###Nurse Scheduling Problem using Discrete Quadratic Model

##Team QuACK

#Problem Statement

We performed DQM (Discrete Quadratic Model) implementation of Nurse Scheduling Model developed by Ikeda, Nakamura and Humble (INH) using hybrid quantum annealing.

For the INH Nurse Scheduling problem we had to assign nurses to shifts complying by three constraints:

1. hard nurse constraint: no consecutive shifts for a nurse
2. hard shift constraint: at least one nurse present for one shift
3. soft nurse constraint: nurses should have “approximately” even schedule (the “softness” of the constraint is due to the approximation)

The nurse scheduling problem is a Non-deterministic Polynomial Time Hard Problem. (NP-hard problem)

This read me contains a holistic overview of the problem and the approaches we took to solve it.

#Discrete Quadratic Model (DQM)

The DQM is a quadratic polynomial which takes discrete variables such as {yellow, red, green} or {6.77, 3.45, 33.44}. Using DQM, encoding for discrete variable problems has become easier. The change from binary variables of BQM to discrete variables opens the door to solve new types of problems using a quantum computer.

The DQM function can be represented by a general form of:

E(\bf{x})

= \sum\_{i=1}^N \sum\_{u=1}^{n\_i} a\_{i,u} x\_{i,u}

+ \sum\_{i=1}^N \sum\_{j=i+1}^N \sum\_{u=1}^{n\_i} \sum\_{v=1}^{n\_j} b\_{i,j,u,v} x\_{i,u} x\_{j,v}

+ c

where there are N discrete variables with n\_i cases each.

#Hybrid Solvers

Hybrid solvers include the use of both CPU and QPU to solve a problem. Hybrid solvers ensure the optimum use of the QPU and delegate other tasks to the CPU and thus ensuring faster results and drastically increase the scope for the configuration space of the problems that we are solving.

#Formulation of the DQM

We formulate the problem into QUDO (Quadratic Unconstrained Discrete Optimization) where the solution space is of discrete variables.

\*copy paste the QUDO from script\*

{Hard nurse constraint in code

Hard shift constraint in code

soft nurse constraint in code}

\*the table format of the schedule\*

\*explanation\*

#Code Input and Output

The code takes an input of the number of nurses and number of number of days and gives an output of an optimized schedule.

#Applications:

Nurse Scheduling by hybrid QA can be used in hospitals to minimize operations as well as maximize the satisfaction of the nursing teams. Volkswagen currently uses D-Wave’s hybrid solver to optimize its paint shop scheduling applications. Hospitals can follow this example and can use our DQM nurse scheduling solution to boost their organizational efficiency.

#References:

1. <https://www.nature.com/articles/s41598-019-49172-3>
2. <https://github.com/dwave-examples/nurse-scheduling>
3. https://docs.dwavesys.com/docs/latest/index.html