

Parallelized QAOA to optimize resource-bound firefighting

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Team Extinguish @ IonQHACK 2025


```
print("Base score: " + str(final_score(graph,XS_brut,counts,sho  
print("Balanced score: " + str(final_score(graph,XS_brut,counts  
print("Connected score: " + str(final_score(graph,XS_brut,counts  
3] ✓ 0.0s
```

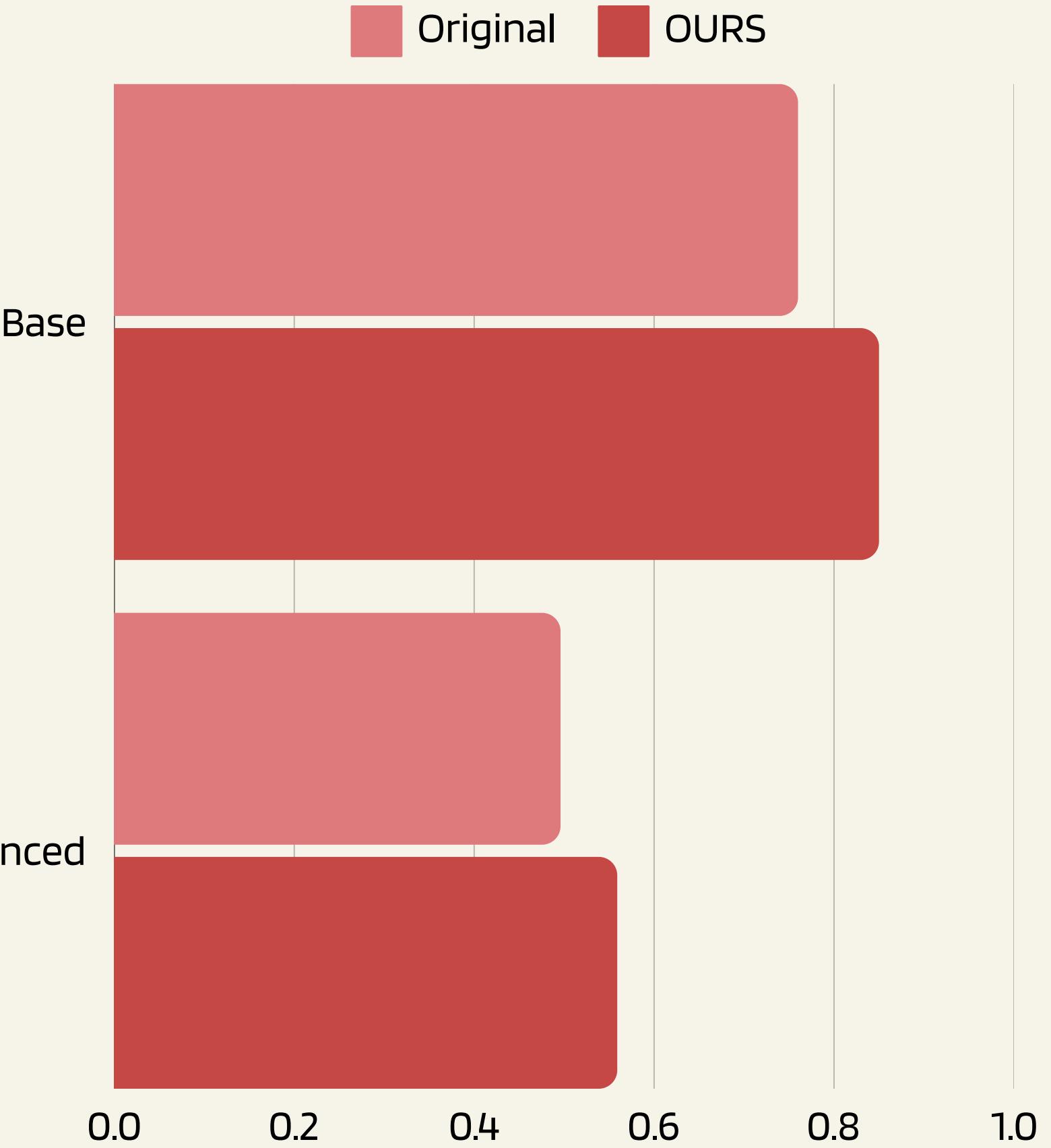
```
Base score: 0.76039  
Balanced score: 0.49614  
Connected score: 0.0002
```

```
# calculate our version of the score for the final solution  
print("Base score: " + str(final_score(graph,XS_brut,counts,sho  
print("Balanced score: " + str(final_score(graph,XS_brut,counts  
print("Connected score: " + str(final_score(graph,XS_brut,counts  
4] ✓ 0.0s
```

```
Base score: 0.83331  
Balanced score: 0.54372  
Connected score: 0.00022
```

```
# calculate our version of the score for the final solution  
print("Base score: " + str(final_score(graph,XS_brut,counts,sho  
print("Balanced score: " + str(final_score(graph,XS_brut,counts  
print("Connected score: " + str(final_score(graph,XS_brut,counts  
5] ✓ 0.0s
```

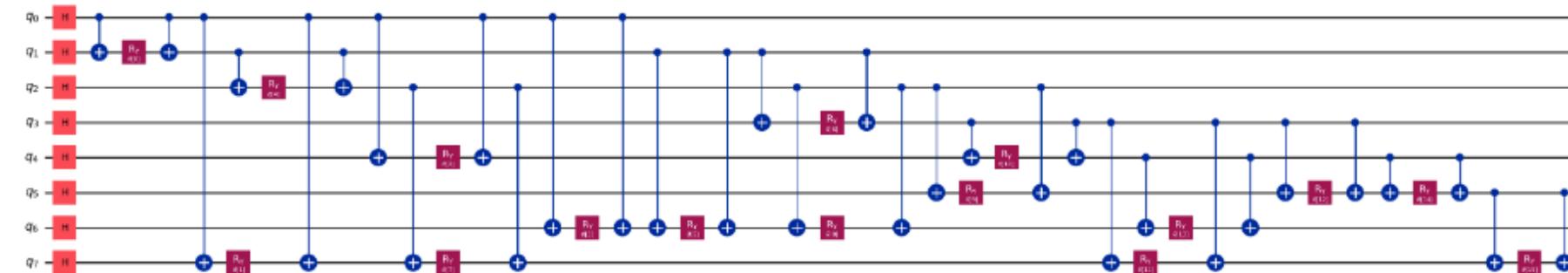
```
Base score: 0.85678  
Balanced score: 0.55904  
Connected score: 0.00023
```



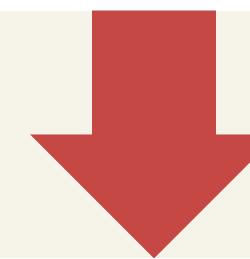
In [260...]

```
ansatz = build_ansatz(graph)
ansatz.draw("mpl", fold=-1)
```

Out[260...]

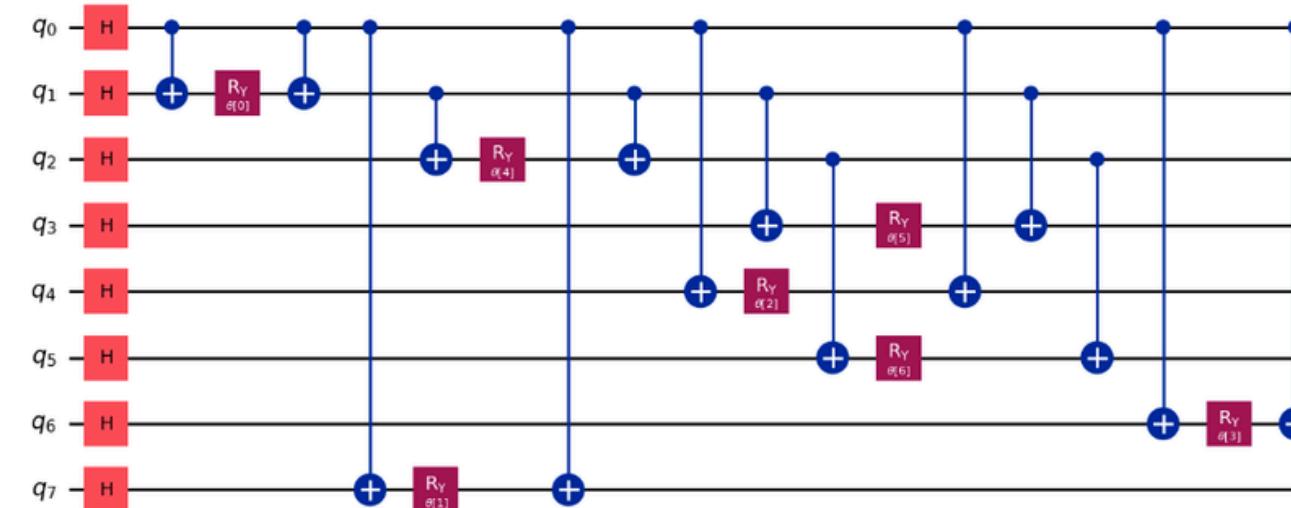


Challenge 1



Smaller circuit depths

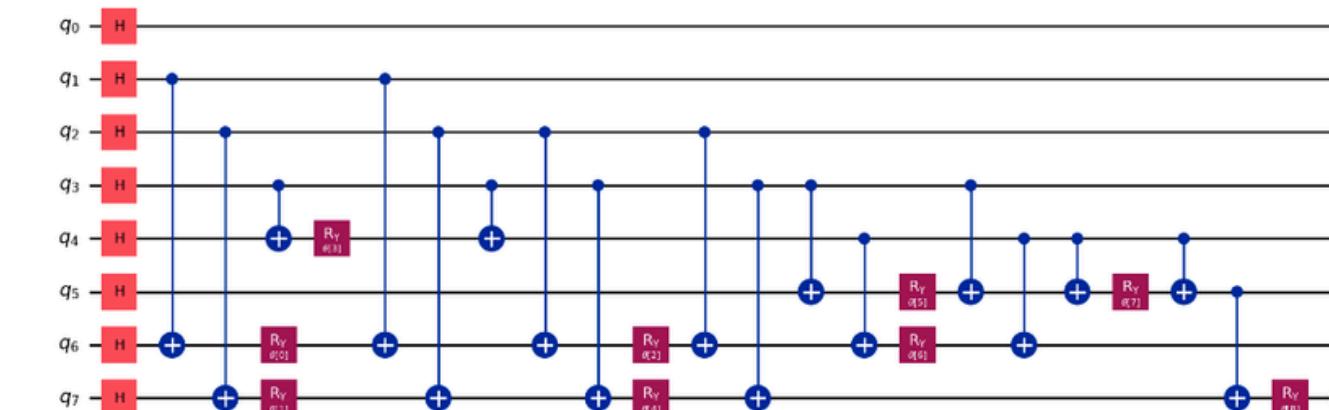
Out[258...]



In [259...]

```
# visualize the ansatz circuit for the graph with the tree edges removed
ansatz_H.draw("mpl", fold=-1)
```

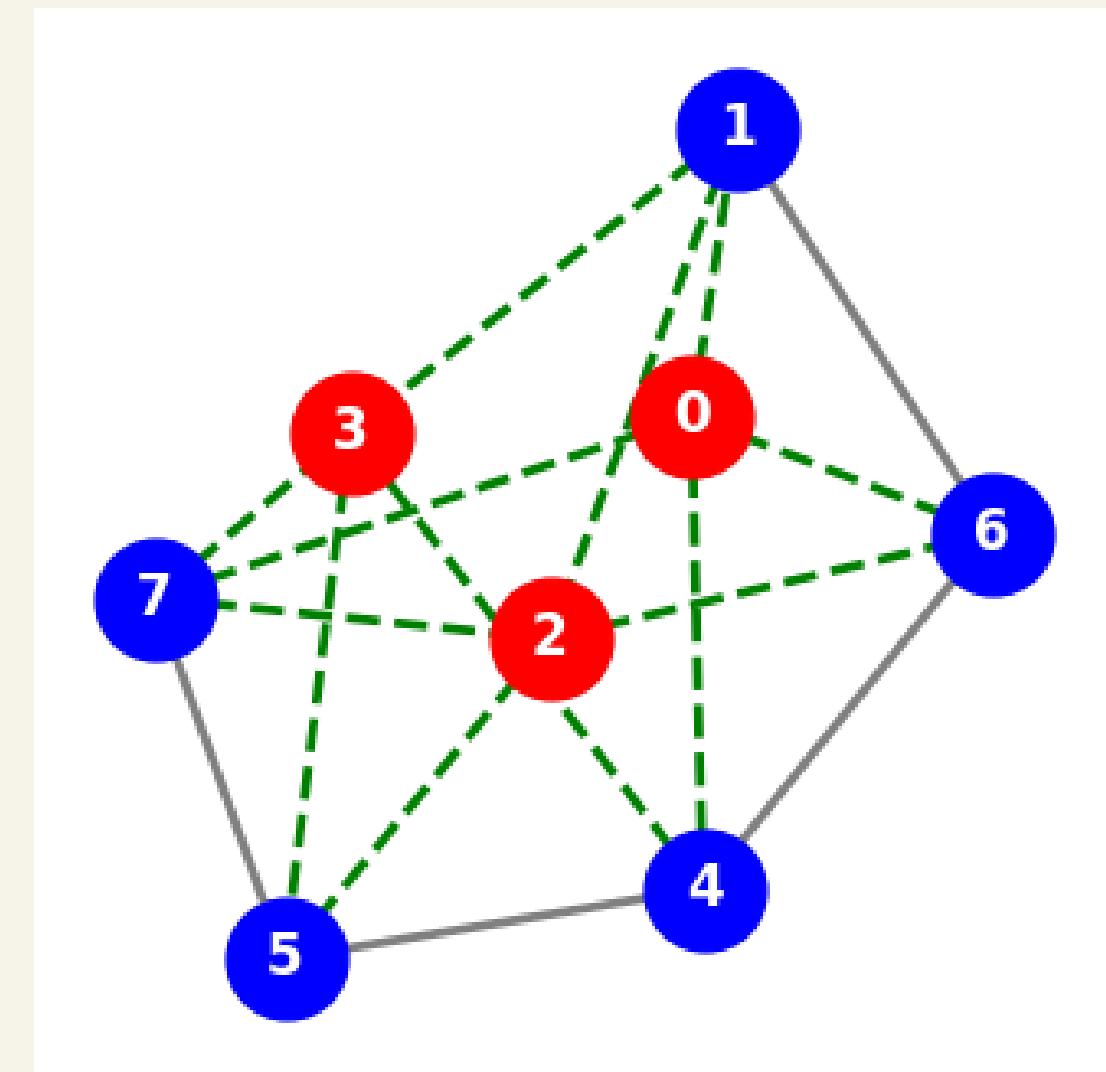
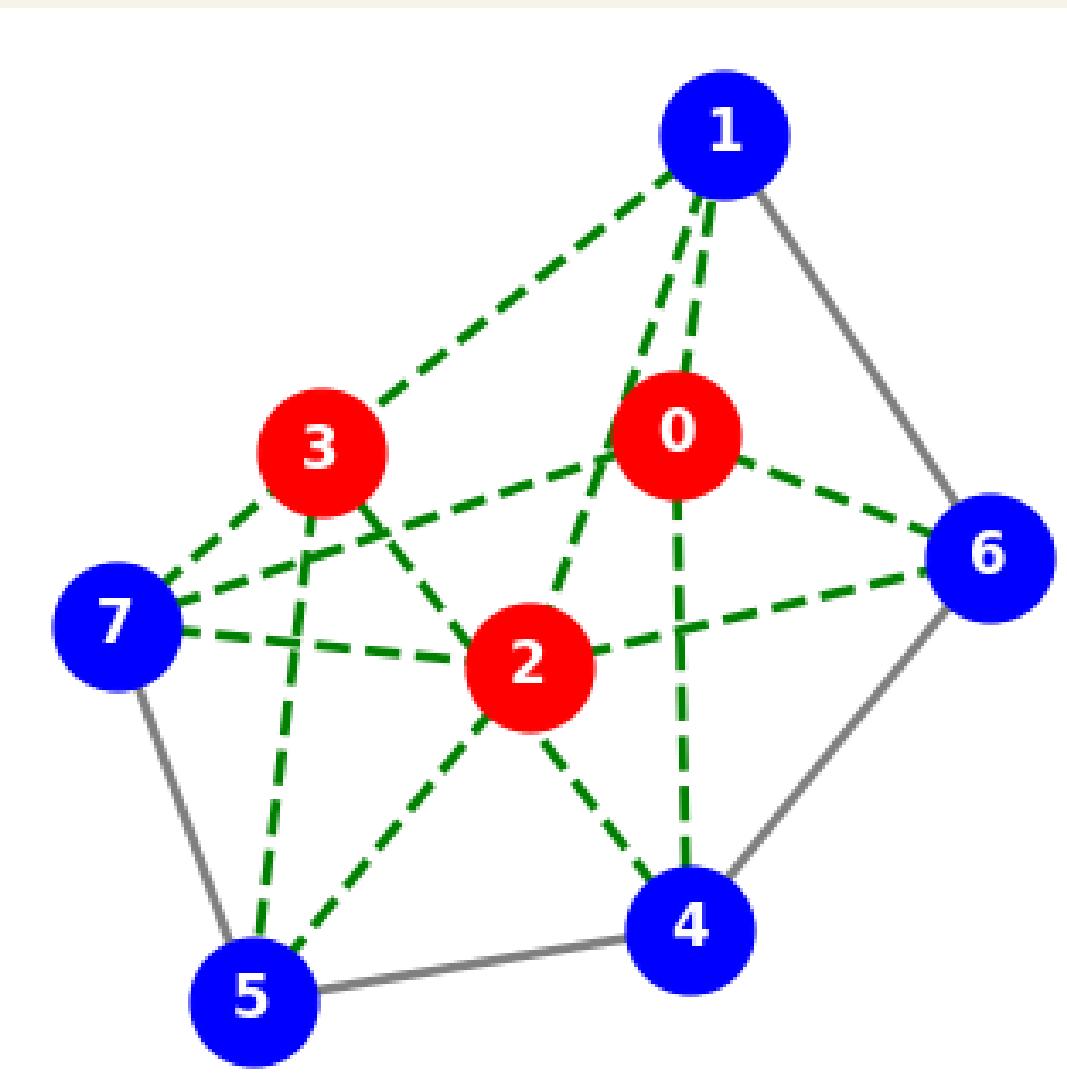
Out[259...]



Challenge 2

1. We add a balancing term to the Hamiltonian that punishes the algorithm for having unbalanced subsets
2. This is constructed as the square of sum of Z-gates on all qubits

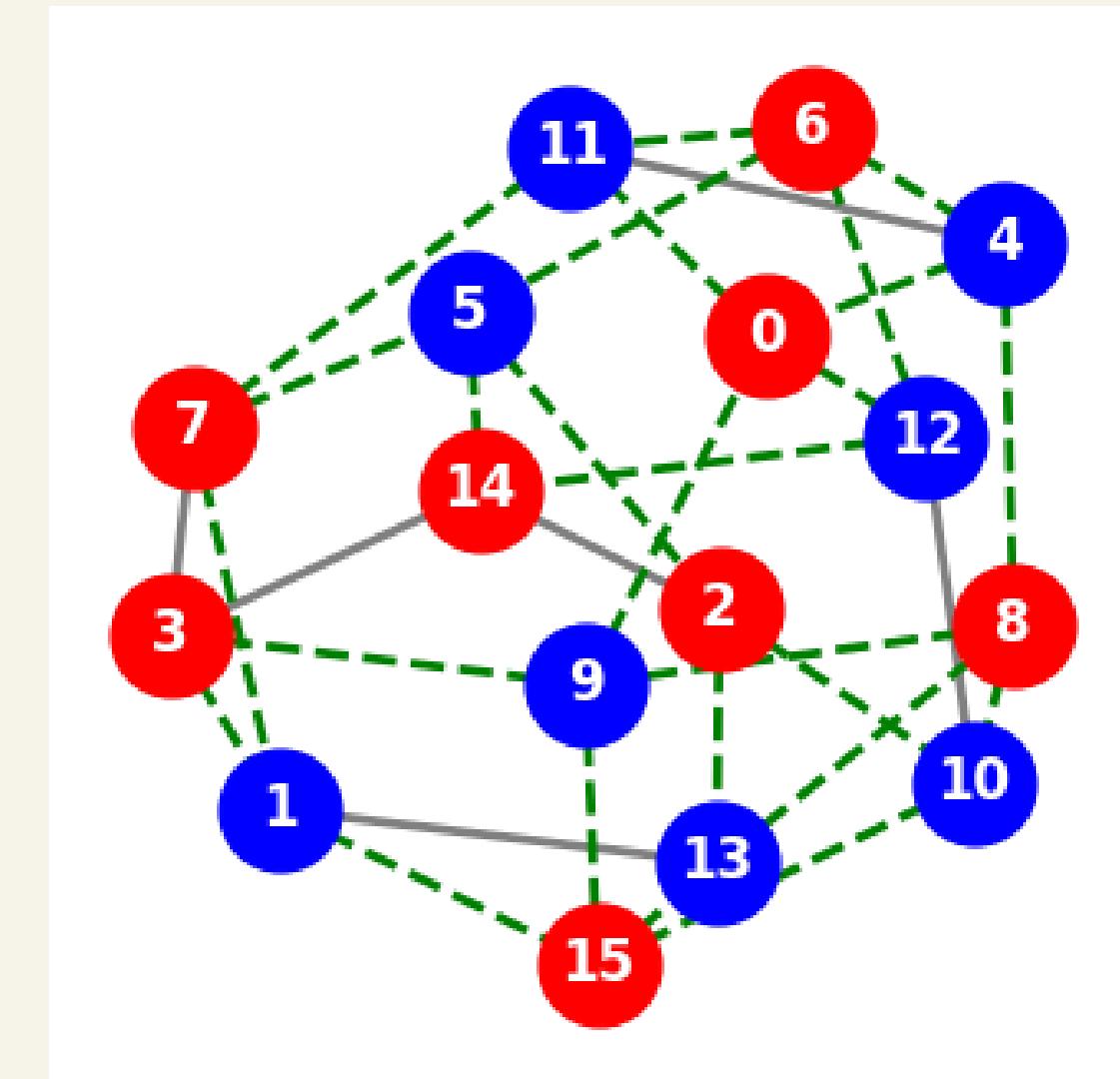
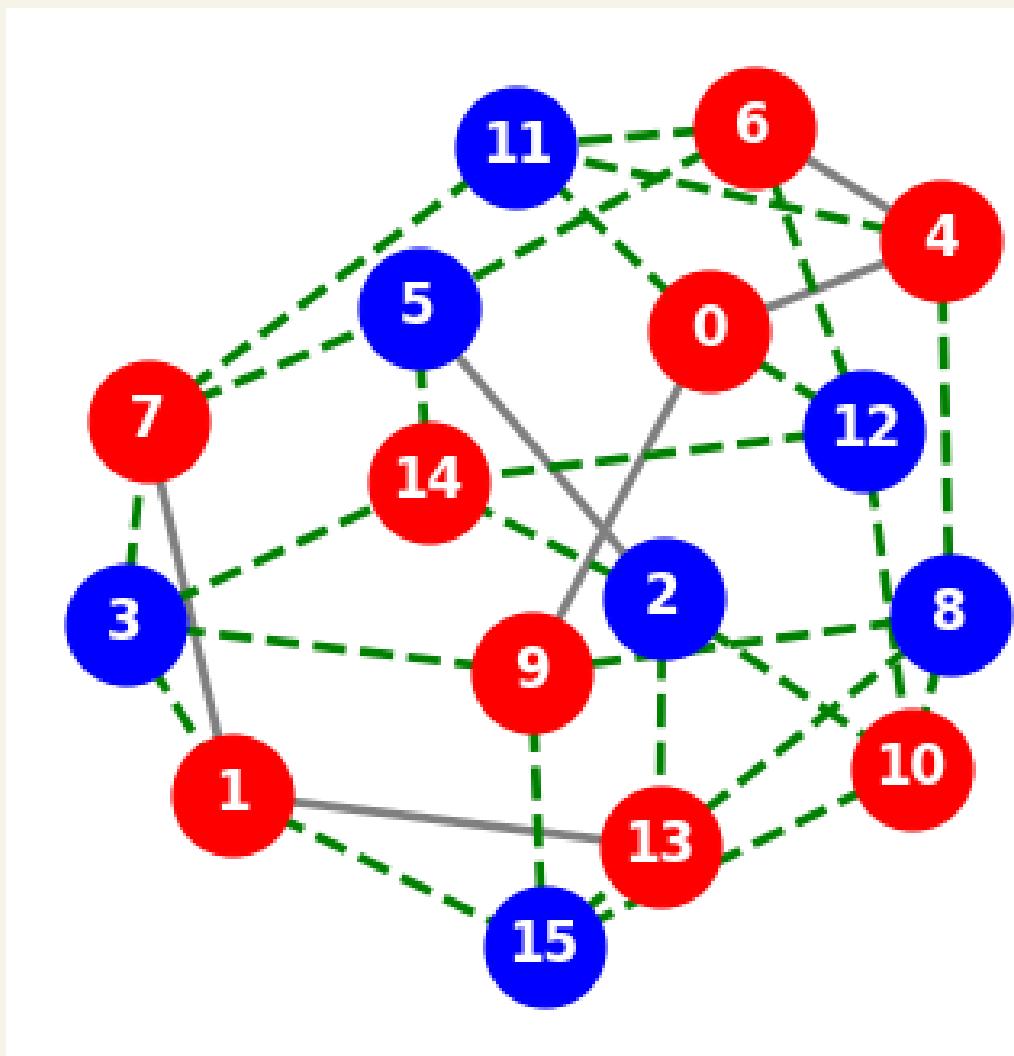
$$H_{total} = H_{max-cut} + \lambda(\sum_{i=1}^n Z_i)^2$$



Challenge 2

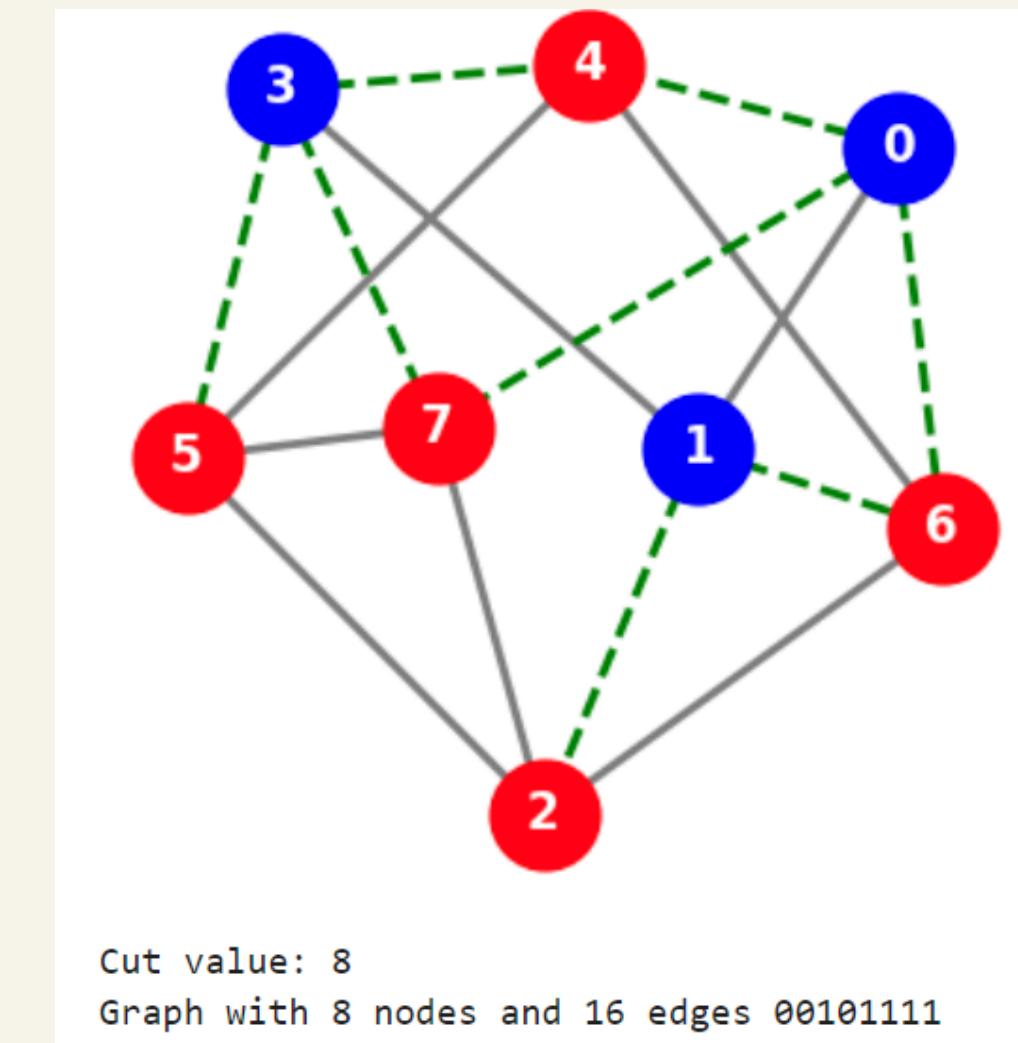
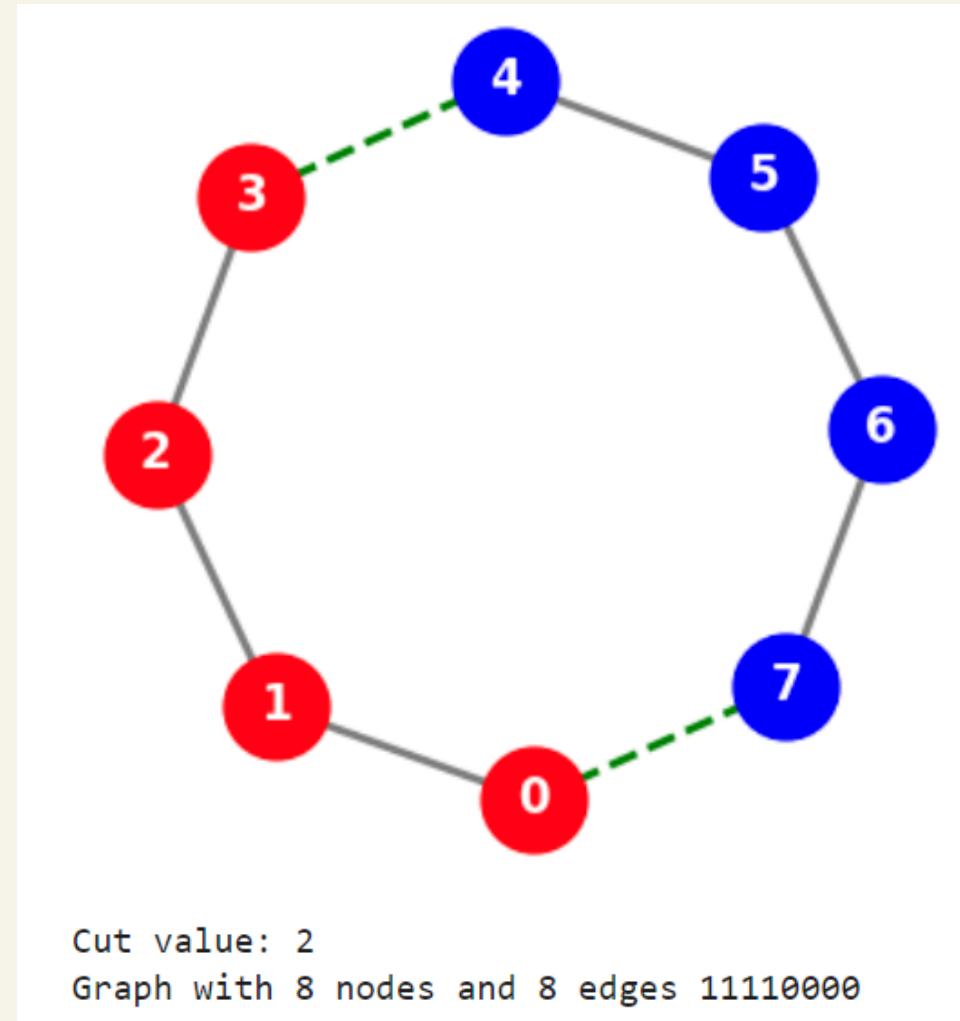
1. We add a balancing term to the Hamiltonian that punishes the algorithm for having unbalanced subsets
2. This is constructed as the square of sum of Z-gates on all qubits

$$H_{total} = H_{max-cut} + \lambda(\sum_{i=1}^n Z_i)^2$$



Challenge 3

1. Use Minimum spanning trees to ensure connectedness
2. Making sure that the minimum spanning tree is sliced only once ensures that the subgraphs are connected
3. We punish slicing the spanning tree to make sure they don't make more than a single cut
4. This naive method introduces instability in the solution and fails to work for large graphs





STEP 1 & STEP 2

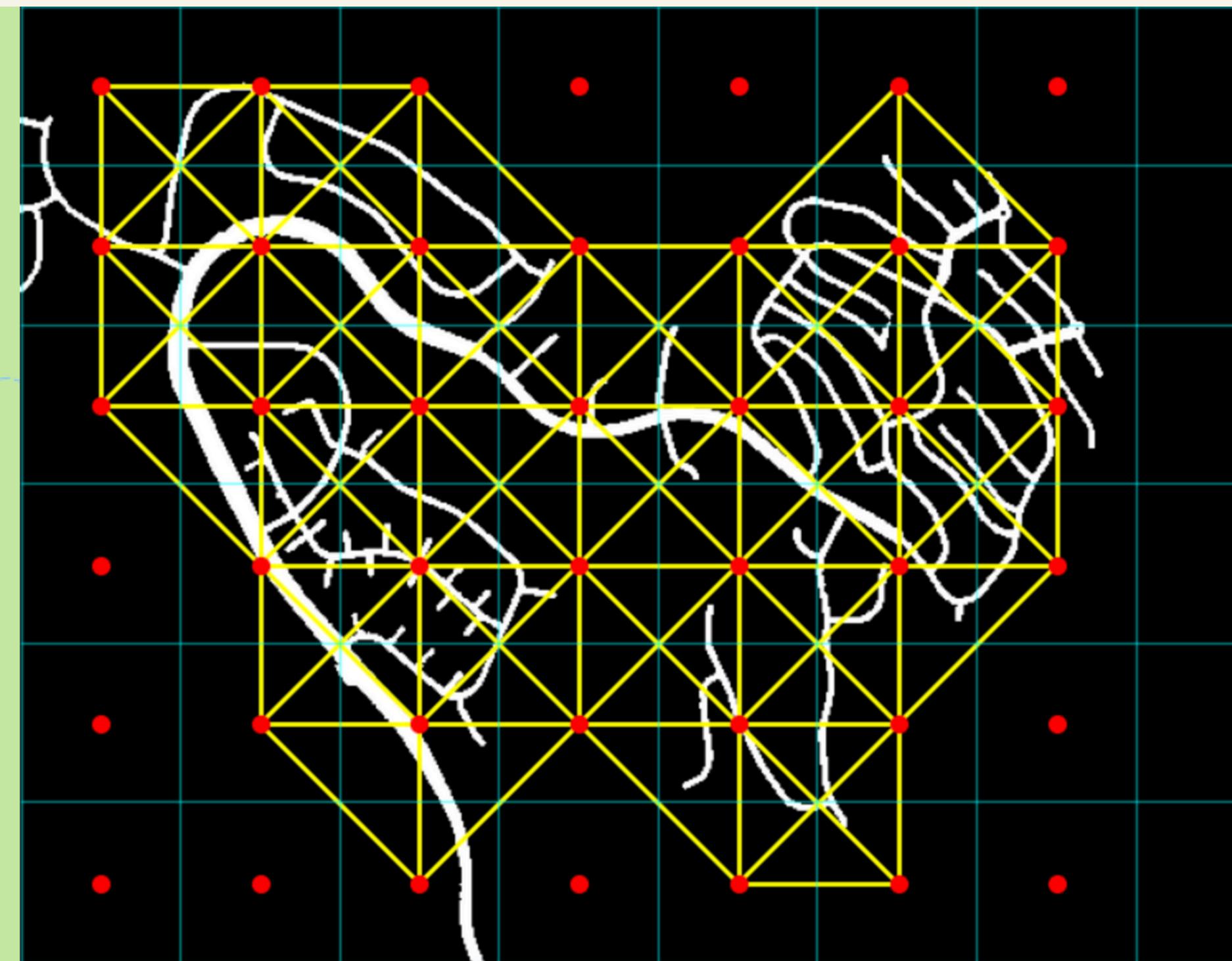
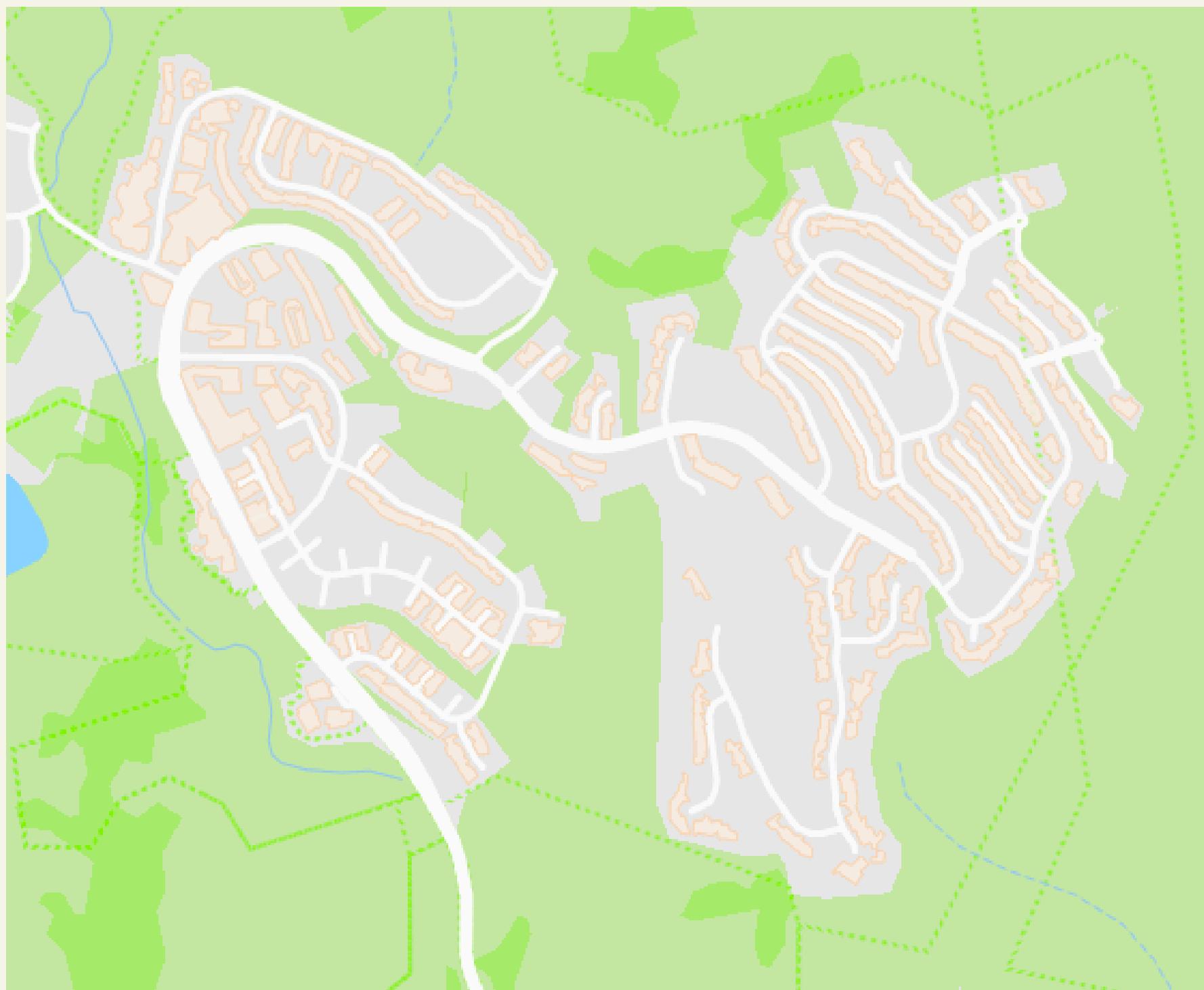
**1. Use Sentinel-2
satellite imagery**



Palisades Los Angeles, CA. Jan 2025

**2. Convert into a
graph 3**

- Grid layout.
- Cells are nodes.
- Edges connect cells within "range" with paths between





IMPACT

- We distribute the limited water and volunteer resources to ONE of the two groups.
- Once a fire is out in one location, the resources have an edge to a Node in the other group that does not have resources and can quickly move over to that.

THANK YOU!

