

# Media Backgrounder

## Digital Annealer

June 2018

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There is a widespread real-world demand for the ability to choose the optimal solution from a number of different feasible options, which are classified as combinatorial optimization problems – essentially finding the best combination from an enormous set of potential elements. These problems can be difficult to solve quickly with existing processors, as the number of combinations increase exponentially when the number of factors taken into consideration increase. In computations using annealing methods, there is a tradeoff between the speed with which the method converges on a solution and the accuracy of the solution.

Using quantum-inspired computing technology and without setting complex parameters, Fujitsu's Digital Annealer computational architecture paves the way for much faster, more efficient materials design, drug discovery, investment portfolio optimization, supply chain optimization, and post-disaster recovery planning. It will also enable the development of new ICT services that support swift and optimal decision-making in such areas as social policy and business, which involve complex intertwined elements.

The Digital Annealer focuses on combinatorial optimization. This refers to finding the most optimal solution from a finite set of options. However, as the finite set of options increases, so the computation power and the time needed to find the solution increases exponentially. For example, in the case of the 'traveling salesman', if the number of cities travelled to by the salesman is 30, then it would take the most powerful classical computer in the market today approximately 800 million years to find the shortest possible route. However, the Fujitsu Digital Annealer can solve this within a second.

As a versatile hardware accelerator for solving combinatorial optimization problems, the technology makes it possible to find a sufficiently precise solution without the need to set complicated parameters. It achieves this by incorporating circuits that automatically control parameters based on the results of observations of conditions within the Digital Annealer during its performance. This can reduce the preparation time involved before applying the Digital Annealer to a problem from about two weeks to less than a day.

### Initial applications

#### Faster Molecule Similarity Search

Chemical and pharmaceutical laboratories use molecule similarity searching, which partially extracts molecules' characteristics, to search for new substances and to develop new drugs. Digital Annealer can search entire molecular structures without relying on extraction, thereby enabling accurate, instant similarity searching.

#### Low-risk, Diversified Investment

Digital Annealer can find the ideal investment allocation to maximize returns by grouping stocks that correlate with price variations, thus optimizing portfolios and reducing risk. Digital Annealer can find the best permutation from among 20 or more stock names (equivalent to more than one quintillion permutations) instantly.

#### Optimized In-stock Part Placement

In factories and distribution warehouses, the time it takes workers to walk around picking parts can be minimized by optimizing work routes and in-stock part placement. In fact, introducing Digital Annealer in Fujitsu group factories successfully reduced workers travel distance by 45 percent each month, increasing productivity significantly.

#### Personalized Digital Marketing Ads

Digital marketing accuracy can be improved by delivering precise individually personalized content to webpage visitors, thereby increasing their willingness to buy. Digital Annealer allows instant display of customized content by providing data (such as age or gender) for each webpage element.

### Available as a cloud service

Fujitsu Digital Annealer is now available as a cloud service, allowing customers to connect with the hardware and middleware that implements Fujitsu's original architecture through APIs. The Digital Annealer cloud service is available in Japan and will be rolled out to North America, Europe, and Asia during the 2018 fiscal year.

In addition to deploying this new cloud service, Fujitsu has also launched the Fujitsu Digital Annealer Technical Service to support the application development for customers to define issues, as well as build and utilize mathematical models. This support includes;

*Formulation verification* - verifying whether the customer's problem can be formulated in a way solvable by Digital Annealer.

*Introduction support* - a customer-specific proof of concept (PoC) support service, including the definition of all requirements from initial idea to required processes, as well as the mathematical modeling required for an effective execution.

*Application construction* - construction of the customer system in the form of an application that connects to the Digital Annealer services.

*Operation* - support and quality assurance of the running system, including problem solving.

### Large scale performance, high flexibility, fast preparation time

The technology involves 1024-bit scale, inter-bit full connectivity to deliver large scale performance and high flexibility, with 16-bit inter-bit connection precision for accuracy of 65,536 scale, which is higher than any other quantum annealing technology that uses superconductivity today. Most of all, Digital Annealer can operate at normal temperature without the need for absolute zero (-273.15°C) temperatures for functioning at quantum state and can fit into a datacenter rack without needing any specific expertise or a complex infrastructure to run or function.

With the Digital Annealer, users will be able to find an optimal solution with high probability without setting complex parameters in advance. A key benefit is its ability to address time-consuming tasks that could previously only be done manually, enabling users to start operations with actual data and to rapidly draw out the full performance potential of the Digital Annealer, potentially shortening preparation times by between one tenth and one hundredth (see **the annealing analogy** below).

Using software developed by 1QBit (1QB Information Technologies Inc.), Fujitsu evaluated the effectiveness of this technology in addressing actual use cases in the chemistry and finance fields. For molecular similarity comparison problems of below 50 atoms (chemistry), and a portfolio optimization problem for 500 stocks (finance), Fujitsu's Digital Annealer technology was able to shorten the preparation period required to find an appropriately precise solution in less than a day, compared to the previous requirement of approximately two weeks.

Fujitsu is aiming for applications for ever-larger-scale problems. It plans to expand the full-scale links in the Digital Annealer from the current 1,024 bits to 8,192 bits, while increasing the precision from 16 bits to up to 64 bits (18.45 quintillion gradations), using a dedicated Digital Annealing processor, the Digital Annealing Unit (DAU), developed using Fujitsu's processor development technology, and the latest cutting-edge CMOS technology. In addition, in order to fulfill applications requiring high frequency usage, Fujitsu also plans to sell on-premises products that can be installed in customer datacenters.

### The annealing analogy

Annealing methods can be compared with a process in which a metal is heated to a high temperature, and then allowed to cool very gradually, causing the crystalline structure of the material to converge on an optimal state. By lowering the temperature, which in this example is controlled by the parameters, from a high point very gradually, the area in which to look for a solution is gradually narrowed down, finding the point of lowest energy. To rapidly locate this state, one can achieve an optimal degree of precision in the solution if the parameters are operated in a similar way to the gradual lowering of the temperature, but this increases computation time, whereas if the parameters are operated in a similar way to quickly lowering the temperature, the computation time becomes shorter, but the precision of the solution decreases, creating a tradeoff. The optimal values for the setting of these parameters, including both the initial values and the way they are changed during operation, varies for each type of problem for which these methods are applied. When using annealing methods for problems for which they've never been applied before for the first time, such as comparing molecular similarity and portfolio optimization, finding optimal parameter settings to begin with for each type of problem enables rapid computation for problems of that type thereafter. However, in order to find the optimal parameter settings to find a sufficiently precise solution in a short timeframe, annealing computation that changes the parameter settings could need to be repeated tens of thousands of times or more which could take a few weeks.

With Digital Annealer technology, the multiple basic circuits that handle optimization processing can be given simple initial parameters and operated in parallel. Moreover, status control circuits installed outside the basic circuits will observe the status during performance of each basic circuit at a set frequency, enabling an efficient search for an optimal solution by adjusting the parameters as appropriate. The result is that users will be able to find an optimal solution with high probability without setting complex parameters in advance. For this reason, tuning tasks that previously had to be done manually, taking up significant time, have become unnecessary, and users can start operations using

actual data, drawing out the full performance of the Digital Annealer in a short period of time, with the capability to shorten preparation times by somewhere between one tenth and one hundredth.

#### Online resources

- Digital Annealer  
Fujitsu Technology Facilitates Application of Combinatorial Optimization Methods to Real-World Problems (press release, September 20, 2017)  
<http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0920-03.html>
- Digital Annealer Cloud Service and Technical Service  
Fujitsu Quantum-Inspired Digital Annealer Cloud Service to Rapidly Resolve Combinatorial Optimization Problems  
<http://www.fujitsu.com/global/about/resources/news/press-releases/2018/0515-01.html>
- Digital Annealer  
Fujitsu Laboratories Develops New Architecture that Rivals Quantum Computers in Utility (press release, October 20, 2016)  
<http://www.fujitsu.com/global/about/resources/news/press-releases/2016/1020-02.html>
- 1QB Information Technologies Inc.  
Fujitsu Laboratories and 1Qbit began collaborations in the AI field, including combinatorial optimization and machine learning, in May 2017. Fujitsu and 1Qbit Collaborate on Quantum Inspired AI Cloud Service (press release, May 16, 2017)  
<http://www.fujitsu.com/global/about/resources/news/press-releases/2017/0516-03.html>

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#### About Fujitsu

Fujitsu is the leading Japanese information and communication technology (ICT) company, offering a full range of technology products, solutions, and services. Approximately 140,000 Fujitsu people support customers in more than 100 countries. We use our experience and the power of ICT to shape the future of society with our customers. Fujitsu Limited (TSE: 6702) reported consolidated revenues of 4.1 trillion yen (US \$39 billion) for the fiscal year ended March 31, 2018. For more information, please see <http://www.fujitsu.com>.

#### About Fujitsu EMEA

Fujitsu promotes a Human Centric Intelligent Society, in which innovation is driven by the integration of people, information and infrastructure. In the Europe, Middle East, India and Africa region (EMEA), our 27,000-strong workforce is committed to Digital Co-creation, blending business expertise with digital technology and creating new value with ecosystem partners and customers. We enable our customers to digitally transform with connected technology services, focused on Artificial Intelligence, the Internet of Things, and Cloud - all underpinned by Security. For more information, please visit <http://www.fujitsu.com/fts/about/>