QCWAVE/QDENSITY - INFORMATION

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1 Introduction

The QCWAVE package is both an updated and extended version of QDENSITY. It updates codes to work on Mathematica 7.0 and 8.0 and it is an extension in several ways. These extensions include: (1) an emphasis on wave-functions (hence the name QCWAVE); (2) it uses an efficient method for the action of gates on states;(3) it provides a flexible and transparent circuit drawing capability; and most importantly (4) QCWAVE includes a "multiverse" approach to simulate the influence of noise. Parallel versions of a given gate or algorithm are run on different processors, each of which is subject to noise and possible error corrections; then, an ensemble average is performed to simulate a real situation. That approach provides a way to study the influence of noise and error correction on quantum computing using the presently available parallel processing capabilities of Mathematica.

2 The Package

The QCWAVE package is contained in two zip files, QDENSITY.zip and notebookj.zip.

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2.1 QDENSITY.zip

Uncompressing QDENSITY.zip, yields a folder QDENSITY. To install the package put that directory in the location indicated by executing the following command in Mathematica:
ToFileName[**{$UserBaseDirectory, Applications}**] .

Within the folder QDENSITY, the basic package commands are in Qdensity, QCWave and Circuits. To access the commands contained therein, execute the following commands in Mathematica:

?QDENSITY`Qdensity`*

?QDENSITY`QCWave`*

?QDENSITY`Circuits`* .

Executing any of these in Mathematica will give more detailed information about usage.

Updated QDENSITY notebooks are in the directory QDENSITY/Documentation/English. It is best to start by executing the notebook Tutorial.nb, and then explore the other 5 notebooks. Additional cases will be posted on the web, as they are developed. [1]

The QCWAVE and Circuit packages will be discussed next.

2.2 notebookj.zip

The notebookj.zip includes the 11 notebooks. The first three to examine are: QCwaveTutorial, CircuitTutorail and AmpPlot. QCwaveTutorial illustrates the new wavefunction aspects of the package and the commands Op1, Op2 and Op3 for one, two and three qubit gates. CircuitTutorial demonstrates how to generate circuit graphs. A cluster graph package will be posted separately on the web. Finally, AmpPlot is a tutorial on various ways to display the values and evolution of the state amplitudes.

The notebooks GroverW, TeleportationW and QFTW present the Grover

[1] Note that a line such as:
XXX To open double click on down arrow here————–> , often appears, with a down-arrow on the right. That indicates cells are merged. To open those merged cells double-click on the down-arrow.

search, the teleportation and the quantum fourier transform algorithms using the QCWAVE wavefunction aspects.

The EC3x and EC3z notebooks illustrate how to setup simple error correction codes; more general cases will be posted on the web.

Finally, the three notebooks MV1-Noise, MV2-Noise and MVn-Noise illustrate how to set up a “multiverse” approach using the parallel computing features of Mathematica 7.0 -8.0, for one, two and n- qubits. These show how to introduce noise scenarios and how to simulate the effects of error correction and serve as a basis for future extensive application of this approach. In order to execute these last three packages, the user must first setup the parallel features. Some advice on that process is delineated next.

3 Parallel Setup

Mathematica 7.0 and 8.0 provide slave-master parallel computing features. At this stage, this is a rather limited form of parallel computing, which does not include direct slave to slave communication such as is provided by the MPI (message passing interface) feature on mainframe parallel computing facilities See our package QCMPI.. On the other hand the CUDA capability of Mathematica 8.0 promises some future parallel advances and we hope that QCWave is a contribution to such applications.

To run the above MV1-Noise, MV2-Noise and MVn-Noise , the user must install Mathematica and the full QDENSITY/QCWAVE package on each computer. Then from the Evaluation pull-down menu in Mathematica, select Parallel Kernel Configuration.. . That will bring up the Preference panel, go to the parallel bar. Check the settings for the Local Kernels, then turn to the Remote Kernels settings bar, where you can activate your available remote kernels. Under the “use custom launch command” the following works to access the account ftabakin on the computer with IP number 10.0 .1 .4.

```
ssh - x - f  ftabakin@10.0 .1 .4 /Applications/Mathematica.app/Contents/MacOS/
   MathKernel - mathlink - linkmode Connect - linkprotocol TCPIP -
 linkname ’ ‘2‘’ - subkernel - noinit

  Note the user has to first  setup and check their  ssh (secure shell) capability fo
computer they wish to access.
```

Good luck! Email us if you have any problems, suggestions, etc. See our web page at http://www.pitt.edu/ tabakin/QDENSITY/

4 Sample output

Sample outputs are provided in the files MV2-NoiseX.nb and in GroverWX.nb.