Supplementary Material

1 PREDICTING TRANSFERABILITY USING PARITY – EXTENSION

Parity of graph correlates with the approximation ratios of a graph on the 6 centers shown in Figure 10 in the main text. This trend can also be used to predict similarity, given two assumptions.

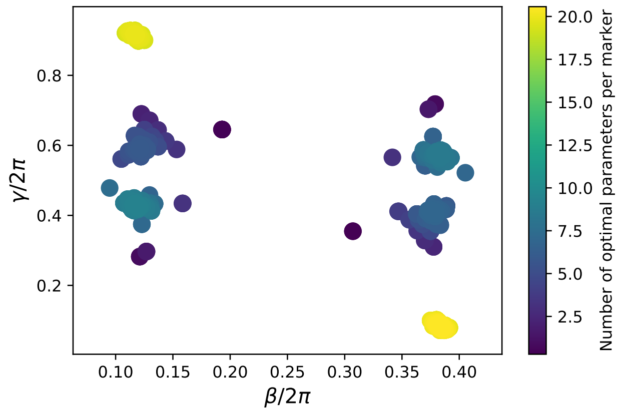

Figure S1. Distribution of optimal parameters of 110 20-node random graphs. For each graph, we plot 20 optimal parameters, obtained from 20 multistarts with random initial points.

First, the 20 computed optima are distributed among the 6 centers. This can be verified for 20-node graphs in Figure S1. Second, we can predict the location of these centers from the following observations from Figure 8 in the main text and Figure S2:

- All graphs have 4 local optima, two of which are universal.
- For perfectly odd and perfectly even graphs, the local optima are distributed equally among the the four local optima.
- The fraction of optimal parameters which are universal increase and that of optimal parameters which are nonuniversal decrease decrease as parity of a graph becomes mixed.
- Graphs that have c_3 as their optima also have c_4 as their optima. The same is true for centers c_5 and c_6.

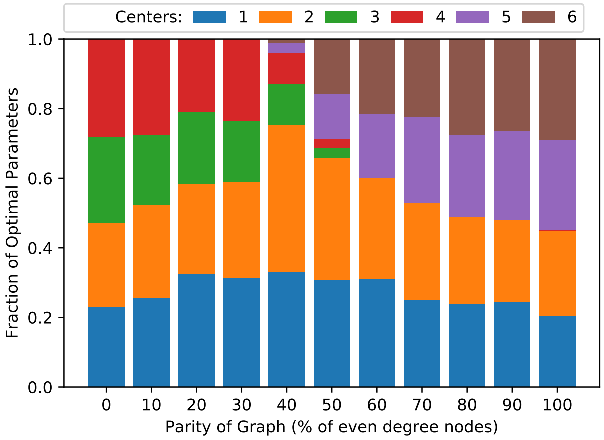

Figure S2. Sorting the computed optimal parameters of 110 20-node random graphs in Figure S1 based on their vicinity to the 6 centers in Figure 10. Clearly, for most graphs, at least half of the computer optimal parameters were universal, that is, near centers $1, 2$.

Algorithm 1 combines these observations to predict the distribution of local optima for a graph among the 6 centers: where $AR(G, c_i)$ is the approximation ratio of graph G at

Algorithm 1 Optima Distribution

procedure OPTIMADISTRIBUTION(G)
    $n_{1,2} = n_{3,4} = n_{5,6} = 0$
    $n_{1,2} = 10$
    if $AR(G, c_3) > 0.75$ **then**
        $n_{3,4} = 10((AR(G, c_3) - 0.75)/0.25)$
        $n_{1,2} += 10 - n_{3,4}$
    else if $AR(G, c_5) > 0.75$ **then**
        $n_{5,6} = 10((AR(G, c_5) - 0.75)/0.25)$
        $n_{1,2} += 10 - n_{5,6}$
    else
        $n_{1,2} += 10$
    end if
    return $n_{1,2}, n_{3,4}, n_{5,6}$
end procedure

center c_i and $n_{i,j}$ is the number of local optima distributed equally among centers c_i, c_j.

Given these assumptions, for a given donor D and acceptor A, we first compute OptimaDistribution(D), that is, distribution of optimal parameters of the donor graph.

Let n_i be the number of optima of the donor graph D occurring at center c_i. Then the subgraph + parity similarity metric is

$$\text{SPS}(D, A) = \frac{1}{20} \sum_{i=1}^{6} n_i AR(A, c_i). \tag{S1}$$

2 COMPARING METRICS

To see correlation between subgraph similarity metric and parity similarity metric, we compare these metrics for the transferability studies performed on the large set of 6–20-node acceptor graphs and fixed 64-, 128-, and 256-node acceptor graphs. Figure S3 shows a correlation between subgraph similarity and parity similarity. Furthermore, we see that for either a high subgraph similarity or high parity similarity we obtain a good approximation ratio.

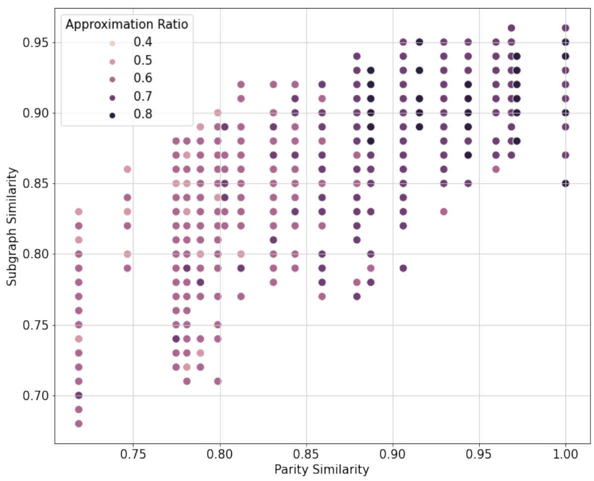

Figure S3. Comparison of subgraph similarity with parity similarity. We see a correlation not only between similarity metrics but also with the approximation ratio.

Furthermore, for the case of 100^2 20-node graph pairs, we do a statistical comparison of the three metrics we propose. There results are given in Table S1. While SPS may not have the best mean squared error or the best Pearson correlation coefficient, it best captures the relationship between parity and transferability coefficients. This is evident

Table S1.

Statistical Comparison	SS	PS	SPS
Mean Squared Error	0.0041	0.0025	.0037
Pearson Correlation Coefficient	0.8298	0.7963	0.7721

from the heatmap in Figure S5 closely resembling the heatmap of Figure 7 in the main text. However, the former assumes that the latter is symmetric about $x = 50\%$, which results in inconsistencies between SPS and true similarity.

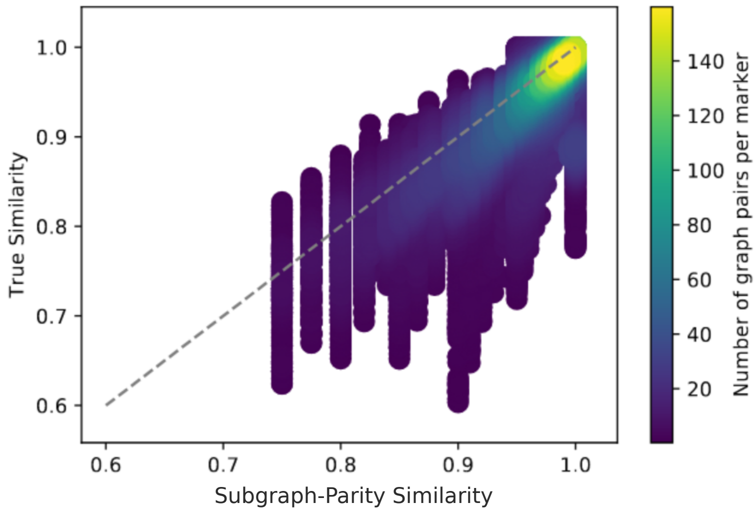

Figure S4. Comparison of subgraph similarity metric SPS with true similarity for 110^2 graph pairs consisting of 20-node graphs.

DATA AVAILABILITY

The data and figures produced for this article can be found in the GitHub repository: `https://github.com/EeshGupta/Transferability-of-QAOA-Parameters-2021`.

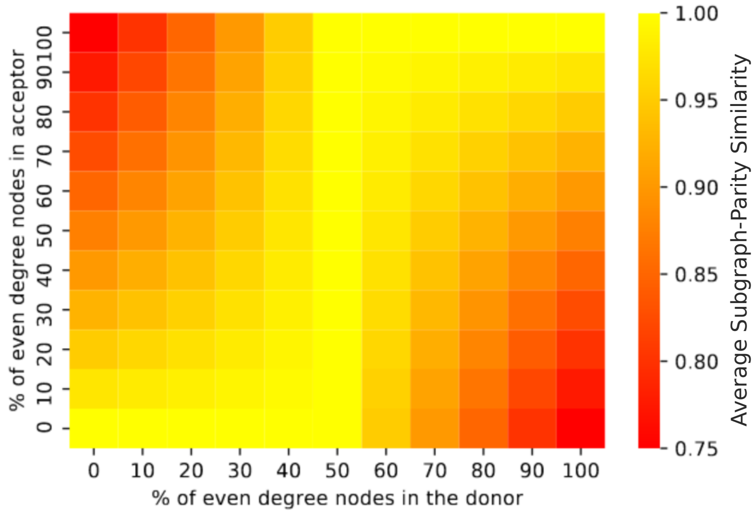

Figure S5. Sorting parity similarity metric SPS for graph pairs based on the parity of the donor and the acceptor.