Intel QS

Intel

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CONTENTS

CHAPTER

ONE

INTEL QUANTUM SIMULATOR

Intel Quantum Simulator (Intel-QS), also known as qHiPSTER (The Quantum High Performance Software Testing Environment), is a simulator of quantum circuits optimized to take maximum advantage of multi-core and multi-nodes architectures. It is based on a complete representation of the qubit state, but avoids the explicit representation of gates and other quantum operations in terms of matrices. Intel-QS uses MPI (message-passing-interface) protocols to handle the communication between distributed resources that are used to store and manipulate the quantum state.

1.1 Build instructions

Intel-QS builds as a shared library which, once linked to the application program, allows to take advantage of the high-performance implementation of circuit simulations. The library can be built on a variety of different systems, from laptop to HPC server systems.

The directory structure of the repository can be found in intel-qs/docs/directory_structure.md.

The library object is: `/builb/lib/libiqs.so`

1.1.1 Requirements

The following packages are required by the installation:

- CMake tools version 3.12+
- MPICH3 library for enabling the distributed communication
- optional: MKL for distributed random number generation
- optional: PyBind11 (installed via conda, not pip) required by the Python bunding of Intel-QS

The first step is cloning the repository:

```
git clone https://github.com/iqusoft/intel-qs.git
cd intel-qs
```

1.1.2 Use Intel Parallel Studio compilers to build Intel-QS

If you wish to build Intel-QS using the latest Intel compiler technologies, then you need to configure your environment properly according to that tool's documentation. Assuming that you have installed Intel Parallel Studio in the standard location on your system, you should invoke the following scripts through the source command on Linux.

```
source /opt/intel/bin/compilervars.sh -arch intel64 -platform linux
source /opt/intel/compiler_and_libraries/linux/mpi/intel64/bin/mpivars.sh
```

Now, use CMake to generate the appropriate makefiles to use the Intel Parallel Studio compilers. The installation follows the out-of-source building and requires the creation of the directory `build`. This directory is used to collect all the files generated during the installation process.

```
mkdir build
cd build
CXX=mpiicpc cmake -DIqsMPI=ON -DIqsUtest=ON ..
make
```

By default, MKL is required when Intel compilers are used.

To re-build Intel-QS with different settings or options, we recommend to delete all content of the `build` directory and then restart from the CMake command.

1.1.3 Use standard GNU tools to build Intel-QS

If you wish to build Intel-QS using only standard GNU compilers type:

```
mkdir build
cd build
CXX=g++ cmake -DIqsMPI=OFF ..
make
```

By default, MKL is not required when GNU compilers are used. Optionally, MPI can be included by setting the option `-DIqsMPI=ON` instead. You must ensure that you have at least version 3.1 of MPICH installed for the build to succeed. https://www.mpich.org

1.1.4 Enable MPI protocol for distributed memory use

The above installation enables MPI functionalities to deploy Intel-QS on High Performance Computing and Cloud Computing infrastructures. There is the option of disabling MPI: simply set the CMake option selection to `-DIqsMPI=OFF` (or just omit the option selection since MPI is disabled by default in the CMake build).

1.1.5 Enable Latest Vector Capability

To compile with the latest instruction set supported by your architecture, there is the option `-DIqsNative`. Compiled with `-DIqsNative=ON`, the latest vector instructions available on your machine, e.g. AVX2, AVX512, are used. By default, `-DIqsNative=OFF`.

If the machine you compile and the machine you run have different vector capabilities, turning on `IqsNative=ON` might cause run-time problems.

Underneath, this option uses `-xhost` with Intel compilers and `-march=native` with GNU compilers.

1.1.6 Enable Python binding (only available without MPI)

By default, whenever MPI is disabled, the building process includes the Python binding for Intel-QS. The binding code uses the Pybind11 library which needs to be installed via 'conda' (and not simply with pip) to include the relevant information in CMake. See this page for more info on this issue.

To disable the Python wrap, even without MPI, set the CMake option selection to `-DIqsPython=OFF`.

1.1.7 Unit test

By default, with MPI either enabled or disabled, the building process includes a suite of unit tests written in the googletest framework. Following the recommended integration, the CMake building process automatically downloads the up-to-date repository of gtest and installs it in the `build` path.

To disable the unit tests, set the CMake option selection to `-DIqsUtest=OFF`.

To run the unit tests, from `/build` launch the executable `./bin/utest`.

1.1.8 Recommended build for HPC.

The recommended building process requires Intel Math Kernel Library and the MPI-ICPC compiler.

When the program is run in hybrid configuration (OpenMP+MPI), we recommend to manage the OpenMP affinity directly. Affinity settings can be set using the syntax: `KMP_AFFINITY=compact,1,0,granularity=fine`. A quick look at the options can be found at this page.

1.2 Docker: build image and run/execute container

`Dockerfile` includes the instructions to build the docker image of an Ubuntu machine with Intel-QS already installed. The image can be 'run' to create a container. The container can be 'executed' to login into the machine.

```
docker build -t qhipster .
docker run -d -t qhipster
docker ps
docker exec -itd <container_id> /bin/bash
```

If Docker is used on a Windows host machine, the last line should be substituted by: `winpty docker exec -itd <container_id> //bin/bash`.

1.3 Getting started with Intel-QS

The simplest way of familiarize with the Intel Quantum Simulator is by exploring the tutorials provided in the directory `tutorials/`. In particular, the code `tutorials/get_started_with_IQS.cpp` provides step-by-step description of the main commands to: define a qubit register object, perform quantum gates, measure one or multiple qubits.

If the Python bindings were enabled, the same learning can be performed using the iPython notebook `tutorials/get_started_with_IQS.ipynb`.

1.4 How to contribute

Thanks for your interest in the project! We welcome pull requests from developers of all skill levels. If you would like to contribute to Intel-QS, please take a look to our *contributing policy* and also to the code of conduct. For any bug, we use GitHub issues GitHub issues. Please submit your request there.

1.5 How to contact us

If you have a question or want to discuss something, feel free to send an email to Justin Hogaboam, Gian Giacomo Guerreschi, or to Fabio Baruffa.

1.6 How to cite

When using Intel Quantum Simulator for research projects, please cite:

Gian Giacomo Guerreschi, Justin Hogaboam, Fabio Baruffa, Nicolas P. D. Sawaya *Intel Quantum Simulator: A cloud-ready high-performance simulator of quantum circuits* arXiv:2001.10554

The original implementation is described here:

Mikhail Smelyanskiy, Nicolas P. D. Sawaya, Alán Aspuru-Guzik *qHiPSTER: The Quantum High Performance Software Testing Environment* arXiv:1601.07195

CHAPTER

TWO

GETTING STARTED WITH INTEL QUANTUM SIMULATOR: EXAMPLES

Tutorial on the basic use of Intel QS through its Python interface: Two examples are provided.

NOTE: Currently, the Python implementation only allows for single-core execution and does not take advantages of the MPI protocol. However the user can familiarize with the same functionalities available in the distributed implementation (only C++ at the moment) and the transition should be relatively straighforward since all methods maintain name and effect.

2.1 Import Intel QS library

Let's start by importing the Python library with the class and methods defined in the C++ implementation.

[2]:
```
# Import the Python library with the C++ class and methods of Intel Quantum Simulator.
# If the library is not contained in the same folder of this notebook, its path has␣
↪to be added.
import sys
sys.path.insert(0, '../lib_python')
import intelqs as simulator

# Import NumPy library with Intel specialization.
import numpy as np
from numpy import random_intel

# Import graphical library for plots.
import matplotlib.pyplot as plt
```

2.2 Example 1

Create the state of a quantum register, having $N > 3$ qubits.

The state is initialized as a computational basis state (using the keyword "base") corresponding to the index 0.

The index corresponds to a N-bit integer in decimal representation. With N qubits there are 2^N indices, from 0 to 2^{N-1}.

[3]:
```
# Allocate memory for the quantum register's state and initialize it to |000...0>.
num_qubits = 4;
if num_qubits<3:
    num_qubits = 4;
psi1 = simulator.QubitRegister(num_qubits, "base", 0, 0);
```

Let us apply a X Pauli gate on qubit 0, effectively flipping it from |0> to |1>, followed by the Hadamard gate on all other qubits.

[4]:
```
# Let us apply a X Pauli gate on qubit 0, effectively flipping it from |0> to |1>.
psi1.ApplyPauliX(0);

# Let us apply an Hadamard gate on all other qubits.
for q in range(1,num_qubits):
    psi1.ApplyHadamard(q);
```

In addition to one-qubit gates, universal quantum computation can be achieved via 2-qubit entangling gates. For example, we now apply a CNOT between qubit 2 (here the control qubit) and qubit 1 (target qubit).

[5]:
```
# Two qubit gates are applied in a similar way. For example, a C-NOT between qubit 2␣
↪(control qubit) and qubit 1 (target qubit):
control = 2;
target = 1;
psi1.ApplyCPauliX( control , target );
```

To extract information from the quantum register, one can obtain the probability of measuring a certain qubit in the computational basis and obtaining the outcome "1" (meaning that the state is in |1>). In this example we measure qubit 1. Once the probability is known, one can draw a random number to simulate the stochastic outcome of the measurement and collapse the wavefunction accordingly.

[7]:
```
# Compute the probability of qubit 1 being in state |1>.
measured_qubit = 1;
prob = psi1.GetProbability( measured_qubit );

print("Probability that qubit {}, if measured, is in state |1> = {}\n".
↪format(measured_qubit, prob));

# Draw random number in [0,1)
r = np.random.rand()
if r < prob:
    # Collapse the wavefunction according to qubit 1 being in |1>.
    print("Simulated outcome is 1. Collapse the function accordingly.")
    psi1.CollapseQubit(measured_qubit,True);
else:
    # Collapse the wavefunction according to qubit 1 being in |0>
    print("Simulated outcome is 0. Collapse the function accordingly.")
    psi1.CollapseQubit(measured_qubit,False);

# In both cases one needs to re-normalize the wavefunction:
psi1.Normalize();
```

```
Probability that qubit 1, if measured, is in state |1> = 0.0

Simulated outcome is 0. Collapse the function accordingly.
```

2.3 Example 2

Create the state of a quantum register, having $N > 3$ qubits.

The state is initialized as a random state (using the keyword "rand"):

This requires a random number generator (RNG), that we initialize just before the second register. Notice that '777' plays the role of the seed to initialize the RNG.

[8]:
```
num_qubits = 4;
if num_qubits<3:
    num_qubits = 4;
psi2 = simulator.QubitRegister(num_qubits, "rand", 777, 0);
```

Let us apply one- and two-qubit gates as in the previous exmaple.

[9]:
```
# Let us apply a X Pauli gate on qubit 0, effectively flipping it from |0> to |1>.
psi2.ApplyPauliX(0);

# Let us apply an Hadamard gate on all other qubits.
for q in range(1,num_qubits):
    psi2.ApplyHadamard(q);
```

One can define an arbitrary single-qubit gate and apply it to the chosen qubit.

In addition one can apply a custom one-qubit gate conditionally on the state of a control qubit.

[10]:
```
# Define an arbitrary single qubit gate and apply it to the chosen qubit.
# The quantum gate G is given by a 2x2 unitary matrix, here using a bi-dimensional␣
↪NumPy array.
G = np.zeros((2,2),dtype=np.complex_);
G[0,0] =  0.592056606032915 + 0.459533060553574j;
G[0,1] = -0.314948020757856 - 0.582328159830658j;
G[1,0] =  0.658235557641767 + 0.070882241549507j;
G[1,1] =  0.649564427121402 + 0.373855203932477j;

qubit = 0;
psi2.Apply1QubitGate(qubit,G);

# It is also possible to apply the arbitrary gate specified by G controlled on the␣
↪state of another qubit.
# G is applied conditioned on the control qubit being in |1>.
control = 1;
target = 2;
psi2.ApplyControlled1QubitGate( control, target, G);

# Notice that this output is directed to the terminal and not re-directed to the␣
↪iPython notebook.
psi2.Print("After all gates.")
```

```
<<the output has been redirected to the terminal>>
```

To extract information from the quantum register, one can obtain the expectation value of Pauli strings.

For example, consider the Pauli string given by:

$$X_0 \otimes id_1 \otimes Z_2 \otimes Y_3$$

Such observable is defined by: - the position of the non-trivial Pauli matrices, in this case {0,2,3} - the corresponding Pauli matrices (X=1, Y=2, Z=3).

To facilitate the verification of the expectation value, we reinitialize the quantum state to |+-01>.

We also consider the Pauli staing

$$X_0 \otimes id_1 \otimes Z_2 \otimes Z_3$$

.

[12]:
```
# Prepare the state |+-01>
index = 2+8;
psi2.Initialize("base",index);
# Notice that GetProbability() does not change the state.
for qubit in range(0,num_qubits):
    prob = psi2.GetProbability( qubit );
    print("Probability that qubit {}, if measured, is in state |1> = {}\n".
↪format(qubit, prob));

psi2.ApplyHadamard(0);
psi2.ApplyHadamard(1);

# The Pauli string given by:  X_0 . id_1 . Z_2 . Y_3
# Such observable is defined by the position of the non-trivial Pauli matrices:
qubits_to_be_measured = [0,2,3]

# And by the corresponding Pauli matrices (X=1, Y=2, Z=3)
observables = [1,3,2]

# The expectation value <psi2|X_0.id_1.Z_2.Y_3|psi2> is obtained via:
average = psi2.ExpectationValue(qubits_to_be_measured, observables, 1.);
print("Expectation value <+-01|X_0.id_1.Z_2.Y_3|+-01> = {}\n".format(average));

# The expectation value <psi2|X_0.id_1.Z_2.Y_3|psi2> is obtained via:
qubits_to_be_measured = [0,2,3]
observables = [1,3,3]
average = psi2.ExpectationValue(qubits_to_be_measured, observables, 1.);
print("Expectation value <+-01|X_0.id_1.Z_2.Z_3|+-01> = {}\n".format(average));

# Trivial expectation:
average = psi2.ExpectationValue([0],[1], 1.);
print("Expectation value <+-01|X_0|+-01> = {}\n".format(average));

# The expectation value <psi2|X_0.id_1.id_2.Z_3|psi2> is obtained via:
average = psi2.ExpectationValue([0,3],[1,3], 1.);
print("Expectation value <+-01|X_0.Z_3|+-01> = {}\n".format(average));
```

```
Probability that qubit 0, if measured, is in state |1> = 0.0

Probability that qubit 1, if measured, is in state |1> = 1.0

Probability that qubit 2, if measured, is in state |1> = 0.0

Probability that qubit 3, if measured, is in state |1> = 1.0

Expectation value <+-01|X_0.id_1.Z_2.Y_3|+-01> = 0.0

Expectation value <+-01|X_0.id_1.Z_2.Z_3|+-01> = -0.9999999999999989

Expectation value <+-01|X_0|+-01> = 1.0
```

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```
Expectation value <+-01|X_0.Z_3|+-01> = -1.0000000000000004
```

[13]:
```
# Prepare the state |+-01>
index = 2+8;
psi2.Initialize("base",index);
# Notice that GetProbability() does not change the state.
for qubit in range(0,num_qubits):
    prob = psi2.GetProbability( qubit );
    print("Probability that qubit {}, if measured, is in state |1> = {}\n".
↪format(qubit, prob));

psi2.ApplyHadamard(0);
psi2.ApplyHadamard(1);

# The Pauli string given by:  X_0 . id_1 . Z_2 . Y_3
# Such observable is defined by the position of the non-trivial Pauli matrices:
qubits_to_be_measured = [0,2,3]

# And by the corresponding Pauli matrices (X=1, Y=2, Z=3)
observables = [1,3,2]

# The expectation value <psi2|X_0.id_1.Z_2.Y_3|psi2> is obtained via:
average = psi2.ExpectationValue(qubits_to_be_measured, observables, 1.);
print("Expectation value <+-01|X_0.id_1.Z_2.Y_3|+-01> = {}\n".format(average));

# The expectation value <psi2|X_0.id_1.Z_2.Y_3|psi2> is obtained via:
qubits_to_be_measured = [0,2,3]
observables = [1,3,3]
average = psi2.ExpectationValue(qubits_to_be_measured, observables, 1.);
print("Expectation value <+-01|X_0.id_1.Z_2.Z_3|+-01> = {}\n".format(average));
```

```
Probability that qubit 0, if measured, is in state |1> = 0.0

Probability that qubit 1, if measured, is in state |1> = 1.0

Probability that qubit 2, if measured, is in state |1> = 0.0

Probability that qubit 3, if measured, is in state |1> = 1.0

Expectation value <+-01|X_0.id_1.Z_2.Y_3|+-01> = 0.0

Expectation value <+-01|X_0.id_1.Z_2.Z_3|+-01> = -0.9999999999999989
```

[14]:
```
# Extra expectation values.

# Prepare the state |+-01>
index = 2+8;
psi2.Initialize("base",index);
psi2.ApplyHadamard(0);
psi2.ApplyHadamard(1);

# The expectation value of X_0:
average = psi2.ExpectationValue([0],[1], 1.);
print("Expectation value <+-01|X_0|+-01> = {}\n".format(average));
```

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```
# The expectation value of X_0.Z_3:
average = psi2.ExpectationValue([0,3],[1,3], 1.);
print("Expectation value <+-01|X_0.Z_3|+-01> = {}\n".format(average));

# The expectation value of X_0.Z_2:
average = psi2.ExpectationValue([0,2],[1,3], 1.);
print("Expectation value <+-01|X_0.Z_2|+-01> = {}\n".format(average));

# The expectation value of X_1.Z_2:
average = psi2.ExpectationValue([1,2],[1,3], 1.);
print("Expectation value <+-01|X_1.Z_2|+-01> = {}\n".format(average));
```

```
Expectation value <+-01|X_0|+-01> = 1.0

Expectation value <+-01|X_0.Z_3|+-01> = -1.0000000000000002

Expectation value <+-01|X_0.Z_2|+-01> = 0.999999999999998

Expectation value <+-01|X_1.Z_2|+-01> = -1.0000000000000002
```

END

[ ]:

CHAPTER

THREE

EXAMPLE USING THE EXTRA FEATURES FOR QAOA CIRCUITS

The Quantum Approximate Optimization Algorithm (QAOA) is a variational algorithm to solve combinatorial problems. Here we provide the syntax to quickly define and simulate QAOA circuits.

As a concrete example, we consider the MaxCut problem on a linear graph of 6 vertices. It is trivially solved analytically, but the numerical procedure extends to more complicated instances.

NOTE: Currently, the Python implementation only allows for single-core execution and does not take advantages of the MPI protocol.

3.1 Import Intel QS library

We start by importing the Python library with the class and methods defined in the C++ implementation.

[1]:
```
# Import the Python library with the C++ class and methods of Intel Quantum Simulator.
# If the library is not contained in the same folder of this notebook, its path has␣
↪to be added.
import sys
sys.path.insert(0, '../build/lib')
import intelqs_py as simulator

# Import NumPy library with Intel specialization.
import numpy as np
from numpy import random_intel

# Import graphical library for plots.
import matplotlib.pyplot as plt
```

3.2 Initialize the Max-Cut problem instance via its adjacency matrix

Specific instance: 0 – 1 – 2 – 3 – 4 – 5

We describe the instance by its adjacency matrix A, represented as a bidimensional NumPy array.

Each of the 2^6 bipartitions of the 6 vertices is associated with a cut value (the number of edges connecting vertices of different color).

[2]:
```
# Number of vertices.
num_vertices = 6;
# Adjacency matrix.
A = np.zeros((num_vertices,num_vertices),dtype=np.int32);
```

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```
# Since A is sparse, fill it element by element.
A[0,1] = 1;
A[1,0] = 1;
A[1,2] = 1;
A[2,1] = 1;
A[2,3] = 1;
A[3,2] = 1;
A[3,4] = 1;
A[4,3] = 1;
A[4,5] = 1;
A[5,4] = 1;
print("The adjacency matrix of the graph is:\n")
print(A)
#print(list(A.flatten()))

# Allocate memory for the diagonal of the objective function.
diag_cuts = simulator.QubitRegister(num_vertices, "base", 0, 0);
max_cut = simulator.InitializeVectorAsMaxCutCostFunction( diag_cuts, list(A.
↪flatten()) );

print("\nThe max value of the cut is : {0:2d}".format(max_cut))
```

```
The adjacency matrix of the graph is:

[[0 1 0 0 0 0]
 [1 0 1 0 0 0]
 [0 1 0 1 0 0]
 [0 0 1 0 1 0]
 [0 0 0 1 0 1]
 [0 0 0 0 1 0]]

The max value of the cut is :  5
```

3.2.1 ### Implement a p=2 QAOA circuit

- initialize the state in $|000000\rangle$
- prepare the state in $|++++++\rangle$
- iterate throught the QAOA steps (here p=2)
- each step is composed by the global operation defined by the cost function C and the transverse field mixing

[3]:
```
# Number of qubits.
num_qubits = num_vertices;
# Allocate memory for the quantum register's state and initialize it to |000000>.
psi = simulator.QubitRegister(num_qubits, "base", 0, 0);

# Prepare state |++++++>
for qubit in range(num_qubits):
    psi.ApplyHadamard(qubit);

# QAOA circuit:
qaoa_depth = 2;
# Random choice of QAOA parameters.
np.random.seed(7777);
```

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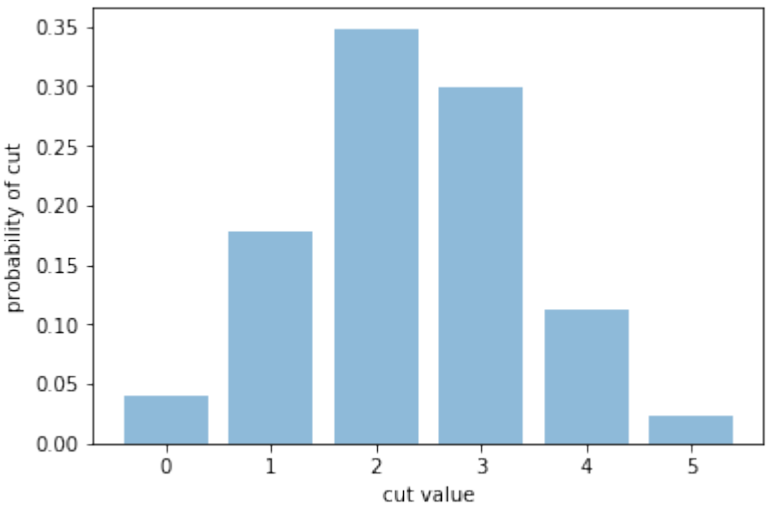
```
gamma = np.random.random_sample((qaoa_depth,))*3.14159;
beta  = np.random.random_sample((qaoa_depth,))*3.14159;

for p in range(qaoa_depth):
    # exp(-i gamma C)
    simulator.ImplementQaoaLayerBasedOnCostFunction(psi, diag_cuts, gamma[p]);
    # exp(-i beta  B)
    for qubit in range(num_qubits):
        psi.ApplyRotationX(qubit,beta[p]);

# At this point |psi> corresponds to the state at the end of the QAOA circuit.
```

3.3 Collect the results and visualize them in a histogram

[4]:
```
# The form of the histogram has been discussed privately.
histo = simulator.GetHistogramFromCostFunction(psi, diag_cuts, max_cut);
print("The probabilities of the cut values are:")
for c in range(max_cut+1):
    print("cut={0:2d} :  {1:1.4f}".format(c,histo[c]))

# Plot histogram.
x = np.arange(max_cut+1)
fig = plt.bar(x, histo, align='center', alpha=0.5)
#plt.xticks(x)
plt.xlabel('cut value')
plt.ylabel('probability of cut')
#plt.title('Summary of results')
plt.show()
```

```
The probabilities of the cut values are:
cut= 0 :  0.0397
cut= 1 :  0.1778
cut= 2 :  0.3483
cut= 3 :  0.2986
cut= 4 :  0.1120
cut= 5 :  0.0236
```



3.4 Simple test

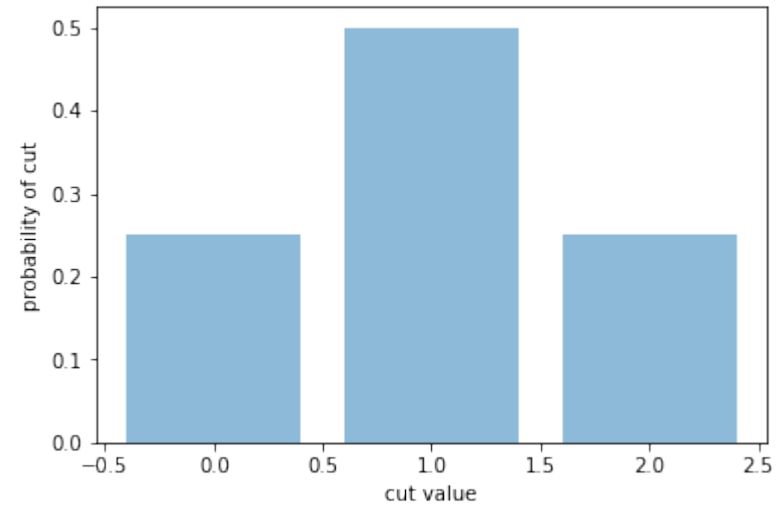
This instance represents a disconnected graph with only two edges, namely: 0 – 1 2 3 4 – 5

We describe the instance by its adjacency matrix A, represented as a bidimensional NumPy array.

Each of the 2^6 bipartitions of the 6 vertices is associated with a cut value (the number of edges connecting vertices of different color). For Half of the bipartitions the 0–1 edge can be cut and for half of the bipartitions, independently of the previous consideration, the 5–6 edge can be cut. The histogram has three bins (cut values = {0,1,2}) and ratio 1:2:1.

[5]:
```
# Number of vertices.
num_vertices = 6;
# Adjacency matrix.
A = np.zeros((num_vertices,num_vertices),dtype=np.int32);
# Since A is sparse, fill it element by element.
A[0,1] = 1;
A[1,0] = 1;
A[num_vertices-2,num_vertices-1] = 1;
A[num_vertices-1,num_vertices-2] = 1;

# Allocate memory for the diagonal of the objective function.
diag_cuts = simulator.QubitRegister(num_vertices, "base", 0, 0);
max_cut = simulator.InitializeVectorAsMaxCutCostFunction( diag_cuts, list(A.
↪flatten()) );

# Number of qubits.
num_qubits = num_vertices;
# Allocate memory for the quantum register's state and initialize it to |000000>.
psi = simulator.QubitRegister(num_qubits, "base", 0, 0);

# Prepare state |++++++>
for qubit in range(num_qubits):
    psi.ApplyHadamard(qubit);

# The form of the histogram has been discussed privately.
histo = simulator.GetHistogramFromCostFunction(psi, diag_cuts, max_cut);
print(histo)

# Plot histogram.
x = np.arange(max_cut+1)
fig = plt.bar(x, histo, align='center', alpha=0.5)
#plt.xticks(x)
plt.xlabel('cut value')
plt.ylabel('probability of cut')
#plt.title('Summary of results')
plt.show()
```

```
[0.2499999999999999, 0.4999999999999999, 0.2499999999999999]
```


0.5
0.4
0.3
0.2
0.1
0.0
probability of cut
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
cut value

END

CHAPTER

FOUR

CONTRIBUTING

Thanks for your interest in the project!

Any contribution, project participation and pull request from developers are welcome. Please follow this process:

- Clone this repository or fork it. Create a new branch and add your modifications.
- Remember to add unit tests to verify the desired behavior of the new features or methods.
- When the first version of the code is ready, create a pull-request to the **development** branch of `iqusoft/intel-qs`.
- Edits may be required to resolve conflicts since it is possible that the repository has changed while you worked on your new contribution. Please resolve the merge conflicts.
- Verify that all unit tests, and not only the one added in the contribution, run correctly.
- The IQS team will help with the revision of the pull-request.

To facilitate the review consider starting with small contributions (a couple files and ~100 lines).For contributions that require substantial changes or changes in many files, please contact the IQS team to discuss the most effective strategy.

Creating your pull request from a fork? We suggest allowing edits from maintainers. Then, anyone with Write access to the upstream repository will be able to add commits to your branch. This can make the review process easier for maintainers since they can make a small change themselves instead of asking you to make the change.

If you would like to contribute to IQS, please visit our wiki page https://github.com/iqusoft/intel-qs/wiki/Contribute.

CHAPTER

FIVE

API REFERENCES

5.1 Class Hierarchy

5.2 File Hierarchy

5.3 Full API

5.3.1 Namespaces

Namespace qaoa

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Namespace qhipster

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Namespaces

Classes

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Namespace qhipster::detail

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Classes

Functions

Namespace std

5.3.2 Classes and Structs

Template Struct extract_value_type

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Struct Documentation

template<typename **T**>
struct extract_value_type

Public Types

typedef *T* **value_type**

Template Struct extract_value_type< X< T > >

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Struct Documentation

template<template<typename> class **X**, typename **T**>
struct extract_value_type<*X*<*T*>>

Public Types

typedef *T* **value_type**

Template Struct AlignedAllocator::rebind

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_alignedallocator.hpp

Nested Relationships

This struct is a nested type of *Template Class AlignedAllocator*.

Struct Documentation

template<typename **U**>
struct qhipster::*AlignedAllocator*::**rebind**

Public Types

typedef AlignedAllocator<*U*, Alignment> **other**

Class GateCounter

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_gate_counter.hpp

Class Documentation

class GateCounter

The *GateCounter* class serves two main purposes: 1) To count the number of gates applied, divided by kind. 2) To estimate the circuit depth if scheduled in a greedy way.

Public Functions

GateCounter(int *new_num_qubits*)

~GateCounter()

void **Reset**()

int **GetTotalGateCount**()

int **GetOneQubitGateCount**()

int **GetTwoQubitGateCount**()

int **GetParallelDepth**()

void **OneQubitIncrement**(int *qubit*)
Update the counters and depth due to the action of a one-qubit gate.

void **TwoQubitIncrement**(int *qubit_0*, int *qubit_1*)
Update the counters and depth due to the action of a two-qubit gate.

void **Breakdown**()
Print the values of counters and depth.

Class Header

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_timer.hpp

Class Documentation

class Header

It was a struct, but this is slightly nicer (due to having a constructor).

Public Functions

Header()

Header(int *num_qubits_*, int *num_procs_*, int *num_records_*)

std::string **sprint**()

Public Members

std::size_t **num_qubits**

std::size_t **num_procs**

std::size_t **num_records**

Template Class NoisyQureg

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_NoisyQureg.hpp

Inheritance Relationships

Base Type

- `public QubitRegister< Type >` (*Template Class QubitRegister*)

Class Documentation

template<class **Type** = *ComplexDP*>
class NoisyQureg : **public** *QubitRegister*<*Type*>

Class that expand `QubitRegister` states by adding noise between "logical" gates.

Parameters

- `num_qubit`: is the number of qubits When we refer to ``experimental" gates, it means that noise gates are excluded. For the simulation to be faithful (i.e. with one-to-one correspondence with the experimental gates), we include among the experimental gates both the gates for the algorithm and those to schedule it according to the connectivity of the specific hardware.

Public Functions

NoisyQureg(unsigned *num_qubits*, unsigned *RNG_seed* = 12345, BaseType *T1* = 2000, BaseType *T2* = 1000)

Constructor.

~NoisyQureg()

Default destructor.

void **Initialize**(std::string *style*, std::size_t *base_index*)

void **ResetTimeForAllQubits**()

Reset to zero the time elapsed for each and every qubit in the register.

void **ApplyNoiseGatesOnAllQubits**()
Apply the noise gates on each and every qubit. Then reset to time counter.

This is useful, for example, at the end of a circuit before measuring the quantities of interest: One has to apply the noise corresponding to the idle evolution between the last logical gate and the final time. The time from last logical gate is then resetted to zero for every qubit.

void **SetDecoherenceTime**(BaseType, BaseType)
Set the decoherence time in terms of T_1 and T_2 values (in accordance to the new noise model).

void **SetGateDurations**(BaseType, BaseType)
Update the duration of single- and two- qubit gates.

unsigned **GetTotalExperimentalGateCount**()
Return the current number of (experimental) 1- and 2-qubit gates.

unsigned **GetOneQubitExperimentalGateCount**()
Return the current number of (experimental) single-qubit gates.

unsigned **GetTwoQubitExperimentalGateCount**()
Return the current number of (experimental) two-qubit gates.

std::vector<unsigned> **GetExperimentalGateCount**(unsigned *q1*)
Return the number of (experimental) gates involving qubit q.

unsigned **GetExperimentalGateCount**(unsigned *q1*, unsigned *q2*)
Return the number of (experimental) gates involving qubits q1,q2.

void **AddNoiseOneQubitGate**(unsigned **const**)
Include and execute the noise gate corresponding to the idle time of a single qubit.

void **AddNoiseTwoQubitGate**(unsigned **const**, unsigned **const**)
Include and execute the noise gate corresponding to the idle time of two qubits.

void **NoiseGate**(unsigned **const**)
Noise gate corresponding to single-qubit rotation with appropriate (stochastic) angle.

Each noise gate is the product of three rotations around X,Y,Z axis (by a small angle each). We compute their product before applying it to the quantum register.

void **NoiseGate_OLD**(unsigned **const**)
Noise gate corresponding to single-qubit rotation with appropriate (stochastic) angle.

** OLD OLD OLD OLD OLD OLD **

Kept for historical reasons, it shouldy be deletead.

To obtain a single rotation around an arbitrary axis we use the relations: | a b c | | h-f | R = | d e f | > u = | c-g | > abs(u) = 2 sin('angle') | g h i | | d-b | > u/abs(u) = rotation axis

void **Apply1QubitGate**(unsigned **const**, qhipster::*TinyMatrix*<*Type*, 2, 2, 32>)

void **ApplyHadamard**(unsigned **const**)

void **ApplyRotationX**(unsigned **const**, BaseType)

void **ApplyRotationY**(unsigned **const**, BaseType)

void **ApplyRotationZ**(unsigned **const**, BaseType)

void **ApplyCPauliX**(unsigned **const**, unsigned **const**)

void **ApplyControlled1QubitGate**(unsigned **const**, unsigned **const**, qhipster::*TinyMatrix*<*Type*, 2, 2, 32>)

Class Permutation

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_permute.hpp

Class Documentation

class Permutation

Public Functions

unsigned **operator[]** (std::size_t *i*)

unsigned **operator[]** (unsigned *i*)

int **operator[]** (int *i*)

std::size_t **size** ()

std::string **GetMapStr** ()

std::string **GetImapStr** ()

Permutation (std::size_t *num_qubits*)

Permutation (std::vector<std::size_t> *m*)

std::size_t **Find** (std::size_t *position*)

void **SetNewPermutation** (std::vector<std::size_t> *m*)

std::string **dec2bin** (std::size_t *in*, std::size_t *num_bits*)

std::size_t **bin2dec** (std::string *in*)

std::size_t **lin2perm_** (std::size_t *v*)

std::size_t **perm2lin_** (std::size_t *v*)

std::string **lin2perm** (std::size_t *v*)

std::string **lin2perm** (std::string *s*)

std::string **perm2lin** (std::size_t *v*)

std::string **perm2lin** (std::string *s*)

void **prange** ()

Public Members

std::vector<std::size_t> **map**

std::vector<std::size_t> **imap**

std::size_t **num_qubits**

Template Class AlignedAllocator

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_alignedallocator.hpp

Nested Relationships

Nested Types

- *Template Struct AlignedAllocator::rebind*

Class Documentation

template<typename **T**, unsigned int **Alignment**>
class qhipster::**AlignedAllocator**

An allocator returning aligned memory.

This class provides an aligned C++98 and C++11 conforming allocator.

Pre The alignment must be a power of 2.

Public Types

typedef *T* ***pointer**

typedef *T* **const** ***const_pointer**

typedef *T* **&reference**

typedef *T* **const &const_reference**

typedef *T* **value_type**

typedef std::size_t **size_type**

typedef std::ptrdiff_t **difference_type**

Public Functions

AlignedAllocator()

AlignedAllocator(*AlignedAllocator* **const&**)

template<typename **U**>
AlignedAllocator(*AlignedAllocator*<*U*, *Alignment*> **const&**)

pointer **allocate**(*size_type n*)

void **deallocate**(*pointer p*, *size_type*)

size_type **max_size**() **const**

void **construct**(*pointer p*, *const_reference t*)

template<typename **C**>
void **destroy**(*C* **c*)

bool **operator==**(*AlignedAllocator* **const&**) **const**

bool **operator!=**(*AlignedAllocator* **const**&) **const**

template<typename **U**, unsigned int **UAlignment**>
bool **operator==**(*AlignedAllocator*<*U*, *UAlignment*> **const**&) **const**

template<typename **U**, unsigned int **UAlignment**>
bool **operator!=**(*AlignedAllocator*<*U*, *UAlignment*> **const**&) **const**

template<typename **U**>
struct rebind

Public Types

typedef *AlignedAllocator*<*U*, *Alignment*> **other**

Class Environment

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Class Documentation

class qhipster::mpi::**Environment**

A trimmed down version of the BOOST::MPI environment. Its purpose is to initialize the MPI library and partition the cluster or single threaded environment for parallel operations. In preparation of the Monte-Carlo simulations required for the noisy implementation, we provide a communicator over the ranks involved in a single MC simulation.

Specifically, we store two communicators:

a. pool_communicator: spanning all the useful ranks

b. state_communicator: spanning those ranks used in a single MC simulation (i.e. state)

Public Functions

Environment(int &*argc*, char **&*argv*)

Intialize the MPI *Environment*.

It receives the same argc and argv arguments passed to the main function. If MPI is present, but has not been initialized, then MPI_Init will be called.

~Environment()

Finalize the MPI *Environment*

If MPI is present and has been initizlized in the constructor then MPI_Finalize will be called here.

Environment(*Environment* **const**&) = delete

Environment &**operator=**(*Environment* **const**&) = delete

Public Static Functions

void **UpdateStateComm**(int *num_states*, bool *do_print_info* = true)
Update the state and pool communicators.

Pre This can only be called when all ranks are still active.

bool **IsUsefulRank**()
Check whether the rank is useful or not.

int **GetPoolRank**()
The rank of the current MPI process: pool or state.

The PoolRank may not corresponds to that from MPI_COMM_WORLD due to dummy ranks. The rank is 0 if MPI is not present.

Pre If MPI is present, this can only be called after intializing MPI.

int **GetStateRank**()

int **GetRank**()

int **GetPoolSize**()
Number of MPI processes.

The PoolSize may not corresponds to that from MPI_COMM_WORLD due to dummy ranks. The number of processes is 1 if MPI is not present.

Pre If MPI is present, this can only be called after intializing MPI.

int **GetStateSize**()

int **GetSize**()

template<class **Type**>
Type **IncoherentSumOverAllStatesOfPool**(*Type local_value*)
Get incoherent average over all states of the pool.

Parameters

- `local_value`: the address of the value stored in the local rank.

int **GetNumRanksPerNode**()

int **GetNumNodes**()

int **GetNodeId**()

int **GetStateId**()

int **GetNumStates**()

void **RemapStateRank**(int *newme*)

Class Exception

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_exception.hpp

Inheritance Relationships

Base Type

- `public exception`

Class Documentation

class `qhipster::mpi::`**Exception** : **public** exception

Catch-all exception class for MPI errors.

Similar to the MPI exception class in the Boost libraries. Instances of this class will be thrown when an MPI error occurs.

Public Functions

Exception(**const** char *_routine_, int _error_code_)

Build a new *Exception* exception.

Parameters

- `routine`: The MPI routine in which the error occurred. This should be a pointer to a string constant: it will not be copied.
- `error_code`: The result code returned from the MPI routine that aborted with an error.

~Exception()

const char ***what**() **const**

A description of the error that occurred.

const char ***routine**() **const**

Retrieve the name of the MPI routine that reported the error.

int **error_code**() **const**

Obtain the result code returned from the MPI routine that caused an error.

Template Class RandomNumberGenerator

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_rng_utils.hpp

Class Documentation

template<typename **Type**>
class qhipster::**RandomNumberGenerator**

Used to generate random numbers that are local to each rank, or common to the state or the complete pool.

The generation of numbers and the method to skip ahead are more efficient when MKL (and in particular VSL) is used.

Public Functions

RandomNumberGenerator()

~RandomNumberGenerator()

RandomNumberGenerator(*RandomNumberGenerator* *source_rng)
Initialize RNG by copying the streams of the source RNG.

std::size_t **GetSeed**()
Get basic quantities.

std::size_t **GetNumGeneratedOrSkippedLocalNumbers**()

std::size_t **GetNumGeneratedOrSkippedStateNumbers**()

std::size_t **GetNumGeneratedOrSkippedPoolNumbers**()

void **SetSeedStreamPtrs**(std::size_t *RNG_seed*)
Set one different seed for each MPI rank (no MKL) or assign different streams (VSL).

void **SkipAhead**(std::size_t *num_skip*, std::string *shared* = "local")
Skip ahead.

void **UniformRandomNumbers**(*Type* *value, std::size_t *size* = 1UL, *Type* *a* = 0., *Type* *b* = 1., std::string *shared* = "local")
Generate random numbers in [a,b):

- size indicates how many numbers
- shared can be: local, state, pool

void **GaussianRandomNumbers**(*Type* *value, std::size_t *size* = 1UL, std::string *shared* = "local")
Generate random gaussian numbers (mean value = 0, std.dev = 1):

- size indicates how many numbers
- shared can be: local, state, pool

void **RandomIntegersInRange**(int *value, std::size_t *size* = 1UL, int *a* = 0, int *b* = 2, std::string *shared* = "local")
Generate random integers in [a,b), default being {0,1}..

- size indicates how many numbers
- shared can be: local, state, pool

Template Class TinyMatrix

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_tinymatrix.hpp

Class Documentation

template<class **ValueType**, unsigned **M**, unsigned **N** = *M*, unsigned **align** = alignof(*ValueType*)>
class qhipster::**TinyMatrix**

A small matrix with dimensions fixed at compile time.

The matrix is stored intenally as a two-dimensional C array, and thus in row-major ordering.

Public Types

using value_type = *ValueType*
the the of elements stored in the matrix

using pointer = *ValueType**
a pointer to elements of the matrix

using const_pointer = *ValueType* **const***
a pointer o elements of a const matrix

using reference = *ValueType*&
a reference to elements of the matrix

using size_type = unsigned
an integral type large enought to store the size of the matrix

using RowType = *ValueType*[N]
the type for a row of the matrix

Public Functions

TinyMatrix()
default-initizlize all matrix elements

template<class **U**>
TinyMatrix(*U init*[*M*][*N*])
initialize from a C-style array of the same dimensions

template<class **U**>
TinyMatrix(std::initializer_list<std::initializer_list<*U*>> **const** &*init*)
initialize from an initializer list, i.e. a compile time given matrix

template<class **U**, unsigned **alignrhs**>
TinyMatrix(*TinyMatrix*<*U*, *M*, *N*, *alignrhs*> **const** &*rhs*)
copy from a matrix with a potentially different type and alignment

TinyMatrix(*TinyMatrix* **const**&) = default
the defaiult copy constructor

TinyMatrix &**operator=**(*TinyMatrix* **const**&) = default
the default assignment

template<class **U**, unsigned **alignrhs**>

TinyMatrix &**operator=** (*TinyMatrix*<*U*, *M*, *N*, *alignrhs*> **const** &*rhs*)
assign from a matrix with a potentially different type and alignment

template<class **U**>
TinyMatrix &**operator=** (*U* **const** (&*rhs*)[M][N])
assign from a C-style array

constexpr *size_type* **numRows** () **const**
the number of matrix rows

constexpr *size_type* **numCols** () **const**
the number of matrix columns

constexpr *size_type* **size** () **const**
the size of the matrix, i.e. the number of matrix elements. This is the same as number of rows times number of columns

value_type **operator()** (unsigned *i*, unsigned *j*) **const**
access a matrix element of a const matrix

Pre i<*numRows()* & j<*numCols()*

Parameters

- `i`: the row index
- `j`: the column index

reference **operator()** (unsigned *i*, unsigned *j*)
access a matrix element

Pre i<*numRows()* & j<*numCols()*

Parameters

- `i`: the row index
- `j`: the column index

template<class **U**, unsigned **alignrhs**>
bool **operator==** (*TinyMatrix*<*U*, *M*, *N*, *alignrhs*> **const** &*rhs*) **const**
compare two matrices element-wise for equality

template<class **U**, unsigned **alignrhs**>
bool **operator!=** (*TinyMatrix*<*U*, *M*, *N*, *alignrhs*> **const** &*rhs*) **const**
compare two matrices element-wise for inequality

template<class **U**>
bool **operator==** (*U* **const** (&*rhs*)[M][N])
compare two matrices element-wise for equality

template<class **U**>
bool **operator!=** (*U* **const** (&*rhs*)[M][N])
compare two matrices element-wise for inequality

const_pointer **getPtr** () **const**
obtain a pointer to the first element of the matrix

RowType &**operator[]** (unsigned *i*)
C-style array subscript

the *TinyMatrix* can be indexed both using the mat(i,j) syntax or the C-style mat[i][j] syntax

RowType **const** &**operator[]**(unsigned *i*) **const**
C-style array subscript for a const matrix

the *TinyMatrix* can be indexed both using the mat(i,j) syntax or the C-style mat[i][j] syntax

template<unsigned **MSub**, unsigned **NSub** = *MSub*>
TinyMatrix<*ValueType*, *MSub*, *NSub*, *align*> **getSubMatrix**(unsigned *i_start* = 0, unsigned *j_start* = 0, unsigned *i_stride* = 1, unsigned *j_stride* = 1) **const**
Get submatrices

Returns the submatrix starting at i_start, j_start of size MSub, NSub using stride i_stride, j_stride

Pre Strides are strictly positive

Pre Parameters actually represent a submatrix (no index out of bounds)

Parameters

- `i_start`: The starting row index \param j_start The starting column index
- `i_stride`: The row stride to use for accessing elements
- `j_stride`: The column stride to use for accessing elements

Template Parameters

- `MSub`: The number of rows of the submatrix
- `NSub`: The number of columns of the submatrix

void **print**(std::string *name*)

std::string **tostr**() **const**

Public Members

std::string **name**

Template Class QubitRegister

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Inheritance Relationships

Derived Types

- `public NoisyQureg< Type >` (*Template Class NoisyQureg*)
- `public QubitRegisterMetric< Type >` (*Template Class QubitRegisterMetric*)

Class Documentation

template<class **Type** = *ComplexDP*>
class QubitRegister

Subclassed by *NoisyQureg< Type >*, *QubitRegisterMetric< Type >*

Public Types

using value_type = *Type*

typedef *extract_value_type*<*Type*>::value_type **BaseType**

Public Functions

QubitRegister()

QubitRegister(std::size_t *num_qubits*, std::string *style* = "", std::size_t *base_index* = 0, std::size_t *tmp_spacesize_* = 0)

QubitRegister(**const** *QubitRegister* &*in*)

QubitRegister(std::size_t *num_qubits*, *Type* *state, std::size_t *tmp_spacesize_* = 0)

~QubitRegister()

void **AllocateAdditionalQubit**()

void **Allocate**(std::size_t *new_num_qubits*, std::size_t *tmp_spacesize_*)

void **Initialize**(std::size_t *new_num_qubits*, std::size_t *tmp_spacesize_*)

void **Initialize**(std::string *style*, std::size_t *base_index*)

Type &**operator[]**(std::size_t *index*)

Type &**operator[]**(std::size_t *index*) **const**

Type **GetGlobalAmplitude**(std::size_t *index*) **const**

std::size_t **LocalSize**() **const**

std::size_t **GlobalSize**() **const**

void **Resize**(std::size_t *new_num_amplitudes*)

std::size_t **size**() **const**

std::size_t **NumQubits**() **const**

Type ***TmpSpace**() **const**

size_t **TmpSize**() **const**

bool **check_bit**(std::size_t *variable*, std::size_t *position*) **const**

std::size_t **set_bit**(std::size_t *variable*, std::size_t *position*) **const**

std::size_t **clear_bit**(std::size_t *variable*, std::size_t *position*) **const**

void **EnableStatistics**()

void **GetStatistics**()

void **DisableStatistics**()

void **ResetStatistics** ()

void **Permute** (std::vector<std::size_t> *permutation_new_vec*)

bool **Apply1QubitGate_helper** (unsigned *qubit*, *TM2x2*<*Type*> **const** &*m*, std::size_t *sstate_ind*, std::size_t *estate_ind*)

void **Apply1QubitGate** (unsigned *qubit*, *TM2x2*<*Type*> **const** &*m*)

bool **ApplyControlled1QubitGate_helper** (unsigned *control_qubit*, unsigned *target_qubit*, *TM2x2*<*Type*> **const** &*m*, std::size_t *sind*, std::size_t *eind*)

void **ApplyControlled1QubitGate** (unsigned *control_qubit*, unsigned *target_qubit*, *TM2x2*<*Type*> **const** &*m*)

bool **ApplySwap_helper** (unsigned *qubit1*, unsigned *qubit2*, *TM2x2*<*Type*> **const** &*m*)

void **ApplySwap** (unsigned *qubit1*, unsigned *qubit2*)

void **ApplyISwap** (unsigned *qubit1*, unsigned *qubit2*)

void **Apply4thRootISwap** (unsigned *qubit1*, unsigned *qubit2*)

void **ApplySqrtISwap** (unsigned *qubit1*, unsigned *qubit2*)

void **ApplyISwapRotation** (unsigned *qubit1*, unsigned *qubit2*, *TM2x2*<*Type*> **const** &*m*)

void **Swap** (unsigned *b1*, unsigned *b2*)

void **ApplyDiagSimp** (unsigned *qubit1*, unsigned *qubit2*, *TM4x4*<*Type*> **const** &*m*)

void **ApplyDiag** (unsigned *qubit1*, unsigned *qubit2*, *TM4x4*<*Type*> **const** &*m*)

void **ApplyDiagControl** (unsigned *qubit1*, unsigned *qubit2*, *TM4x4*<*Type*> **const** &*m*)

void **ApplyDiagGeneral** (unsigned *qubit1*, unsigned *qubit2*, *TM4x4*<*Type*> **const** &*m*)

void **Apply2QubitGate** (unsigned **const** *qubit_high*, unsigned **const** *qubit_low*, *TM4x4*<*Type*> **const** &*m*)

void **ApplyRotationX** (unsigned **const** *qubit*, *BaseType theta*)

void **ApplyRotationY** (unsigned **const** *qubit*, *BaseType theta*)

void **ApplyRotationZ** (unsigned **const** *qubit*, *BaseType theta*)

void **ApplyPauliX** (unsigned **const** *qubit*)

void **ApplyPauliY** (unsigned **const** *qubit*)

void **ApplyPauliZ** (unsigned **const** *qubit*)

void **ApplyPauliSqrtX** (unsigned **const** *qubit*)

void **ApplyPauliSqrtY** (unsigned **const** *qubit*)

void **ApplyPauliSqrtZ** (unsigned **const** *qubit*)

void **ApplyT** (unsigned **const** *qubit*)

void **ApplyToffoli** (unsigned **const** *qubit1*, unsigned **const** *qubit2*, unsigned **const** *qubit3*)

void **ApplyHadamard** (unsigned **const** *qubit*)

void **ApplyCRotationX** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*, *BaseType theta*)

void **ApplyCRotationY** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*, *BaseType theta*)

void **ApplyCRotationZ** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*, *BaseType* *theta*)

void **ApplyCPauliX** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*)

void **ApplyCPauliY** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*)

void **ApplyCPauliZ** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*)

void **ApplyCPauliSqrtZ** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*)

void **ApplyCHadamard** (unsigned **const** *control_qubit*, unsigned **const** *target_qubit*)

void **ApplyCPhaseRotation** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *theta*)

void **TurnOnFusion** (unsigned *log2llc* = 20)

void **TurnOffFusion** ()

bool **IsFusionEnabled** ()

void **ApplyFusedGates** ()

void **TurnOnSpecialize** ()

void **TurnOffSpecialize** ()

bool **GetClassicalValue** (unsigned *qubit*, *BaseType* *tolerance* = 1.e-13) **const**

bool **IsClassicalBit** (unsigned *qubit*, *BaseType* *tolerance* = 1.e-13) **const**

void **CollapseQubit** (unsigned *qubit*, bool *value*)

BaseType **GetProbability** (unsigned *qubit*)

BaseType **ExpectationValueX** (unsigned **const** *qubit*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueY** (unsigned **const** *qubit*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueZ** (unsigned **const** *qubit*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueXX** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueXY** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueXZ** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueYX** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueYY** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueYZ** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueZX** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueZY** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValueZZ** (unsigned **const** *qubit*, unsigned **const** *qubit2*, *BaseType* *coeff* = 1.)

BaseType **ExpectationValue** (std::vector<unsigned> &*qubits*, std::vector<unsigned> &*observables*, *BaseType* *coeff* = 1.)

BaseType **GetT1** ()

BaseType **GetT2** ( )

BaseType **GetTphi** ( )

void **SetNoiseTimescales** (*BaseType T1*, *BaseType T2*)

void **ApplyNoiseGate** (**const** unsigned *qubit*, **const** *BaseType duration*)

bool **operator==** (**const** *QubitRegister* &*rhs*)

BaseType **MaxAbsDiff** (*QubitRegister* &*x*, *Type sfactor* = *Type*(1.0, 0.))

BaseType **MaxL2NormDiff** (*QubitRegister* &*x*)

void **dumpbin** (std::string *fn*)

double **Entropy** ( )

std::vector<double> **GoogleStats** ( )

void **Normalize** ( )

BaseType **ComputeNorm** ( )

Type **ComputeOverlap** (*QubitRegister*<*Type*> &*psi*)

void **Print** (std::string *x*, std::vector<std::size_t> *qbits* = { })

double **HP_Distrpair** (unsigned *pos*, *TM2x2*<*Type*> **const** &*m*)

double **HP_Distrpair** (unsigned *control*, unsigned *qubit*, *TM2x2*<*Type*> **const** &*m*)

qhipster::*RandomNumberGenerator*<*BaseType*> ***GetRngPtr** ( )

void **ResetRngPtr** ( )

void **SetRngPtr** (qhipster::*RandomNumberGenerator*<*BaseType*> **rng_ptr*)

void **SetSeedRngPtr** (std::size_t *seed*)

Public Members

std::size_t **num_qubits**

std::vector<*Type*, qhipster::*AlignedAllocator*<*Type*, 256>> **state_storage**

Type ***state**

Permutation ***permutation**

Timer ***timer**

GateCounter ***gate_counter**

std::size_t **llc_watermarkbit**

bool **imported_state**

bool **specialize**

bool **fusion**

unsigned **log2llc**

std::vector<std::tuple<std::string, *TM2x2*<*Type*>, unsigned, unsigned>> **fwindow**

Public Static Functions

void **SetDoPrintExtraInfo**(bool *value*)

Template Class QubitRegisterMetric

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_QubitRegisterMetric.hpp

Inheritance Relationships

Base Type

- `public QubitRegister< Type >` (*Template Class QubitRegister*)

Class Documentation

template<class **Type** = *ComplexDP*>
class QubitRegisterMetric : **public** *QubitRegister*<*Type*>

Public Functions

QubitRegisterMetric(int *iNQubits*)

int **GetTotalQubitGateCount**()

int **GetOneQubitGateCount**()

int **GetTwoQubitGateCount**()

int **GetParallelDepth**()

void **ApplyHadamard**(int)

void **ApplyRotationX**(int, double)

void **ApplyRotationY**(int, double)

void **ApplyRotationZ**(int, double)

void **ApplyCPauliX**(int, int)

void **ApplyControlled1QubitGate**(int, int, qhipster::*TinyMatrix*<*Type*, 2, 2, 32>)

Class Time

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_timer.hpp

Class Documentation

class Time

Stores the time spent in the various part of the computation/communication.

Public Functions

Time()

bool **timed**()

std::string **sprint**(bool *combinedstats*)

Public Members

double **start**

bool **exists**

std::size_t **cpos**

std::size_t **tpos**

std::size_t **ncalls**

double **total**

double **sn_time**

double **sn_bw**

double **dn_time**

double **dn_bw**

double **tn_time**

double **tn_bw**

double **cm_time**

double **cm_bw**

double **flops**

double **gflops**

Class Timer

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_timer.hpp

Class Documentation

class Timer

The *Timer* class serves two purposes: 1) To provide a reliable and static call to Wtime() (since MPI_Wtime may not be available). 2) To provide a tidy way of profiling the code.

Public Functions

Timer(bool *combinedstats* = false)

Timer(int *num_qubits_*, int *my_rank_*, int *num_procs_*)

~Timer()

void **Reset**()

double **Wtime**()

void **Start**(std::string *s*, std::size_t *cpos*, std::size_t *tpos* = 999999)
Start the timer.

void **record_sn**(double *time*, double *bw*)

void **record_dn**(double *time*, double *bw*)

void **record_tn**(double *time*, double *bw*)

void **record_cm**(double *time*, double *bw*)

void **Stop**()
Stop the timer.

void **Breakdown**()
Print the statistics to screen.

Public Members

std::map<std::string, *Time*>::iterator **curiter**

5.3.3 Functions

Template Function __attribute__

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Function Documentation

template<typename Type> __attribute__((noinline)) void Loop_SN(std __attribute__((noinline)

Function GetQhipsterVersion

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg_version.hpp

Function Documentation

std::string **GetQhipsterVersion**(void)

Function perm

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_permute.hpp

Function Documentation

std::size_t **perm**(std::size_t *v*, std::size_t **map*, std::size_t *num_qubits*)

Template Function qaoa::GetExpectationValueFromCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
QubitRegister<*Type*>::BaseType qaoa::**GetExpectationValueFromCostFunction**(**const** *QubitRegister*<*Type*> &*psi*, **const** *QubitRegister*<*Type*> &*diag*)

Template Function qaoa::GetExpectationValueSquaredFromCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
QubitRegister<*Type*>::BaseType qaoa::**GetExpectationValueSquaredFromCostFunction**(**const** *QubitRegister*<*Type*> &*psi*, **const** *QubitRegister*<*Type*> &*diag*)

Template Function qaoa::GetHistogramFromCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
std::vector<**typename** *QubitRegister*<*Type*>::BaseType> qaoa::**GetHistogramFromCostFunction**(**const** *QubitRegister*<*Type*> &*psi*, **const** *QubitRegister*<*Type*> &*diag*, int *max_value*)

Template Function qaoa::GetHistogramFromCostFunctionWithWeightsBinned

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
std::vector<**typename** *QubitRegister*<*Type*>::BaseType> qaoa**::GetHistogramFromCostFunctionWithWeightsBinned**

Template Function qaoa::GetHistogramFromCostFunctionWithWeightsRounded

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
std::vector<**typename** *QubitRegister*<*Type*>::BaseType> qaoa**::GetHistogramFromCostFunctionWithWeightsRounde**

Template Function qaoa::ImplementQaoaLayerBasedOnCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
void qaoa::**ImplementQaoaLayerBasedOnCostFunction**(*QubitRegister*<*Type*> &*psi*, *QubitRegister*<*Type*> &*diag*, **typename** *QubitRegister*<*Type*>::BaseType *gamma*)

Template Function qaoa::InitializeVectorAsMaxCutCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
int qaoa::**InitializeVectorAsMaxCutCostFunction**(*QubitRegister*<*Type*> &*diag*, std::vector<int> &*adjacency*)

Template Function qaoa::InitializeVectorAsWeightedMaxCutCostFunction

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qaoa_features.hpp

Function Documentation

template<typename **Type**>
QubitRegister<*Type*>::BaseType qaoa::**InitializeVectorAsWeightedMaxCutCostFunction**(*QubitRegister*<*Type*> &*diag*, std::vector<**typename** *QubitRegister*<*Type*>::BaseType> &*adjacency*)

Function qhipster::detail::BX

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

int `qhipster::detail::`**`BX`**(long *x*)

Template Function qhipster::detail::highestBitImpl

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

template<class **`Integral`**>
`constexpr` unsigned `qhipster::detail::`**`highestBitImpl`**(*Integral* *i*, unsigned *pos*)

Template Function qhipster::floor_power_of_two

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

template<class **`Integral`**>
unsigned `qhipster::`**`floor_power_of_two`**(*Integral* *x*)

Template Function qhipster::highestBit

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

template<class **`Integral`**>
`constexpr` unsigned `qhipster::`**`highestBit`**(*Integral* *i*)

returns the highest bit set in a non-zero integer

This function returns the highest bit set in a non-zero integer.

Pre The integer `i` is non-zero

Parameters

- `[in] i`: the non-zero integer of which the highest bit is returned

Template Function qhipster::ilog2

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

template<class **Integral**>
unsigned int `qhipster::ilog2` (*Integral* *n*)

Returns the logarithm base 2 of a non-zero integer.

This function returns the the logarithm base 2 of a non-zero integer

Pre The integer `i` is a power of 2

Parameters

- `[in] i`: the non-zero integer of which the logarithm base 2 is returned

Template Function qhipster::isPowerOf2

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

template<class **Integral**>
constexpr bool `qhipster::isPowerOf2` (*Integral* *i*)

checks whether an integer is a power of 2

Parameters

- `[in] i`: an integer to be checked

Function qhipster::mpi::Barrier

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::Barrier`()

Function qhipster::mpi::PoolBarrier

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::PoolBarrier`()
An MPI barrier.

It waits until all MPI processes have reached this call. This function does nothing if MPI is not present.

Function qhipster::mpi::PoolPrint

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::PoolPrint`(std::string *s*, bool *all* = false)
Print from all MPI processes.

It prints a string from all processes if `all` is true or just from the master process with rank 0 if `all` is false. If MPI is not present it prints the string.

If `all` is set, the string is prefixed by the number of the MPI process.

Parameters

- `s`: the string to be printed
- `all`: a flag to specify if all processes should print or just the master process

Function qhipster::mpi::Print

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::Print`(std::string *s*, bool *all* = false)

Function qhipster::mpi::StateBarrier

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::`**`StateBarrier`**`()`

Function qhipster::mpi::StatePrint

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_env.hpp

Function Documentation

void `qhipster::mpi::`**`StatePrint`**`(`std::string *s*, bool *all* = false`)`

Function qhipster::popcnt(uint32_t)

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

Warning: doxygenfunction: Unable to resolve multiple matches for function "qhipster::popcnt" with arguments (uint32_t) in doxygen xml output for project "My Project" from directory: ./doxyoutput/xml. Potential matches:

```
- long popcnt(uint32_t x)
- long popcnt(uint64_t x)
```

Function qhipster::popcnt(uint64_t)

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_bitops.hpp

Function Documentation

Warning: doxygenfunction: Unable to resolve multiple matches for function "qhipster::popcnt" with arguments (uint64_t) in doxygen xml output for project "My Project" from directory: ./doxyoutput/xml. Potential matches:

```
- long popcnt(uint32_t x)
- long popcnt(uint64_t x)
```

Template Function qhipster::ShuffleFisherYates

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_rng_utils.hpp

Function Documentation

template<typename **Type**, typename **TypeFloat**>
void `qhipster::`**`ShuffleFisherYates`**(std::vector<*Type*> *&array*, *RandomNumberGenerator*<*TypeFloat*> **rnd_generator_ptr*, std::string *shared* = "local")

Template Function qhipster::toString

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_conversion.hpp

Function Documentation

template<class **T**>
std::string `qhipster::`**`toString`**(*T* **const** *&val*)
convert to a string

This function converts any value to a string, by writing it into a string stream.

Pre Writing into a std::istream using operator<< needs to be implemented for the type

Parameters

- `[in] val`: the value to be converted to a string

Function qhipster::WhatCompileDefinitions

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Function Documentation

void `qhipster::`**`WhatCompileDefinitions`**()
Utility method to inform on the currently set compiler flags.

Template Function ScaleState

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Function Documentation

template<typename **Type**>
void **ScaleState**(std::size_t *start*, std::size_t *end*, *Type* **state*, **const** *Type* &*s*, *Timer* **timer*)

Function time_in_seconds

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Function Documentation

double **time_in_seconds**(void)

5.3.4 Variables

Variable c11

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:

Variable c12

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:

Variable c13

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

```
__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:
```

Variable c21

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

```
__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:
```

Variable c22

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

```
__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:
```

Variable c23

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

```
__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:
```

Variable c31

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

```
__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:
```

Variable c32

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:

Variable ind_shift

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:

Variable m

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

__attribute__((noinline)) void Loop_SN(std __attribute__((noinline)) void Loop_DN(std std:

Variable specialize

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

bool `QubitRegister::`**`specialize`**

Variable timer

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_highperfkernels.hpp

Variable Documentation

Timer *QubitRegister::**timer**

5.3.5 Defines

Define __str__

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

__str__(*s*)

Define D

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

D(*x*)

Define DO_PRAGMA

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

DO_PRAGMA(*x*)

Define INFO

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

INFO(*x*)

Define noexcept

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_alignedallocator.hpp

Define Documentation

noexcept

Define QHIPSTER_MPI_CHECK_RESULT

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_mpi_exception.hpp

Define Documentation

QHIPSTER_MPI_CHECK_RESULT(*MPIFunc*, *Args*)

Call the MPI routine MPIFunc with arguments Args (surrounded by parentheses). Checks the return value of MPIFunc call and throws a qhipster::mpi::exception if the result is not MPI_SUCCESS.

Define QHIPSTER_VERSION_STRING

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg_version.hpp

Define Documentation

QHIPSTER_VERSION_STRING

Define sec

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

sec()

Define TODO

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

TODO(*x*)

Define UL

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

UL(*x*)

Define xstr

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Define Documentation

xstr(*s*)

5.3.6 Typedefs

Typedef BaseType

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Typedef Documentation

typedef *QubitRegister*<Type>::BaseType NoisyQureg::**BaseType**

Typedef ComplexDP

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Typedef Documentation

using ComplexDP = std::complex<double>

Typedef ComplexSP

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_utils.hpp

Typedef Documentation

using ComplexSP = std::complex<float>

Typedef TM2x2

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Typedef Documentation

using TM2x2 = qhipster::*TinyMatrix*<Type, 2, 2, 32>

Typedef TM4x4

- Defined in file__home_docs_checkouts_readthedocs.org_user_builds_intel-qs_checkouts_docs_include_qureg.hpp

Typedef Documentation

using TM4x4 = qhipster::*TinyMatrix*<Type, 4, 4, 32>

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