of traffic optimization. The potential benefits are high. Better air quality means lower levels of respiratory and other diseases, and increased citizen well-being. Lower carbon emissions feed through to national targets, allowing governments to focus their spending on other vital policy areas. More efficient journeys will raise productivity, reduce frustration and encourage economic growth.

However, traffic is always in flux. An optimal calculation right now won't be valid in a few seconds as a host of new complications come into play - accidents, new journeys getting underway, changing weather conditions – to name a fraction of the possibilities.

Digital Annealer's ability to perform successive, real-time calculations on unbelievably complex variables stands head and shoulders above today's computers. These struggle to perform the calculation at all. Early modeling suggests that digital annealing holds the potential to reduce traffic congestion by up to 40 percent, by dispersing traffic to less congested routes.

Quantum-inspired computing – tomorrow's breakthrough, today

Conventional thinking says these unbelievably complicated optimization calculations – the kind that can handle quintillions of calculations in real time – are impossible. That's why an increasing number of CTOs are looking towards the next generation of computing - to quantum computing. They understand if they can crack real-time optimization, they have a huge disruptive advantage.

Quantum computing is a hugely exciting prospect. The only problem is that the current commercially-available quantum computers are not ready to solve real world problems from a scale and accuracy perspective, and hence practical use of quantum computers remains some distance in the future. Optimists think perhaps five years – a more realistic assessment could be 10, 15 even 20 years away. Even if academic and research papers announce the arrival of quantum, this is far from being something usable in a commercial, business context.

The core advantage of using quantum computing to tackle optimization problems is that it does not have to work out each calculation separately, in a linear progression. Instead, it calculates all the possibilities simultaneously – a massive advantage.

But what if you could harness this advantage today without waiting for true quantum computing? What if you could perform simultaneous calculation on existing computer architectures today, using your current data center or cloud environment?

That's exactly what Fujitsu customers have achieved using FUJITSU Quantum-Inspired Computing Digital Annealer. Let's be clear – these are not experiments: they are calculations on sub-sets of live production systems, service and portfolio data that are being fed into real business processes and used to make disruptive business decisions that have dramatically improved efficiency.

The FUJITSU Quantum-Inspired Computing Digital Annealer is here today and combines the speed of quantum with the certainty of digital.

Real-time optimization – and production-ready today

Digital Annealer is capturing serious attention. The world's leading industry analysts see it as a unique solution to achieve optimization – in fact, they're predicting it provides the solution for tomorrow's business battleground.

The FUJITSU Quantum-Inspired Computing Digital Annealer addresses any customer challenge that can be translated into an optimization problem, right at the core of the business.

Not only does it deliver the ultimate goal of real-time optimization on existing assets, it does not require any of the expensive, complex wrap-arounds you might associate with quantum computing.

On the other hand, the Digital Annealer, delivered by Fujitsu as an end-to-end consulting and development solution, means you can adopt real-time optimization today, within your existing IT architecture and – just as important – your existing workflows and processes. There is neither a need to create new supporting infrastructure – nor for complex management and maintenance, as the Digital Annealer is a subscription-based service.

Nor do you need to make organizational changes or employ exotically-qualified computer scientists. Fujitsu's Digital Annealer Solution team works with you to establish the most fertile area to deploy optimization and assess whether digital annealing is the right approach for you. If it is, we'll advise on integrating the Digital Annealer into your existing architecture and take you through every step of the way to reach optimization that delivers disruptive advantages in the marketplace.

Digital Annealer is your bridge to quantum computing

There is little question that true quantum computing is going to shake up the world of computing in the future, although the need to make investment decisions is still some years away. But that future is coming faster than many people expect - within 20 years it is likely that quantum computers will have an important role in the range of computing options available to enterprises.

With the quantum-inspired Digital Annealer Solution, you not only gain a disruptive advantage in the here and now, you can also prepare your organization for the future by familiarizing it with the massive opportunities that quantum optimization brings. And, as it's an end-to-end solution, this is all without massive upheaval or investment.

Little wonder that the world's most advanced organizations are already contacting Fujitsu to find out how the Digital Annealer Solution can transform their business. Are you going to join them?

What is quantum-inspired computing?

The FUJITSU Quantum-Inspired Computing Digital Annealer is a unique technology that combines the power, speed and precision of quantum computing in optimization calculations, with the ease-of-use and known characteristics of digital architectures.

The idea of a quantum computer goes back a surprisingly long time – about 40 years. Early quantum theorists soon realized that the quantum properties of superposition, quantum tunneling and entanglement opened up the theoretical possibility of a new way of processing data simultaneously – rather than one calculation at a time - that promised to be spectacularly faster and far better suited to massive volumes.

Sooner or later – probably in about 10-15 years' time – production quantum devices will be available. Within 20 years, they will stop seeming exotic and enter the business mainstream.

But right now, we are not there. Quantum computing remains experimental, expensive, complicated and temperamental. However, quantum-inspired computing, with the Fujitsu Digital Annealer, is here today.

Annealing is a mathematical technique for approximating the best achievable answer in a combinatorial optimization, but there has always been a trade-off between precision and risk. Seeking high precision used to imply the need for more time to calculate the answer – often more time than was available - while accepting a 'good enough' answer introduced an increasing amount of risk and the need for a security buffer.

The goal is precision, because the more precise the calculation you can achieve, the more cost-efficient the final process will be, leading to less waste. Quantum annealing – on quantum devices may someday provide that precision.

Fujitsu's scientists recognized early that the software being developed for quantum computers could be applied to digital architectures. Based on this insight, Fujitsu created the Digital Annealer, a unique circuit design inspired by the quantum phenomena. It has a fully-connected architecture enabling the free exchange of signals across all bits and can, therefore, solve large-scale combinatorial optimization problems instantly.

Fujitsu has co-created the quantum inspired algorithm for this new architecture, working with Toronto University, which has a leading research position in the field, and 1QB Information Technologies (1QBit), based in Vancouver, Canada, the leading commercial player in quantum software. This algorithm is compatible with those being developed for prototyping true quantum (quantum annealing or 'quantum gate') computers, meaning that solutions developed with Digital Annealer today will be compatible with quantum gate computers, when these eventually emerge.

Another advantage with the Digital Annealer is that users can find an optimal solution with high probability without setting complex parameters in advance. This makes it possible to start operations with actual data, potentially shortening preparation times by between one tenth and one hundredth.

What gives Digital Annealer its unique advantages?

The power of the Digital Annealer end-to-end solution lies in Fujitsu's quantum-inspired digital architecture that leverages innovations in ultra-high-density circuit integration and high-performance processing. The Digital Annealer solution today supports an 8,192-bit fully connected architecture with a promising roadmap to support a 1 million-bit scale solution. This ground-breaking solution is inspired by the key characteristics of quantum computing - superposition, quantum tunneling and entanglement - enabling the Digital Annealer to evaluate multiple potential options simultaneously – and deliver lightning-fast insights.

When it comes to performance, FUJITSU Quantum-Inspired Computing Digital Annealer is:

- Up to 10,000 times faster than industry standard computing*

- 12 Moore's Law generations ahead of current processors

- Set to support much larger-scale optimization calculations in real-time with a promising roadmap to 1 million-bit scale.

Yet, from a practical perspective, the Digital Annealer operates at data center temperatures and does not need special cooling: in other words, it works with digital circuits at room temperature, and fits into a standard data center rack – or can be run in the cloud – without needing any specific expertise or a complex infrastructure to function.
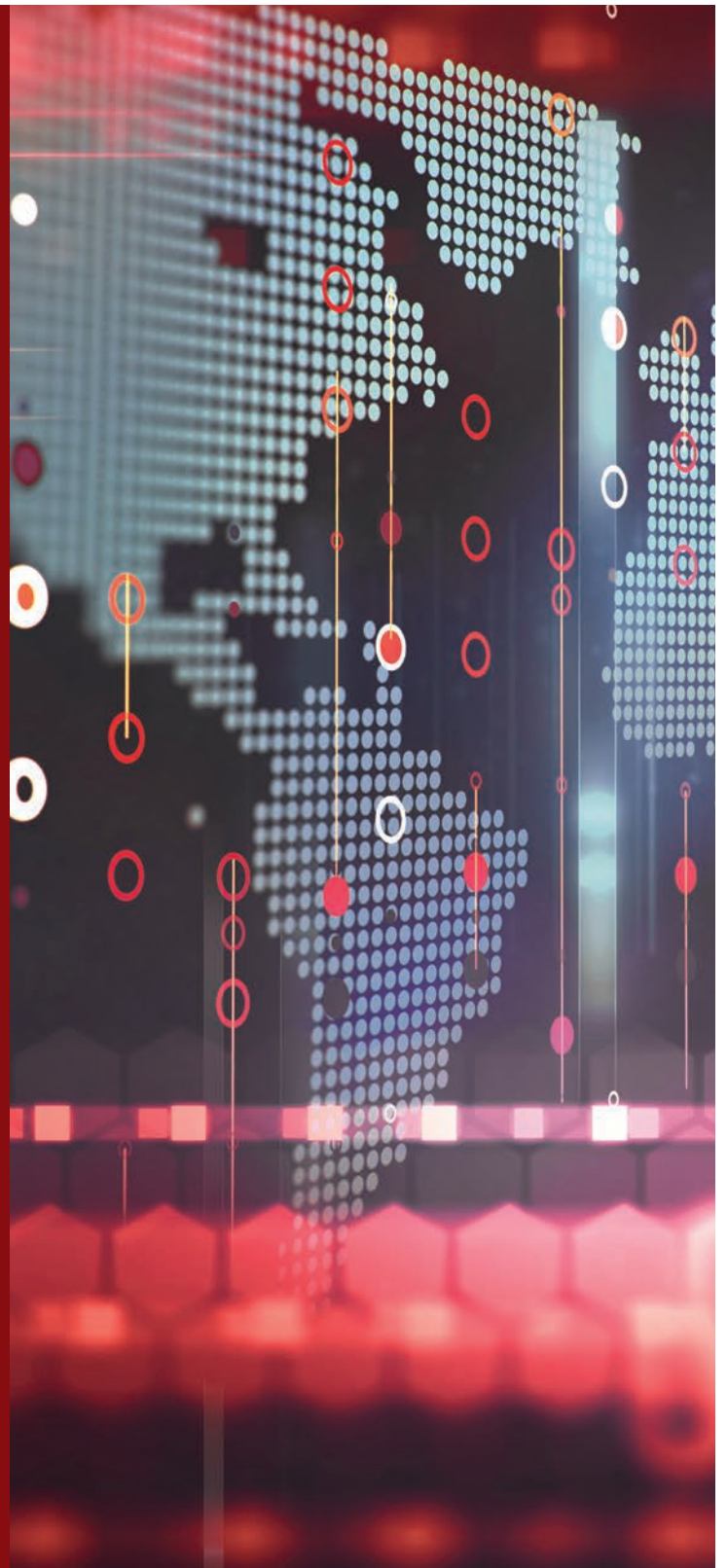
* The performance comparison was conducted by evaluating the quadratic assignment problem (QAP) on the Digital Annealer against a general purpose, multi-core, Xeon multi-processor system.

fujitsu.com/DigitalAnnealer