

D-Wave Leap tools

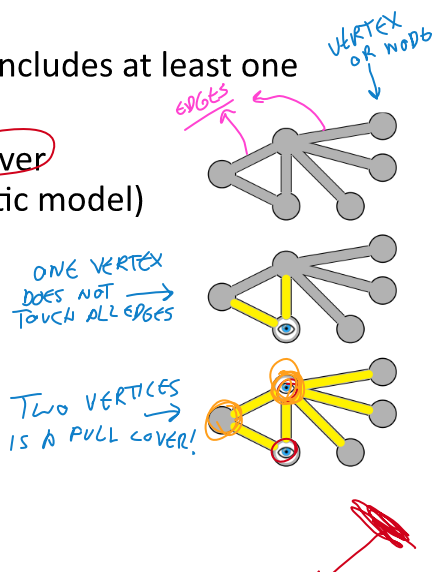
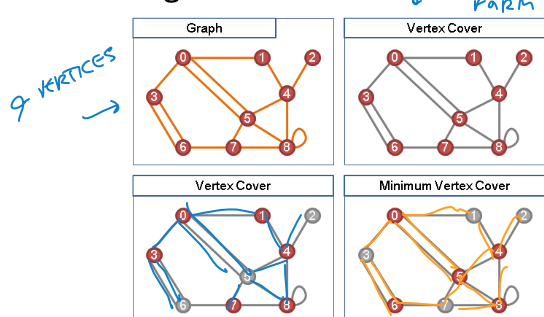
Examples: Vertex cover, map coloring

ANNOUNCEMENTS

- 1) AG WILL BE ONLINE SOON, ONLY 4 PROBLEMS (D-WAVE LEAP) ⇒ AG DUE APRIL 10
- 2) FINAL EXAM: TAKE HOME, START APRIL 14 9am, ENDS 48 HOURS LATER.
- 3) INFO ABOUT FINAL: I WILL TELL YOU A BRIEF DESCRIPTION OF EACH PROBLEM ONCE CES (COURSE EXP. SURVEY) REACHES 90%!
→ RIGHT NOW ONLY 2/9 RESPONSES.. 😞 89% 😊
- 4) TODAY IS LAST CLASS! $\sqrt{2}$

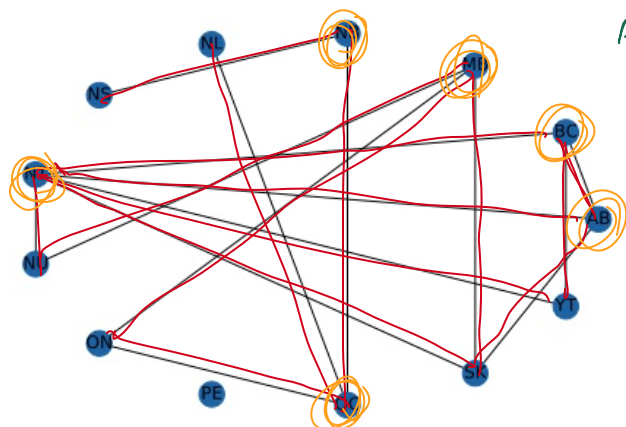
Minimum vertex cover problem

- Given a graph, find the **smallest** set of vertices that includes at least one endpoint of every edge of the graph.
- dwave_networkx contains a function `min_vertex_cover` that converts this problem to a BQM (binary quadratic model) and solves it using the QPU.



https://docs.ocean.dwavesys.com/en/latest/examples/min_vertex.html#min-vertex

Provinces of Canada: Min. Vertex Cover?



AB, BC, MB, NT, QC
NB

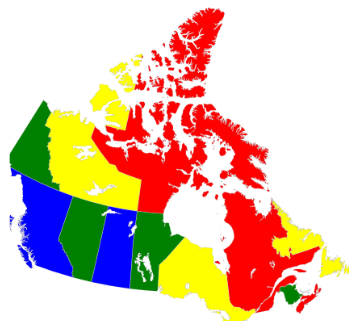
- See implementation in [Vertex_Cover_Example.ipynb](#)

Map coloring problem

- The map coloring problem is an example of CSP (Constraint satisfaction problem), similar to 3-SAT. D-Wave has convenient tools to implement CSPs.
- One way to solve the map coloring problem uses unary encoding:

Table 5 Translating Color to Binary.

Color	Naturals	Unary Encoding
Blue	1	$q_B, q_G, q_R, q_Y = 1, 0, 0, 0$
Green	2	$q_B, q_G, q_R, q_Y = 0, 1, 0, 0$
Red	3	$q_B, q_G, q_R, q_Y = 0, 0, 1, 0$
Yellow	4	$q_B, q_G, q_R, q_Y = 0, 0, 0, 1$



- For each province, this QUBO imposes the "once color" constraint:

$$E(q) = (q_B + q_G + q_R + q_Y - 1)^2$$

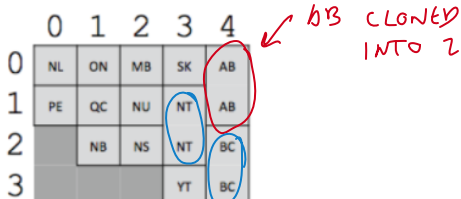
$\hat{=} - (q_B + q_G + q_R + q_Y) + 2(q_B q_G + q_B q_R + \dots)$

- Adding positive interactions between provinces ensure that they do not receive the same color. E.g. for BC and AB:

$$E(q) = \sum_{C \in \{B, G, R, Y\}} (+) q_C^{BC} q_C^{AB}$$

POSITIVE COUPLING

- The graph will usually not fit in the Chimera architecture. To embed, use clones (similar to chaining but for many qubits):



- More info here: https://docs.dwavesys.com/docs/latest/c_handbook_1.html

- See implementation in [Map_Coloring_Example.ipynb](#), with demonstration of D-Wave inspector to see how the graph was embedded in the QPU.