D:Wave
The Quantum Computing Company™

D-Wave System Software Release Notes

USER MANUAL

2020-04-17

Overview

This document describes the contents of D-Wave software releases. It highlights the new features, describes any changes to default system behavior, and lists any known or resolved issues that may affect your use of the D-Wave system.

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D-Wave User Manual 09-1045C-K

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CHAPTER 1

INTRODUCTION

1.1 Intended Audience

This document is intended for users of the D-Wave™ system. This includes:

- End-users
- Resource managers and system administrators

1.2 Scope

This document describes the latest release of the solver application programming interface (SAPI) web services components, including Leap™ . It includes a list of the new features in the release, describes any changes to default system behavior, and lists any known or resolved issues that may affect your use of the D-Wave system.

To see the list of releases at a glance, and to see whether a particular release introduces changes to the client libraries, refer to the *Release Information* chapter.

1.3 Related Documents

See also the following related documents:

- Leap™ Knowledge Base, available here: https://support.dwavesys.com/hc/en-us
- *D-Wave Problem-Solving Handbook*
- *Solver Computation Time*
- *Technical Description of the D-Wave Quantum Processing Unit*
- *Postprocessing Methods on D-Wave Systems*

1.4 Revision History

Revision	Date	Summary of Change
09-1045C-K	2020-04-02	Updated for Release 3.1.33
09-1045C-J	2020-03-20	Updated for Release 3.1.32
09-1045C-I	2020-03-03	Updated for Release 3.1.31
09-1045C-H	2020-02-17	Updated for Release 3.1.30
09-1045C-G	2020-01-08	Updated for Release 3.1.27
09-1045C-F	2019-12-05	Updated for Release 3.1.26
09-1045C-E	2019-11-21	Updated for Release 3.1.25
09-1045C-D	2019-10-24	Updated for Release 3.1.24
09-1045C-C	2019-10-11	Updated for Release 3.1.23
09-1045C-B	2019-09-30	Updated for Release 3.1.22
09-1045C-A	2019-08-28	Updated for Release 3.1.21
09-1045B-Z	2019-08-16	Updated for Release 3.1.20
09-1045B-Y	2019-08-02	Updated for Release 3.1.19
09-1045B-X	2019-07-24	Updated for Release 3.1.18
09-1045B-W	2019-07-10	Updated for Release 3.1.17
09-1045B-V	2019-06-26	Updated for Release 3.1.16
09-1045B-U	2019-06-12	Updated for Release 3.1.15
09-1045B-T	2019-05-27	Updated for Release 3.1.14
09-1045B-S	2019-04-29	Updated for Release 3.1.13
09-1045B-R	2019-04-17	Updated for Release 3.1.12
09-1045B-Q	2019-04-01	Updated for Release 3.1.11
09-1045B-P	2019-03-18	Updated for Release 3.1.10
09-1045B-O	2019-02-28	Updated for Release 3.1.9
09-1045B-N	2019-01-23	Updates for Release 3.1.8.
09-1045B-M	2019-01-04	Updates for Release 3.1.7.
09-1045B-L	2018-12-12	Updates for Release 3.1.6.
09-1045B-K	2018-11-28	Updates for Release 3.1.5.
09-1045B-J	2018-11-13	Updates for Release 3.1.4.
09-1045B-I	2018-10-31	Updates for Release 3.1.2.
09-1045B-H	2018-10-17	Updates for Release 3.1.1.
09-1045B-G	2018-10-02	Updates for Release 3.1.0.
09-1045B-F	2018-09-26	Updates for Release 3.0.18.
09-1045B-E	2018-09-19	Updates for Release 3.0.17. Added release dates for the online system updates.
09-1045B-D	2018-09-05	Updates for Release 3.0.16.
09-1045B-C	2018-08-28	Updates for Release 3.0.15.
09-1045B-B	2018-08-22	Updates for Release 3.0.14.
09-1045B-A	2018-08-08	Updates for Release 3.0.13.
09-1045A-Z	2018-08-01	Updates for Release 3.0.12.
09-1045A-Y	2018-07-16	Updates for Release 3.0.11.
09-1045A-X	2018-07-12	Updates for Release 3.0.10.
09-1045A-W	2018-06-26	Updates for Release 3.0.9.
09-1045A-V	2018-06-18	Updates for Release 3.0.8.
09-1045A-U	2018-06-11	Updates for Release 3.0.7.
09-1045A-T	2018-06-04	Updates for Release 3.0.6.
09-1045A-S	2018-05-28	Updates for Release 3.0.5.
09-1045A-R	2018-05-10	Updates for Release 3.0.4.

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Revision	Date	Summary of Change
09-1045A-Q	2018-04-27	Updates for Release 3.0.3.
09-1045A-P	2018-04-12	Updates for Release 3.0.2.
09-1045A-O	2018-04-02	Updates for Release 3.0.1.
09-1045A-N	2018-03-15	Updates to show that flux-bias offsets are also supported on the D-Wave 2X platform.
09-1045A-M	2018-02-21	Changes to access instructions for virtual graphs tools.
09-1045A-L	2018-02-19	Addition of known issues in Release 3.0.
09-1045A-K	2018-01-19	Updates for Release 2.12 through Release 3.0.
09-1045A-J	2017-04-18	Updates for Release 2.11.
09-1045A-I	2017-03-15	Updates for Release 2.10.3.
09-1045A-H	2017-01-09	Added this revision history table and the feature summary chapter.
09-1045A-G	2017-01-06	Minor corrections.
09-1045A-F	2016-12-06	Updates for Release 2.10.
09-1045A-E	2016-10-31	Updates for Release 2.8. Merged separate release notes into this single document.

CHAPTER 2

RELEASE INFORMATION

2.1 System Requirements

Qubist and Jupyter Notebooks require the latest stable version of Chrome or Safari.

2.2 Software Versions

This release includes the following versions of the product components:

Component	Version Number
SAPI and Qubist	3.1.33
SAPI client libraries	3.0.1

2.3 Feature Summary

This table summarizes the D-Wave software changes by release.

Note: For users of the Leap Quantum Application Environment, introduced in Release 3.1.0, see the Knowledge Base for a list of the new features added since the launch. Access Leap here: https://cloud.dwavesys.com/leap.

Rel.	Client Update	Features	Supported Platforms
3.1.33	No	No customer-facing changes	N/A
3.1.32	No	No customer-facing changes	N/A
3.1.31	No	No customer-facing changes	N/A
3.1.30	No	*New Hybrid Solver Service* *New Online Integrated Developer Environment* *New Problem Inspector* *Integrated Examples* *New Subscription Options*	All
3.1.29	No	No customer-facing changes	N/A
3.1.28	No	No customer-facing changes	N/A
3.1.27	No	No customer-facing changes	N/A
3.1.26	No	*New Solver Property: quota_conversion_rate* *New Solver Property: category*	All
3.1.25	No	*New Jupyter Notebook: Hybrid Computing*	2000Q online
3.1.24	No	*Access to Problems Submitted Prior to October 16, 2019*	2000Q online
3.1.23	No	No customer-facing changes	N/A
3.1.22	No	No customer-facing changes	N/A
3.1.21	No	No customer-facing changes	N/A
3.1.20	No	No customer-facing changes	N/A
3.1.19	No	*More Flexible Anneal Schedules Now Possible*	2000Q online
3.1.18	No	No customer-facing changes	N/A
3.1.17	No	No customer-facing changes	N/A
3.1.16	No	*General Availability of D-Wave Hybrid* *New Jupyter Notebook: Feature Selection*	All
3.1.15	No	No customer-facing changes	N/A
3.1.14	No	No customer-facing changes	N/A
3.1.13	No	*New Solver Property: tags*	2000Q online
3.1.12	No	No customer-facing changes	N/A
3.1.11	No	No customer-facing changes	N/A
3.1.10	No	See Leap Knowledge Base	N/A
3.1.9	Yes	*Time-Dependent Gain in Hamiltonian Biases* *Security Patches*	2000Q only
3.1.8	No	See Leap Knowledge Base	N/A
3.1.7	No	See Leap Knowledge Base	N/A
3.1.6	No	See Leap Knowledge Base	N/A
3.1.5	No	See Leap Knowledge Base	N/A

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Rel.	Client Update	Features	Supported Platforms
3.1.4	No	See Leap Knowledge Base	N/A
3.1.3	No	See Leap Knowledge Base	N/A
3.1.2	No	See Leap Knowledge Base	N/A
3.1.1	No	No customer-facing changes	N/A
3.1.0	No	*New Cloud Platform: Leap Quantum Application Environment*	2000Q online only
3.0.18	No	No customer-facing changes	N/A
3.0.17	No	*Change to the Maximum Problem Duration*	2000Q online only
3.0.16	No	No customer-facing changes	N/A
3.0.15	No	*Problem Queue Limits per User*	2000Q online only
3.0.14	No	*New Qubist Session Timeout*	N/A
3.0.13	No	*Statistics Reports Allow Multiple Selection*	N/A
3.0.12	No	No customer-facing changes	N/A
3.0.11	No	No customer-facing changes	N/A
3.0.10	No	*New Interactive Examples Online*	2000Q online only
		Jupyter Notebooks No Longer Save User Data	2000Q online only
		PML Features and Documentation Deprecated	2000Q online only
3.0.9	No	*API Response Now Shows Estimated Completion Time*	All
3.0.8	No	*Changes to the Problem Scheduler*	All
3.0.7	No	Fixes only	N/A
3.0.6	No	No customer-facing changes	N/A
3.0.5	No	Fixes only	N/A
3.0.4	No	*Solver API: New HTTP Response Code*	All
		Changes to the Problem Scheduler	All
3.0.3	No	No customer-facing changes	N/A
3.0.2	No	*Qubist: PML Library Access Changes*	2000Q online only
3.0.1	No	*Qubist: PML Feature Visibility Changes*	2000Q online only
3.0	Yes	*Reverse Annealing*	2000Q only
		Virtual Graphs	All[1]
		Flux-Drift–Compensation Flag	All
		Reduce-Intersample-Correlation Flag	All
		Probabilistic Machine Learning Features	2000Q online only
		Online Learning Resources	2000Q online only
		D-Wave Open-Source Tools	Depends on tool
		Multifactor Authentication	All
2.14	No	*Stricter Password Rules*	All
		Password Lockout Policy	All
2.13	No	No customer-facing changes	N/A
2.12	No	*D-Wave Web Services for PML*	2000Q online only (limited)
2.11	Yes	*Support for Variations on the Global Anneal Schedule*	2000Q only
		Maximum Run Duration Visible via SAPI	All
		D-Wave Reference Examples Available via Qubist	2000Q online only
		Usability Improvements for the Qubist Web UI	All
2.10.3	No	*Beta Parameter Now Available in Qubist*	All
		Qubist Changes to Support VFYC Solvers	All
		Changes to Postprocessing Defaults for VFYC Solver	All

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Rel.	Client Update	Features	Supported Platforms
2.10	No	*Deprecated readout_thermalization Parameter*	All
		New Documents: QPU Properties per System	All
2.9	No	No customer-facing changes	N/A
2.8	No	*Statistics Improvements*	All
		Usability Improvements for Problem Definition	All
2.7	No	No customer-facing changes	N/A
2.6	Yes	*Improved Color Map*	All
		Support for Multiple Solver Scheduling	All
		Support for Custom EULA	All
		Support for Notifications by Project	All
		Changes to Quota Expiration	All
		Changes to Documentation Packaging	All
2.5	Yes	*Support for Anneal Offsets*	2000Q only
2.4	Yes	*Enhancements to System Timers*	All
		Multiple Spin-Reversal Transforms	All
		New Solver: Virtual Full-Yield Chimera	All
		New Error-Handling Functions	All
		Fixed-Time User Quota	All
		Support for LDAP Credentials	All
		Changes to Solution Data in Qubist	All
		New Documents	All

[1] The extended J range is unavailable on D-Wave 2X systems.

CHAPTER 3

KNOWN ISSUES

This section describes the known issues in this release.

3.1 Leap™ IDE: Flickering Display

Users who open the Leap™ IDE may notice flickering in the display.

Recommended Action: Configure your browser to allow cookies from the dwavesys.io domain.

CHAPTER 4

RELEASE 3.1.31

4.1 Release Date (Online System)

2020-03-18

4.2 Resolved Issues

This release resolves the following issue:

- Customers with custom contracts may have noticed errors on the Leap Dashboard, related to the time they had remaining on the system. This issue has been resolved.

CHAPTER 5

RELEASE 3.1.30

5.1 Release Date (Online System)

2020-02-26

5.2 New Features

5.2.1 New Hybrid Solver Service

This release introduces the Leap™ hybrid solver service (HSS), which includes cloud-based quantum-classical hybrid solvers to which you can submit problems formulated as arbitrarily structured binary quadratic models (BQMs). These hybrid solvers, which implement state-of-the art classical algorithms together with intelligent allocation of the quantum processing unit (QPU) to parts of the problem where it benefits most, are designed to accommodate even very large problems. This first release of the HSS includes the **hybrid_v1** solver that accepts problems of up to 10,000 variables. It is a portfolio solver, meaning that in parallel to QPU processing it runs a variety of classical algorithms, making it suited to a wide range of problems.

Submit problems to the hybrid solver as you would submit any BQM-formulated problem; from Ocean software's dwave-system tool, use the new *LeapHybridSampler*.

See the Structural Imbalance in a Social Network example in the Ocean software documentation.

5.2.2 New Online Integrated Developer Environment

This release introduces a new online integrated developer environment (IDE) as part of Leap. The Leap IDE provides a ready-to-code environment in the cloud for Python development. Accessible from your browser, it is configured with the latest Ocean SDK and includes the new D-Wave problem inspector and standard Python debugging tools. Seamless GitHub integration means that developers can easily access D-Wave's latest code examples, develop quantum applications, and contribute to the Ocean tools from within the IDE. Powered by gitpod.io, the Leap IDE is customizable via a Docker file.

5.2.3 New Problem Inspector

This release introduces a tool for visualizing problems submitted to, and answers received from, a D-Wave structured solver such as a D-Wave 2000Q quantum computer.

`dwave-inspector` provides a graphic interface for examining D-Wave quantum computers' problems and answers. The D-Wave system solves problems formulated as BQMs that are mapped to its qubits in a process called minor-embedding. Because the way you choose to minor-embed a problem (the mapping and related parameters) affects solution quality, it can be helpful to see it.

See the Using the Problem Inspector example in the Ocean software documentation.

5.2.4 Integrated Examples

This release introduces a D-Wave code examples GitHub repository and its search page on the Leap website. This collection of examples already contains over a dozen examples, including examples of factoring, graph problems, feature selection, and more. The new page on the Leap website enables you to filter the examples by tags such as problem type, industry, and tags.

5.2.5 New Subscription Options

This release adds new Leap subscription options that enable you to upgrade your account for additional time in blocks that suit your need and budget. With the introduction of *New Hybrid Solver Service*, subscriptions now provide access to D-Wave's hybrid solvers as well as its QPUs.

5.3 Documentation Enhancements

This release updates the following system documents:

- *Solver API REST Web Services Developer Guide* has been updated to support uploading of large problems in multiple parts.
- *Solver Properties and Parameters Reference* has been updated to support Leap's hybrid solvers.
- *Solver Computation Time* has been renamed and updated to support Leap's hybrid solvers.

The online system documentation now includes a "Using Leap's Hybrid Solvers" section.

CHAPTER 6

RELEASE 3.1.26

6.1 Release Date (Online System)

2019-12-11

6.2 New Features

6.2.1 New Solver Property: category

This release introduces a new solver property, *category*, that identifies the solver type; for example, `qpu`.

6.2.2 New Solver Property: quota_conversion_rate

This release introduces a new solver property, *quota_conversion_rate*, so you can see the rate at which a particular solver consumes user or project quota. Some solver types might consume quota at different rates.

CHAPTER 7

RELEASE 3.1.25

7.1 Release Date (Online System)

2019-11-27

7.2 New Features

7.2.1 New Jupyter Notebook: Hybrid Computing

Try out the new *Hybrid Computing* Jupyter Notebook, which demonstrates how you can apply `dwave-hybrid` solvers to your problem, create hybrid workflows, and develop custom hybrid components.

Jupyter Notebooks are available online through Leap.

CHAPTER 8

RELEASE 3.1.24

8.1 Release Date (Online System)

2019-10-30

8.2 Changes to Default System Behavior

8.2.1 Access to Problems Submitted Prior to October 16, 2019

As a result to enhancements made to the problem-storage infrastructure, information about problems submitted to the cloud systems prior to October 16, 2019 is no longer available. All problems submitted after this date are accessible as before.

CHAPTER 9

RELEASE 3.1.19

9.1 Release Date (Online System)

2019-08-07

9.2 New Features

9.2.1 More Flexible Anneal Schedules Now Possible

For the online systems, this release introduces more flexible parameters for generating anneal schedules. Specifically, you can now create an anneal schedule with up to 12 points in its waveform (the previous configured maximum was 4), and the annealing slope range is expanded to -1.0 to 1.0 (the previous configured range was 0.0 to 1.0). Furthermore, the anneal fractions need not increase monotonically, which means that sawtooth patterns are possible.

For more information on modifying the default anneal schedule, see *Technical Description of the D-Wave Quantum Processing Unit*.

CHAPTER 10

RELEASE 3.1.16

10.1 Release Date (Online System)

2019-06-26

10.2 New Features

10.2.1 General Availability of D-Wave Hybrid

D-Wave Hybrid is now part of the Ocean SDK. D-Wave Hybrid provides a simple, open-source hybrid workflow platform for building and running quantum-classical hybrid applications.

Download the Ocean SDK

10.2.2 New Jupyter Notebook: Feature Selection

Try out the new *Feature Selection* Jupyter Notebook, which uses a hybrid sampler to showcase a machine learning technique. Jupyter Notebooks are available online through Leap.

CHAPTER 11

RELEASE 3.1.13

11.1 Release Date (Online System)

2019-04-01

11.2 New Features

11.2.1 New Solver Property: `tags`

This release introduces a new solver property, `tags`, that may hold attributes about a solver that you can use to have a client program choose one solver over another.

For example, the following attribute identifies a solver as lower-noise:

```
"tags": ["lower_noise"]
```

CHAPTER 12

RELEASE 3.1.9

12.1 Release Date (Online System)

2019-03-06

12.2 New Features

12.2.1 Time-Dependent Gain in Hamiltonian Biases

This release increases user control of the Hamiltonian that represents the D-Wave system's quantum anneal by introducing a time-dependent gain on its linear coefficients.

The *h_gain_schedule* parameter described in the *Solver Properties and Parameters Reference* guide enables users to specify the $g(t)$ function in,

$$\mathcal{H}_{ising} = -\frac{A(s)}{2}\left(\sum_i \hat{\sigma}_x^{(i)}\right) + \frac{B(s)}{2}\left(\sum_i g(t) h_i \hat{\sigma}_z^{(i)} + \sum_{i>j} J_{i,j}\hat{\sigma}_z^{(i)}\hat{\sigma}_z^{(j)}\right) \tag{12.1}$$

where $\hat{\sigma}_{x,z}^{(i)}$ are Pauli matrices operating on a qubit q_i (the quantum one-dimensional Ising spin) and h_i and $J_{i,j}$ the qubit biases and coupling strengths.

Currently this feature is used experimentally for a form of material simulation described in http://science.sciencemag.org/content/361/6398/162.

12.2.2 Security Patches

This release implements security patches for some known vulnerabilities.

CHAPTER 13

RELEASE 3.1.0

13.1 Release Date (Online System)

2018-10-02

13.2 New Features

13.2.1 New Cloud Platform: Leap Quantum Application Environment

With this release, D-Wave launches Leap™ , our new Quantum Application Environment. Access it here: https://cloud.dwavesys.com/leap.

As an existing user of the online D-Wave system, your account has already been migrated to Leap. Log in using your existing credentials.

Note: Demos and Jupyter Notebooks send problems to the QPU. This time comes from your existing project quota.

Leap works best on the latest version of Chrome or Safari, on desktops, laptops, and tablets.

CHAPTER 14

RELEASE 3.0.17

14.1 Release Date (Online System)

2018-09-19

14.2 Changes to Default System Behavior

14.2.1 Change to the Maximum Problem Duration

To improve the responsiveness of our online system, this release reduces the maximum problem run duration from 3 seconds to 1 second. This change is expected to affect only those users who submit problems with long anneal times and large numbers of reads.

For problems that run longer than 1 second, the system will:

- Block the problem from submitting
- Return a message indicating that the upper limit in microseconds on user-specified timing related parameters has been exceeded; for example, `12010000 > 1000000`

If you encounter the limit, divide the number of reads you need across a set of smaller problems and resubmit the problems.

This change affects only the online system; on-premise systems are unaffected.

Note: For information on user-specified timing-related parameters that may affect problem duration, see *Solver Computation Time*.

14.3 Resolved Issues

This release resolves the following issue:

- In the previous release, the online training packages could not be downloaded for local installation. This issue has been resolved.

CHAPTER 15

RELEASE 3.0.15

15.1 Release Date (Online System)

2018-08-29

15.2 Changes to Default System Behavior

15.2.1 Problem Queue Limits per User

Starting in this release, you can have a maximum of 1000 problems in your queue. If you attempt to submit more than this, the problem submission fails and the API returns an error message. This limit affects the online D-Wave system only.

CHAPTER 16

RELEASE 3.0.14

16.1 Release Date (Online System)

2018-08-22

16.2 Changes to Default System Behavior

16.2.1 New Qubist Session Timeout

Starting in this release, Qubist sessions time out after 24 hours. After this period, you will need to log in again.

CHAPTER 17

RELEASE 3.0.13

17.1 Release Date (Online System)

2018-08-08

17.2 New Features

17.2.1 Statistics Reports Allow Multiple Selection

When creating a statistics report from Qubist, users can now select multiple projects and administrators can select multiple groups and users. To add items to any currently selected with your mouse, press the Control (to add one item to your selection) or Shift (to add multiple consecutive items to your selection) button on your keyboard. Previously, a drop-down menu gave a choice between a single selection or the All option.

17.3 Resolved Issues

This release resolves the following issue:

- In past releases, usage statistics on Qubist did not always display correctly for end-of-month hours, and differed between users viewing the same reports from different timezones. This issue has been resolved: displayed usage statistics are now in Universal Time Coordinated (UTC) and no longer dependent on local timezones.

CHAPTER 18

RELEASE 3.0.10

18.1 Release Date (Online System)

2018-07-12

18.2 New Features

18.2.1 New Interactive Examples Online

D-Wave continues to add interactive examples in the form of Jupyter Notebooks. Depending on your project assignment, you may see new material in the Online Learning portion of Qubist.

18.3 Changes to Default System Behavior

18.3.1 Jupyter Notebooks No Longer Save User Data

Starting in this release, the Jupyter Notebooks in the Online Learning portion of Qubist no longer store user data. This means that the code in the notebook cells reverts to its default state when you exit the notebook or leave your session idle for 30 minutes.

Download any changes that you want to keep.

18.3.2 PML Features and Documentation Deprecated

Probabilistic machine learning (PML) features have been deprecated and the associated documentation removed from Qubist:

- *Managing Problems via D-Wave Web Services for PML*
- *Training Probabilistic Machine Learning Models using D-Wave Sampling Libraries*

CHAPTER 19

RELEASE 3.0.9

19.1 Release Date (Online System)

2018-06-26

19.2 New Features

19.2.1 API Response Now Shows Estimated Completion Time

For submitted problems, responses returned from the REST API now include fields that show the estimated completion time:

- `earliest_estimated_completion`—About when we expect the problem to be solved if the current usage continues
- `latest_estimated_completion`—About when we expect the problem to be solved if users from all projects in the system are submitting problems

CHAPTER 20

RELEASE 3.0.8

20.1 Release Date (Online System)

2018-06-18

20.2 Changes to Default System Behavior

20.2.1 Changes to the Problem Scheduler

The algorithm for the scheduler has changed in this release. The scheduler now considers the following factors to schedule work more fairly and efficiently:

- User's recent history (new in this release)
- Percentage of solver usage allocated to the project (introduced in Release 3.0.4)
- Recent usage for the project and the user (introduced in Release 3.0.4)

Most end users will not notice any changes. Resource managers will notice the following new field when managing projects in Qubist: **Percentage allocation**.

Note: The **Priority** field, previously used for this purpose, is now used only to identify those projects with a critical priority (0); that is, that must run before any others.

CHAPTER 21

RELEASE 3.0.7

21.1 Release Date (Online System)

2018-06-11

21.2 Resolved Issues

This release resolves the following issue:

- In past releases, you could not paste an MFA code from your clipboard into Qubist. This issue has been resolved.

CHAPTER 22

RELEASE 3.0.5

22.1 Release Date (Online System)

2018-05-28

22.2 Resolved Issues

This release resolves the following issue:

- The Virtual Graph Jupyter Notebook had a missing package causing an error message to appear. This issue has been resolved.

CHAPTER 23

RELEASE 3.0.4

23.1 Release Date (Online System)

2018-05-10

23.2 New Features

23.2.1 Solver API: New HTTP Response Code

This release introduces HTTP response code 429: "Too Many Requests." The Solver API returns this response when the request rate exceeds the permissible limit.

23.3 Changes to Default System Behavior

23.3.1 Changes to the Problem Scheduler

The algorithm for the scheduler has changed in this release. Instead of probabilistically choosing the next problem to run, the scheduler instead considers the following factors to schedule work more fairly and efficiently:

- Percentage of solver usage allocated to the project
- Recent usage for the project and the user

Most users will not notice any changes.

23.4 Resolved Issues

This release resolves the following issue:

- HTTP GET requests to the `/problems/<problem_id>/answer/` SAPI end point failed, returning only the response headers with an empty response body. This issue has been resolved.

CHAPTER 24

RELEASE 3.0.2

24.1 Release Date (Online System)

2018-04-12

24.2 Changes to Default System Behavior

24.2.1 Qubist: PML Library Access Changes

In previous releases, client libraries related to probabilistic machine learning (PML) were available to all customers on the **Downloads** page in Qubist, even though they were only *usable* by those customers with relevant contracts. As of Release 3.0.2, these features are visible only to authorized customers.

Note: Regardless of customer contract, all PML-related documentation is still available on Qubist.

CHAPTER 25

RELEASE 3.0.1

25.1 Release Date (Online System)

2018-04-02

25.2 Changes to Default System Behavior

25.2.1 Qubist: PML Feature Visibility Changes

In the previous release, features related to probabilistic machine learning (PML) were visible to all customers via the Qubist user interface, even though they were only *usable* by those customers with relevant contracts. As of Release 3.0.1, these features are visible only to authorized customers.

Note: Regardless of customer contract, all PML-related documentation is still available on Qubist.

25.3 Resolved Issues

This release resolves the following issue:

- Timeout errors could cause resource managers to see a "504 Bad Gateway" message when accessing database details via Qubist. This issue has been resolved.
- MFA messages were occasionally sent when a user attempted to access the system from a known device or browser. This issue has been resolved.

CHAPTER 26

RELEASE 3.0

26.1 Release Date (Online System)

2018-01-19

26.2 New Features

26.2.1 Reverse Annealing

This release introduces *reverse annealing*, a technique that makes it possible to refine known good local solutions thereby increasing performance for certain applications.[1] Reverse annealing involves (1) annealing backward from a known classical state to a mid-anneal state of quantum superposition, (2) searching for optimum solutions at this mid-anneal point while in the presence of an increased transverse field (quantum state), and then (3) proceeding forward to a new classical state at the end of the anneal.

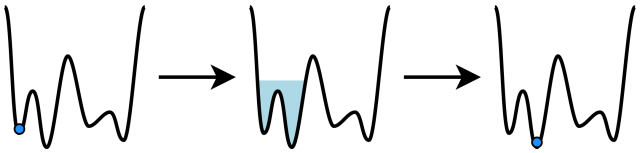

Figure 26.1: Reverse annealing process. The anneal starts at a specified classical state (left), then performs a local quantum annealing search stimulated by an increased transverse field (middle), then settles in a new classical state as the transverse field is removed (right).

This feature leverages features introduced in Release 2.11 that enable users to define an anneal schedule. They do so by defining a waveform that specifies points at which to change the standard schedule. In this release, users can define a schedule that begins its evolution at $s = 1$, a classical state.

Note: For reverse annealing, the maximum number of points allowed for an anneal schedule waveform is one *more* than the number given by the *max_anneal_schedule_points* solver

[1] For more information, see *Reverse Annealing for Local Refinement of Solutions*, D-Wave White Paper Series, no. 14-1018A-A, 2017.

property.

Note: This feature is not supported on D-Wave 2X and earlier systems.

Solver Changes

As well as using the existing *anneal_schedule* parameter for the schedule waveform, this feature introduces two new solver parameters:

- *initial_state*—Classical state of all qubits at the start of the reverse anneal.
- *reinitialize_state*—Boolean flag controlling whether the initial state is to be reinitialized for every anneal-readout cycle.

Changes to the C Client

This feature introduces the following data type:

- `sapi_ReverseAnneal`—Controls the initial state of the system at the start of a reverse anneal

The `sapi_QuantumSolverParameters` struct now includes the following entry to support this feature:

- `const sapi_ReverseAnneal* reverse_anneal;`

26.2.2 Virtual Graphs

The D-Wave *virtual graph* feature provides tools and interactive examples that simplify the process of minor-embedding by enabling you to more easily create, optimize, use, and reuse an embedding for a given working graph. When you submit an embedding and specify a chain strength using these tools, they automatically calibrate the qubits in a chain to compensate for the effects of biases that may be introduced as a result of strong couplings.

Note: Despite the similarity in name, the virtual graphs feature is unrelated to D-Wave's virtual full-yield Chimera (VFYC) solver.

See the following resources to learn more about virtual graphs:

- Interactive Jupyter Notebook example, available to online users through the **Online Learning** link on Qubist.
- **Whitepaper** describing measured performance improvements resulting from these features: See *Virtual Graphs for High-Performance Embedded Topologies*, D-Wave White Paper Series, no. 14-1020A, 2017. This and other white papers are available from https://www.dwavesys.com/resources/publications.

Tools Installation

The virtual graph utility and associated tools are available as a Python package from the D-Wave PyPI server.

Note: This package is presently available only for Python.

To install the package:

```
pip install dwave-system --extra-index-url https://pypi.dwavesys.com/simple
```

Downloaded with this package is a dependency called `dwave-system-tuning` that has a restricted license. To view the license details:

```
from dwave.system.tuning import __license__
print(__license__)
```

Underlying Controls: Extended J Range and Flux-Bias Offsets

Two underlying controls that support the virtual graphs feature are also available for direct use: *extended J range* and *flux-bias offsets*. These controls allow chains (logical qubits) to behave more like physical qubits on the working graph. The extended J range effectively doubles the energy scale available for embedded problems that use strong chains of qubits to build the underlying graph. This increased range means that the problem couplings are less affected by ICE and other effects. However, strong negative couplings can bias a chain and therefore flux-bias offsets must be applied to compensate.

Note: Extended J range and flux-bias offsets are incompatible with autoscale and spin-reversal transforms. Also, be aware that the extended J range is not available on D-Wave 2X systems.

Solver Changes

This feature introduces two new properties and a new parameter:

- *extended_j_range*—Property that shows whether extended J range is supported and what the range is.
- *per_qubit_coupling_range*—Property that identifies the limits on the total coupling strength possible for a qubit.
- *flux_biases*—Parameter that takes a list of flux-bias offset values with which to calibrate a chain.

Changes to the C Client

This feature introduces the following data types:

- `sapi_DoubleArray`—Holds the array of flux-bias offset values.[2]
- `sapi_VirtualGraphProperties`—Holds the extended *J* range and the per-qubit coupling ranges.

The `sapi_QuantumSolverParameters` struct now includes the following entry to support this feature:

- `const sapi_DoubleArray* flux_biases;`

26.2.3 Flux-Drift-Compensation Flag

By default, the D-Wave system regularly measures and compensates for flux drift. The procedure it follows to do so is described in detail in Appendix A of *Technical Description of the D-Wave Quantum Processing Unit*. In this release, you have the option of disabling this compensation.

Solver Changes

This feature introduces a new solver parameter:

- *flux_drift_compensation*—Boolean flag. Enabled by default.

Changes to the C Client

The `sapi_QuantumSolverParameters` struct now includes the following entry to support this feature:

- `int flux_drift_compensation;`

26.2.4 Reduce-Intersample-Correlation Flag

This release introduces a flag that reduces sample-to-sample correlations caused by the spin-bath polarization effect by adding an additional delay to the anneal-read cycle.

Solver Changes

This feature introduces a new solver parameter:

- *reduce_intersample_correlation*—Boolean flag. Disabled by default.

[2] Prior to this release, this data type was called `sapi_AnnealOffsets`. It is now used for both anneal-offset arrays and flux-bias arrays. The old name continues to be supported for backward compatibility purposes.

Changes to the C Client

The `sapi_QuantumSolverParameters` struct now includes the following entry to support this feature:

- `int reduce_intersample_correlation;`

26.2.5 Probabilistic Machine Learning Features

In this release, all users of D-Wave's online system can access the probabilistic machine learning (PML) features that had a limited release in Release 2.12. See *Release 2.12* for details. Qubist now includes additional functionality as described in *Managing Problems via D-Wave Web Services for PML*. These features are not included in on-premise D-Wave installations.

Note: Access to PML-related solvers is controlled by project assignment, as is the case for all solvers. Contact D-Wave for information about access to PML resources.

26.2.6 Online Learning Resources

D-Wave has created a number of examples as interactive Jupyter Notebooks so you can get hands-on experience with different features and applications of the system. If you are a user of D-Wave's online system, click the **Online Learning** link in Qubist to access them. If you have an on-premise system, contact D-Wave Support for access.

26.2.7 D-Wave Open-Source Tools

D-Wave is creating open-source tools to make application development for quantum computers more rapid and efficient. Now available on github, these open-source client libraries and reference examples facilitate collaborative projects that can leverage quantum computing system resources. The tool chains provide programming abstractions for application engineers as well as modular components for algorithms experts to modify and expand. Software developers can now explore, develop, and share their quantum computing programs with the ecosystem of D-Wave system users. See https://github.com/dwavesystems.

26.3 Changes to Default System Behavior

26.3.1 Multifactor Authentication

Starting in this release, secure system access is controlled through multifactor authentication (MFA). When logging on to Qubist for the first time, or when logging on from a new browser, device, or location, you must first enter a verification code.

Note: For on-premise D-Wave system installations, MFA is enabled by default. If an alternative secure authentication mechanism is already in place at the site, system administrators can disable the D-Wave MFA feature.

26.3.2 Timing Changes

Two features introduced in this release may impact the total problem run time.

- Reverse Annealing—If `reinitialize_state=true`, then initialization time is required before every anneal-readout cycle.
- Reduce Intersample Correlation—If enabled, this feature adds an additional thermalization delay before each anneal-readout cycle.

See *Solver Computation Time* for more information.

26.3.3 Autoscaling Default

While autoscaling remains enabled by default for embedded problems that use the standard J range, it is disabled when problems use the extended J range.

26.4 Documentation Enhancements

This release introduces the following documents:

- *D-Wave Problem-Solving Handbook*—Guides users through best-practice steps of solving a given problem on the D-Wave system. Provides reference problems with similar methods of solution and techniques to map the problem to a supported formulation, minor-embed the reformulated problem, and configure the QPU to best achieve useful results. It shows ways to overcome known difficulties such as large numbers of variables, imprecision in configuring qubit biases and coupler strengths, and broken chains of logical qubits. Additionally, it describes available software tools and references helpful literature.
- *Solver Properties and Parameters Reference*—Provides an alphabetical reference of all SAPI solver properties and parameters for the different solver types. While much of the content was previously published as part of the three client library developer

guides (C, MATLAB, and Python), the material has been reorganized and expanded for this release. In particular, this document includes a new compatibility matrix that outlines how solver parameters interact with each other.

- *Solver API REST Web Services Developer Guide*—Describes the SAPI REST interface, including the calls you may use to submit and manage problems and access the available solvers. Of interest to users who may be developing their own clients to access the solvers.

Note: The introduction of *D-Wave Problem-Solving Handbook* means that programming-related material has been removed from *Technical Description of the D-Wave Quantum Processing Unit*.

The following documents are obsolete and have been removed from Qubist:

- *MATLAB Quick Start Guide*
- *Release Notes for D-Wave Web Services for PML*

26.5 Resolved Issues

This release resolves the following issues:

- An error in example provided in the SAPI C client library, `sapi-c-client-2.11-linux64`, could cause a segfault when run. This issue has been resolved.
- *Developer Guide for C* had an incorrect description of the C header file, `sapi_Code.h`. This issue has been resolved.

CHAPTER 27

RELEASE 2.14

27.1 Changes to Default System Behavior

27.1.1 Stricter Password Rules

Starting in this release, rules for user passwords are more strict. Choose a password that meets the following criteria:

- Is not too similar to your personal information (first or last name, for example).
- Is between 8 and 128 characters.
- Contains at least 1 digit, 1 upper case letter, 1 lower case letter, and 1 special character.
- Is not a "common password" (the system checks a master list of common passwords).

After several unsuccessful attempts to properly set a password that matches the above criteria, the system locks password-entry attempts.

27.1.2 Password Lockout Policy

After several unsuccessful login attempts, the system locks subsequent login attempts until the lockout period expires.

CHAPTER 28

RELEASE 2.12

28.1 New Features

28.1.1 D-Wave Web Services for PML

Release 2.12 introduces D-Wave Web Services for Probabilistic Machine Learning (PML) features. It includes the following D-Wave components:

- Qubist—Web-based interface to the D-Wave system through which users obtain authentication credentials, access resources for download, monitor problems, and manage data.
- D-Wave Sampling Service—Python libraries running probabilistic sampling algorithms that interface to computational resources. Functions in these libraries draw samples from classical and quantum Boltzmann distributions that researchers use to train a probabilistic model. These libraries usually run in the remote environment; however, local versions of the libraries are available for development purposes.
- D-Wave Remote Execution Library—Client that submits machine learning problems to run in the remote environment.
- Network-attached storage resources—Stores shared datasets needed to train probabilistic models, as well as results and other user data.
- SAPI—Solver API, the interface through which researchers can sample from the D-Wave QPU.
- SAPI client libraries—Provides SAPI calls for accessing the QPU.
- Computational resources—GPUs, CPUs, and QPUs.

The following third-party components are integrated in the D-Wave Web Services for Probabilistic Machine Learning environment:

- TensorBoard—Open-source data visualization tools.
- Jupyter Hub—Hosted interactive Jupyter Notebooks providing detailed examples.

Several other packages, such as TensorFlow and NumPy, are installed on the solvers. Click on a solver name from within Qubist to view its properties, including a list of packages and their version numbers.

28.2 Documentation Enhancements

The release of D-Wave Web Services for Probabilistic Machine Learning includes the following new documents:

- *Training Probabilistic Machine Learning Models using D-Wave Sampling Libraries*—Provides background on probabilistic modeling and its utility in machine learning. Introduces the D-Wave Sampling Service and provides high-level guidelines on sampling from known distributions and from the QPU. Includes reference information for D-Wave Sampling Service and Matlib library functions.
- *Managing Problems via D-Wave Web Services for PML*—Describes how to submit and manage problems within the D-Wave Web Services for Probabilistic Machine Learning environment. Includes reference information for D-Wave Remote Execution Library library functions.

The following document has been significantly revised:

- *Getting Started with the D-Wave System*—Introduces the D-Wave quantum computer, provides key background information on how the system works, and explains how to construct a simple problem that the quantum computer can solve.

CHAPTER 29

RELEASE 2.11

29.1 Release Date (Online System)

2017-04-18

29.2 New Features

29.2.1 Support for Variations on the Global Anneal Schedule

Note: Variations on the global anneal schedule are not supported on D-Wave 2X and earlier systems. For D-Wave 2000Q systems, the maximum number of points in a schedule is system-dependent.

In the standard application of quantum annealing in D-Wave systems, qubits evolve according to a predetermined schedule, in which energy changes smoothly as a function of scaled time. As in previous releases, you can change the default duration using the *annealing_time* parameter when submitting a problem.

Some types of research, however, may benefit from more fine-grained adjustments to the default anneal schedule. To provide this level of control, Release 2.11 introduces features that enable you to change the shape of the energy waveform by providing points at which to *pause* or *quench* (i.e., abruptly terminate) the anneal process; see Figure 29.1. This level of control helps investigate what is happening partway through the annealing process.

Unlike the anneal offsets feature (see *Support for Anneal Offsets*)—which allows you to control the annealing path of *individual qubits* separately—anneal schedule changes apply to *all qubits* in the working graph.

Solver Changes

SAPI has a new parameter and a new property to support this feature:

- *anneal_schedule*—Parameter that enables variations on the standard global anneal schedule.

  An anneal schedule variation is defined by a series of pairs of floating-point numbers

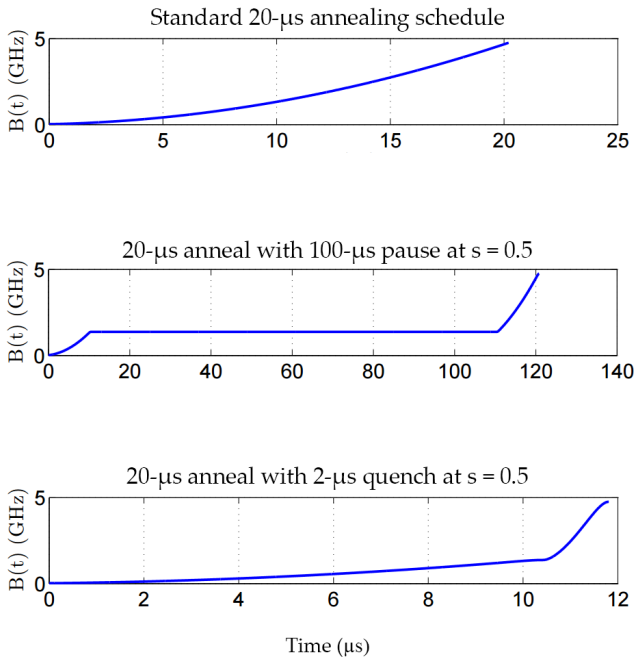

Figure 29.1: Annealing schedule variations.

identifying points in the schedule at which to change slope. The first element in the pair is time *t* in microseconds; the second, normalized persistent current *s* in the range [0,1]. The resulting schedule is the piecewise-linear curve that connects the provided points.

- *max_anneal_schedule_points*—Property that shows the maximum number of points at which the anneal schedule (waveform) can be changed for the solver.

New C Data Types

For the C client, this feature introduces the following data types:

- `sapi_AnnealSchedule`—Holds the array of anneal schedule points.
- `sapi_AnnealSchedulePoint`—Holds the values for time *t* and normalized persistent current *s*.
- `sapi_AnnealScheduleProperties`—Identifies the maximum number of points possible for the solver as well as its annealing time range.

29.2.2 Maximum Run Duration Visible via SAPI

The D-Wave system limits your ability to submit long-running problems to prevent you from inadvertently monopolizing QPU time. This limit varies by system. Release 2.11 introduces a new solver property, *max_run_duration_range*, that allows you to see the limit for your system.

29.2.3 D-Wave Reference Examples Available via Qubist

Several D-Wave reference examples are now available online, via Qubist. Access them by clicking the **Online Learning** link in the menu bar and log on to the online learning platform using your usual D-Wave credentials.

29.2.4 Usability Improvements for the Qubist Web UI

This release includes several improvements to the usability of Qubist.

Solver API Page

The Solver API page has been redesigned to make all key resources for D-Wave users available in one central place:

- Download links for the C, MATLAB, and Python developer packs
- SAPI base URL, which you copy and paste when generating an API token
- List of solvers to which you have access

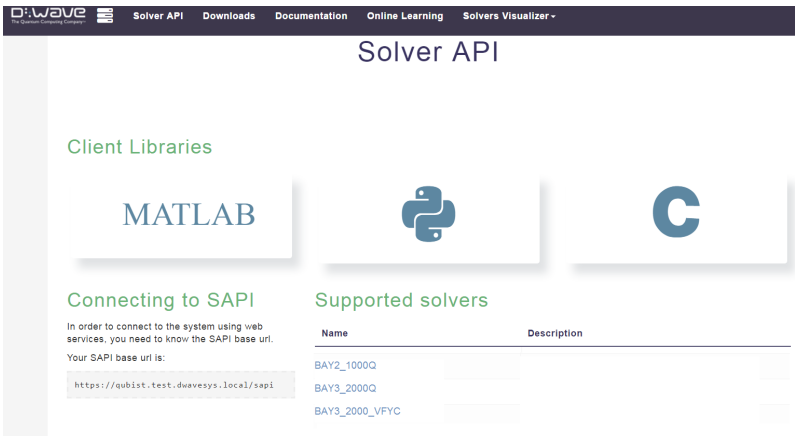

Figure 29.2: New Solver API page.

HTML and PDF Links Available for Documentation

Although previous releases provided access to both HTML and PDF versions of the D-Wave documentation, the PDF versions were available only from the Resource Downloads page. In this release, HTML and PDF links are available for all documents from the Documentation page. Furthermore, the relevant developer guides are available, in both formats, from the client library download pages as well.

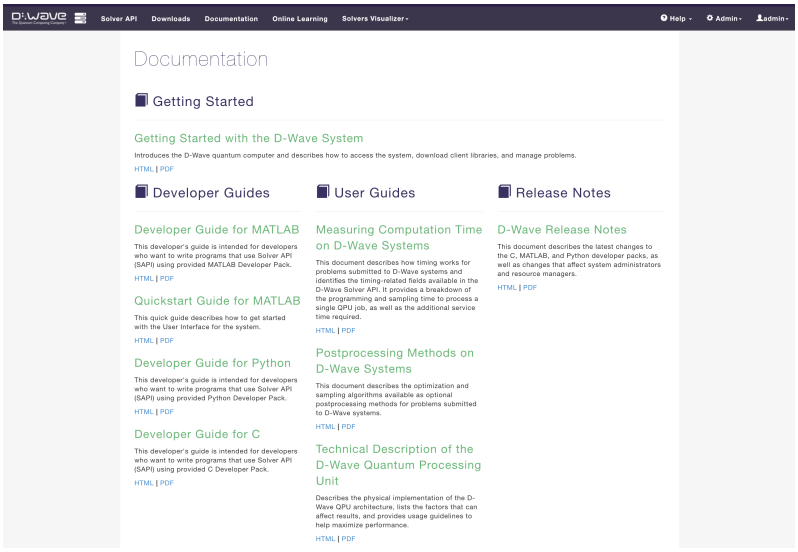

Figure 29.3: HTML and PDF links for D-Wave documentation.

Sample Code for Connecting to SAPI

From each client library page, you can now access sample code that allows you to connect to the Solver API with an active token, and to print all solvers accessible by that token. Note that you can also access the related documentation from the client library pages as well.

The example below shows the MATLAB client library page.

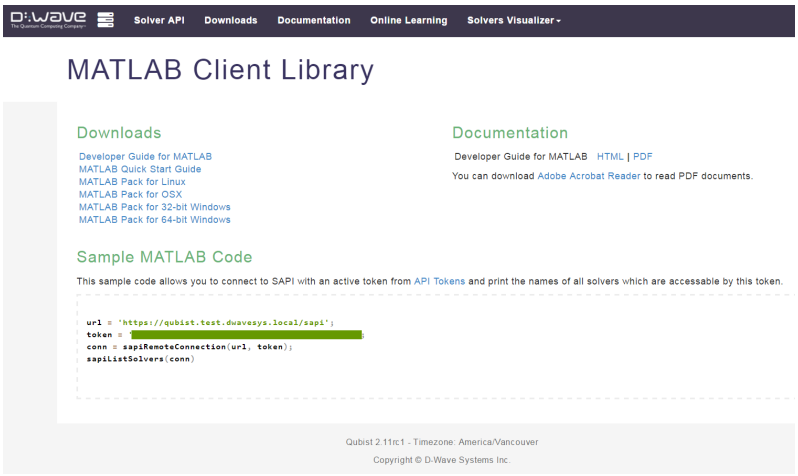

Figure 29.4: Sample client code available in the Solver API.

Downloads Available from Menu Bar

You can now access the Downloads page via the new Downloads link in Qubist menu bar. As before, all developer packs and documentation are available here.

29.3 Changes to Default System Behavior

29.3.1 C Client: Combined sapi_Chains and sapi_Embeddings Data Types

As of Release 2.11, the `sapi_Embeddings` data type replaces the `sapi_Chains` type. For backward compatibility, `sapi_Chains` is now a typedef of the other.

29.4 Resolved Issues

This release resolves the following issues:

Table 29.1: Resolved Issues in Release 2.11.

#	Description
872	The C function `sapi_findEmbedding` did not report success or failure status correctly. This issue is resolved; SAPI now returns an error if embedding is unsuccessful.
1386	Remote connection calls failed if they included unicode strings. This issue is resolved.

CHAPTER 30

RELEASE 2.10.3

30.1 Release Date (Online System)

2017-03-15

30.2 New Features

30.2.1 Beta Parameter Now Available in Qubist

When submitting sampling problems, users can specify inverse temperature β using the `beta` parameter in SAPI. The sampling postprocessing algorithm uses this value to affect the statistics of the Boltzmann distribution of the returned solutions.

The `beta` parameter has been available in the SAPI client libraries for many releases. New in this release is the ability to specify this value via the new **Beta** field in the **Submit Problem** page in Qubist.

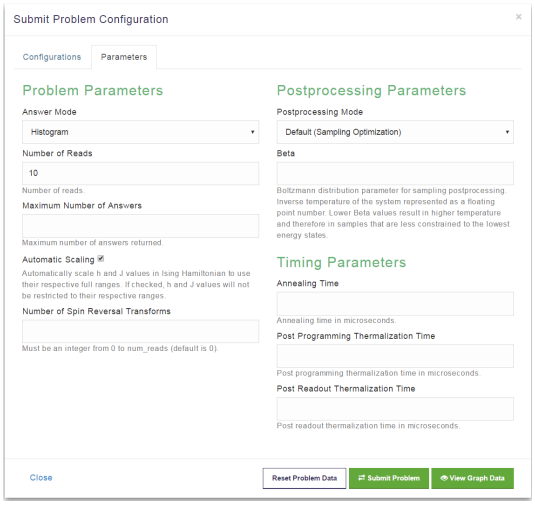

Figure 30.1: Beta parameter available in Qubist for sampling problems.

Note: As in statistical mechanics, β represents inverse temperature: $1/(k_B T)$, where T is the thermodynamic temperature in kelvin and k_B is Boltzmann's constant. In the D-Wave software, postprocessing refines the returned solutions to target a Boltzmann distribution characterized by β, which is represented by a floating point number without units. When choosing a value for β, be aware that lower values result in samples less constrained to the lowest energy states. For more information on β and how it is used in the sampling postprocessing algorithm, see *Postprocessing Methods on D-Wave Systems*.

30.2.2 Qubist Changes to Support VFYC Solvers

This release introduces changes to Qubist to better support virtual full-yield (VFYC) solvers, first introduced in Release 2.4 (see *New Solver: Virtual Full-Yield Chimera*):

- The **Solver Properties** page now identifies whether the solver is a VFYC solver.
- The **Submit Problem** page no longer lists "None" as a postprocessing option for problems submitted to a VFYC solver. (Postprocessing is always required for problems submitted to these solvers.)

30.3 Changes to Default System Behavior

30.3.1 Changes to Postprocessing Defaults for VFYC Solver

This release introduces changes to the default behavior of VFYC solvers. As of Release 2.10.3, the sampling postprocessing algorithm runs by default, and the value of the `beta` parameter (relevant only for sampling postprocessing) defaults to `10`. In contrast, in previous releases, the optimization postprocessing algorithm ran by default for this solver and—if the sampling postprocessing algorithm was specified instead—the `beta` value defaulted to `1`.

Be aware that this change is not backwards compatible. Update any code that relies on the postprocessing or `beta` defaults for VFYC solvers as needed to get the behavior you want.

CHAPTER 31

RELEASE 2.10

31.1 Release Date (Online System)

2016-12-06

31.2 Changes to Default System Behavior

31.2.1 Deprecated readout_thermalization Parameter

The *readout_thermalization* parameter is deprecated and will eventually be removed from the API. Plan code updates accordingly.

Note: This user-specified parameter contributes to the *qpu_delay_time_per_sample* value returned via SAPI. Without *readout_thermalization*, the delay between anneals is a constant value.

31.3 New Documents: QPU Properties per System

As of Release 2.10, system-specific documents are available listing the properties of each calibrated D-Wave QPU. Available properties vary slightly per system, but may include:

- Number of couplers
- Qubit temperature (mK)
- M_{AFM} (pH)
- Average single qubit thermal width
- Problem h range
- Problem J range
- Timing details
- Readout error rate
- $A(s)$ and $B(s)$ values

31.4 Known Issues

31.4.1 Problems Submitted to Software Solvers via Qubist UI

Problems submitted to a remote software solver via the **Submit Problem** page in Qubist may return incorrect answers. This issue does not affect hardware solvers, local software solvers, or any problem submitted via the SAPI clients.

To avoid this issue, use the SAPI clients rather than Qubist when submitting problems to remote software solvers.

CHAPTER 32

RELEASE 2.8

32.1 Release Date (Online System)

2016-10-31

32.2 New Features

32.2.1 Statistics Improvements

Release 2.8 introduces several enhancements to the display of the plotted statistics available in Qubist. From the Statistics page, you can now perform the following additional operations to explore the data:

- Showing or hiding contributors to the visualized data
- Zooming in and out, including by region
- Panning across a region
- Autoscaling and resetting axes
- Displaying and comparing additional details by hovering over plot points

32.2.2 Usability Improvements for Problem Definition

When defining a problem through Qubist, users can now directly specify the desired qubit weights and coupler strengths as an alternative to using the slider to set these values. This usability improvement makes it easier to set precise values.

32.3 Changes to Default System Behavior

32.3.1 Change to Statistics Refresh Default

Starting in Release 2.8, statistics in Qubist are not automatically refreshed by default. Resource managers can enable this behavor if desired.

32.4 Documentation Changes

Previously, D-Wave provided separate sets of release notes per SAPI client. Starting in Release 2.8, release notes are delivered in a single document, now called *D-Wave System Software Release Notes*.

CHAPTER 33

RELEASE 2.6

33.1 New Features

33.1.1 Improved Color Map

This release improves the colors displayed in the Chimera graph on Qubist. This display-only enhancement does not affect system operation.

33.1.2 Support for Multiple Solver Scheduling

This release improves the internal scheduling in systems running multiple solvers. This improvement does not change system administration or problem management activities.

33.1.3 Support for Custom EULA

This release enables resource managers and system administrators to define an end-user license agreement (EULA) particular to your organization. Do so by configuring it as a *custom region* in Qubist. See the *D-Wave System Administrator Guide* for instructions.

33.1.4 Support for Notifications by Project

Resource managers and system administrators can now send notifications to all users assigned to a project.

33.2 Changes to Default System Behavior

33.2.1 Changes to Quota Expiration

This release introduces changes to when quotas expire. The new behavior is as follows, per reporting period:

- Fixed-Time — Quota expires after specified allocation has been spent on the QPU, regardless of elapsed clock or calendar time.
- Hourly — Quota expires at the start of every hour (:00), regardless of time spent on the QPU.
- Daily — Quota expires at 12:00 a.m. each day, regardless of time spent on the QPU.
- Weekly — Quota expires at 12:00 a.m. each Monday (just after midnight on Sunday), regardless of time spent on the QPU.
- Monthly — Quota expires at 12:00 a.m. on the first day of the month (just after midnight on the last day of the prior month), regardless of time spent on the QPU.

33.2.2 Changes to Documentation Packaging

Starting in Release 2.6, the D-Wave user documentation is no longer bundled with the Solver API client download packages. Retrieve the latest versions of the documentation from Qubist.

33.3 Resolved Issues

This release resolves the following issues:

Table 33.1: Resolved Issues in Release 2.6.

#	Description
1568	The MATLAB `sapiUnembedAnswer` function may have produced incorrect results if the `brokenChains` parameter was set to `weighted_random` and the `embeddings` parameter contained a singleton chain (a variable mapping to a single qubit).

CHAPTER 34

RELEASE 2.5

34.1 New Features

34.1.1 Support for Anneal Offsets

In the standard application of quantum annealing in D-Wave systems, all qubits evolve simultaneously, experiencing equal changes to tunneling energy and making an equal contribution to the classical energy function. In some situations, however, it is beneficial to *offset* the annealing paths of the qubits, so that some are annealed slightly before others. This technique can improve both optimization and sampling performance for certain types of problems. Release 2.5 introduces a new user parameter and several new solver properties to support the anneal offsets feature.

Solver Changes

New user parameter:

- *anneal_offsets*—Array indicating whether and by how many normalized offset units to modify the annealing path for each qubit.

New solver properties (values vary slightly by QPU):

- *anneal_offset_ranges*—Minimum and maximum shift possible per qubit, in normalized offset units.
- *anneal_offset_step*—Step size for the anneal offset in normalized offset units, typically ~0.005.
- *anneal_offset_step_phi0*—Step size of anneal offset in annealing flux bias units, Φ_0.

Note: Anneal offsets are not supported on D-Wave 2X and earlier systems. Before using this feature, query the solver properties using SAPI calls to determine whether it is supported and, if so, to obtain the available tuning ranges per qubit.

New C Data Types

For the C client, this feature introduces:

- New `sapi_AnnealOffsets` data type to hold the `anneal_offsets` array.[1]
- New fields in the `sapi_QuantumSolverParameters` and `sapi_SolverProperties` data types to hold the new solver properties.
- New `sapi_ParametersProperty` data type to list the allowed parameters for a solver. (Not all solvers support offset annealing paths.)

34.2 Documentation Changes

The following new documents are available on Qubist in Release 2.5:

- *Getting Started with the D-Wave System*—Introduces the D-Wave system to new users.
- *Technical Description of the D-Wave Quantum Processing Unit*—Describes the physical implementation of the D-Wave QPU architecture, lists the factors that can affect results, and provides usage guidelines to help maximize performance.

The *Programming with QUBOs* document has been removed from the documentation package as of Release 2.5.

[1] As of Release 2.15, `sapi_AnnealOffsets` is replaced by `sapi_DoubleArray`.

CHAPTER 35

RELEASE 2.4

35.1 New Features

35.1.1 Enhancements to System Timers

This release improves the timers that measure computational time on the D-Wave™ system and introduces changes to the related keywords for accessing timing information through the Solver API. These enhancements enable users to better measure and characterize system performance.

The new keywords are available in the client libraries and visible in the Qubist web user interface. The timing-related keywords in previous releases of the Solver API are deprecated (but still available) in Release 2.4 and will be unavailable in future releases. Plan updates to any code that uses the old keywords.

The following table maps old names to new ones:

Old name (deprecated)	New name
total_real_time	*qpu_access_time*
run_time_chip	*qpu_sampling_time*
anneal_time_per_run	*qpu_anneal_time_per_sample*
readout_time_per_run	*qpu_readout_time_per_sample*

New timing keywords in this release of the Solver API are as follows:

- *qpu_programming_time*
- *qpu_delay_time_per_sample*
- *total_processing_time*
- *post_processing_overhead_time*

For more information about timing, including descriptions of all timing-related keywords, see *Solver Computation Time*.

35.1.2 Multiple Spin-Reversal Transforms

Previous releases of the Solver API supported only a single spin-reversal transform. Release 2.4 adds support for multiple transforms to better support the needs of certain machine-learning and heuristic solvers. The maximum number of transforms possible equals number of reads specified when a problem is submitted.

35.1.3 New Solver: Virtual Full-Yield Chimera

This release introduces a virtual full-yield Chimera (VFYC) solver, which uses a hybrid algorithm to solve problems defined on a VFYC graph. Use it to prototype algorithms based on an idealized abstraction of the system without being concerned about missing qubits or couplers that might affect a given QPU. For problems submitted to this solver, postprocessing always runs to accommodate any missing qubits.

Note: Be aware that because the full-yield Chimera solver only emulates an ideal system, performance varies from system to system.

To understand how the optimization and sampling postprocessing methods work with results obtained via this new solver, see *Postprocessing Methods on D-Wave Systems*.

35.1.4 New Error-Handling Functions

Release 2.4 introduces new error-handling functions:

- Asynchronous retry function—Retries communication for asynchronous problems that have failed for non-solving reasons. For instance, network errors during communication with the SAPI server may cause problems to fail in the client, even though the problem might be solved successfully. This function forces the client to retry communication with the server.
- Asyncronous status function—Provides information about asynchronous problems, including solving status, communication status, error information, and submission and solve times.

Function names for each SAPI client are below.

Table 35.1: New error-handling functions.

C	MATLAB	Python
sapi_asyncRetry	sapiAsyncRetry	retry
sapi_asyncStatus	sapiAsyncStatus	status

35.1.5 Fixed-Time User Quota

As well as being able to assign user quotas for QPU access based on elapsed clock or calendar time (e.g., hourly, weekly, monthly, and so on), in this release resource managers and system administrators can now assign a fixed total time allocation to a user. This quota does not expire until the user has spent the allocated time on the QPU, regardless of elapsed time. For example, if assigned 10 hours of QPU time, a user could take this time all at once (in a 10-hour block) or over a much longer period.

35.1.6 Support for LDAP Credentials

In Release 2.4, users can log on to the Qubist web user interface using LDAP credentials (if configured by their resource manager or system administrator). Other means of authentication are still supported.

35.2 New Documents

Two new documents are available on the Qubist web user interface in Release 2.4:

- *Solver Computation Time* — Describes how timing works for problems submitted to D-Wave systems and identifies the timing-related fields available in the D-Wave Solver API. It provides a breakdown of the programming and sampling time to process a single QPU job, as well as the additional service time required.
- *Postprocessing Methods on D-Wave Systems* — Provides an overview of the optimization and sampling postprocessing methods available, presents the results of a number of tests conducted by D-Wave, and describes the role of postprocessing in results obtained by the VFYC solver.

35.3 Changes to Default System Behavior

35.3.1 Changes to Solution Data in Qubist

For problems submitted with more than 1000 reads (num-reads), Qubist users can no longer access details of the solution through the web user interface (UI). Likewise, the solutions to such problems can no longer be visualized through Qubist. This change was made to preserve the performance of the UI. For such problems, the following Qubist components are unavailable as of Release 2.4:

- Problem Status > Solutions tab
- Visualize Data button

Regardless of the number of reads, users can still access all solution details through the Solver API client libraries as before.