Exercise: Programming

Session Outline

- Introduce where to find the code and how to open it
- Exercise: program the set partitioning and max cut QUBOs
- Review the solution (tomorrow)

Session Goals

1. Practice programming a QUBO onto Advantage

Material

Exercises – Leap Access

If you have access to Leap

1. Log in to Leap
2. In a new tab open up https://github.com/CornerstonesQC/Annealing_Challenges
   a) The instructions are in the ReadMe and the exercises are in the Day 2 folder. Note that both the set partitioning and max cut exercises are here.
3. To open up the code in the Leap IDE, type https://ide.dwavesys.io/# in front of the github URL.
   a) Alternatively open https://ide.dwavesys.io/#https:// github.com/CornerstonesQC/Annealing_Challenges
   b) You may complete the exercise in the Leap IDE

Exercises – No Leap Access

If you **DO NOT have access to Leap**

1. Install Ocean locally if you haven't already
   https://docs.ocean.dwavesys.com/en/latest/overview/install.html
2. Open and clone or copy the code in the Day 2 folder here:
   https://github.com/CornerstonesQC/Annealing_Challenges
   a) The instructions are in the ReadMe and the exercises are in the Day 2 folder. Note that both the set partitioning and max cut exercises are here
3. Instead of using the *DWaveSampler* and *EmbeddingComposite,* use *SimulatedAnnealing* instead. Replace the sampling code in the files with this:

```
from neal import SimulatedAnnealingSampler

sampler = SimulatedAnnealingSampler()
Sampleset = sampler.sample(bqm)
```

SimulatedAnnealingSampler documentation:
https://docs.ocean.dwavesys.com/en/latest/docs_neal/sdk_index.html

Reminders

Example: Set Partitioning

Problem

Partition the numbers in [-5, 9, 4] into two sets such that the sum of each set is equal

$$E_{qubo} = 260x_0 + 36\,x_1 - 64x_2 - 360x_0\,x_1 + 288x_1x_2 - 160x_0\,x_2$$

x_0	x_1	x_2	E
0	0	0	0
0	0	1	-64
0	1	0	36
0	1	1	260
1	0	0	260
1	0	1	36
1	1	0	-64
1	1	1	0

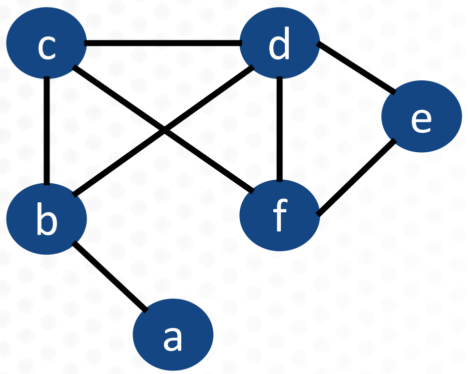
Example: Maximum Cut

Problem

Partition the set so that the partition cuts through a maximum number of edges

Step 5. Combine objectives and constraints

$$E_{qubo} = \sum_{(i,j)\in E} -x_i - x_j + 2x_i\, x_j$$



Let's expand this for our problem:

$$E_{qubo} = \begin{array}{c} \begin{array}{cccccc} a & b & c & d & e & f \end{array} \\ \begin{Bmatrix} -1 & 2 & 0 & 0 & 0 & 0 \\ & -3 & 2 & 2 & 0 & 0 \\ & & -3 & 2 & 0 & 2 \\ & & & -4 & 2 & 2 \\ & & & & -2 & 2 \\ & & & & & -3 \end{Bmatrix} \end{array} \begin{array}{c} a \\ b \\ c \\ d \\ e \\ f \end{array}$$

Challenge

How would you rewrite the maximum cut code so that it can run on any graph (like what we did with the antennas example).

The QUBO for the maximum cut problem is:

$$E_{qubo} = \sum_{(i,j)\in E} -x_i - x_j + 2x_i\, x_j$$