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Questão 1

Criar grafos conexos com diferentes quantidades de vértices e graus de conectividade.

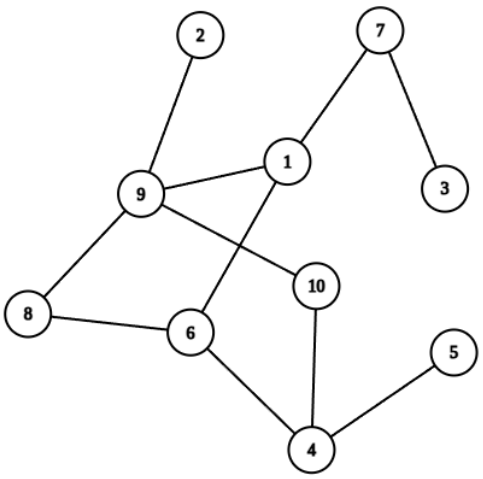
```c
void gera_arestas_aleatorias(Grafo* grafo, float grau_conexidade) {
    int numVertices = grafo->numVertices;
    int arestas = (int)(grau_conexidade * numVertices * (numVertices - 1)) / 2;

    if (arestas < numVertices - 1) {
        printf("Impossivel gerar um grafo conexo, faltam arestas.\n");
    }
```

Veja que a função **gera_arestas_aleatorias** garante a conexidade do grafo ao criar uma árvore base conectando todos os vértices com **numVertices - 1** arestas, formando assim um grafo conexo antes de adicionar arestas aleatórias extras.

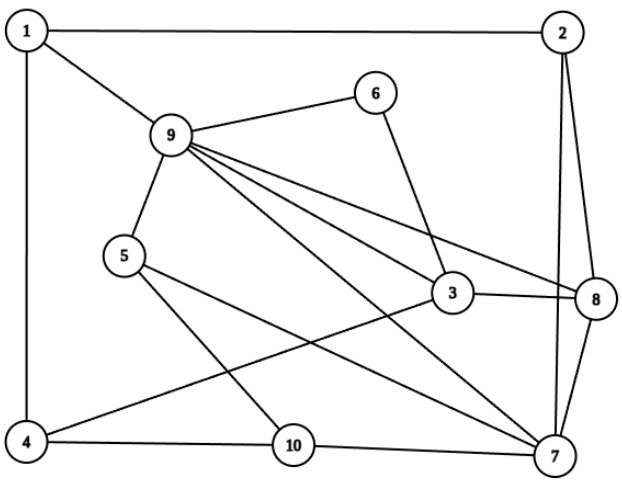
Matriz de Adjacência (10 vértices) e 25% de conectividade:

0 0 0 0 0 1 1 0 1 0
0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 1 0 0 0
0 0 0 0 1 1 0 0 0 1
0 0 0 1 0 0 0 0 0 0
1 0 0 1 0 0 0 1 0 0
1 0 1 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 1 0
1 1 0 0 0 0 0 1 0 1
0 0 0 1 0 0 0 0 1 0



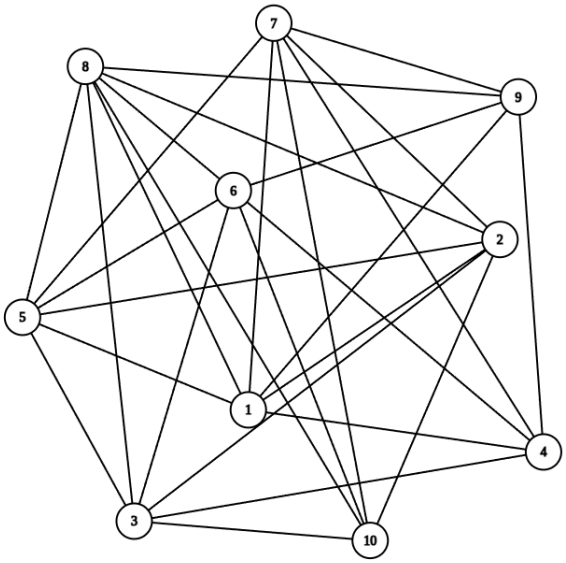
Matriz de Adjacência (10 vértices) e 40% de conectividade :

0 1 0 1 0 0 0 0 1 0
1 0 0 0 0 0 1 1 0 0
0 0 0 1 0 1 0 1 1 0
1 0 1 0 0 0 0 0 0 1
0 0 0 0 0 0 1 0 1 1
0 0 1 0 0 0 0 0 1 0
0 1 0 0 1 0 0 1 1 1
0 1 1 0 0 0 1 0 1 0
1 0 1 0 1 1 1 1 0 0
0 0 0 1 1 0 1 0 0 0



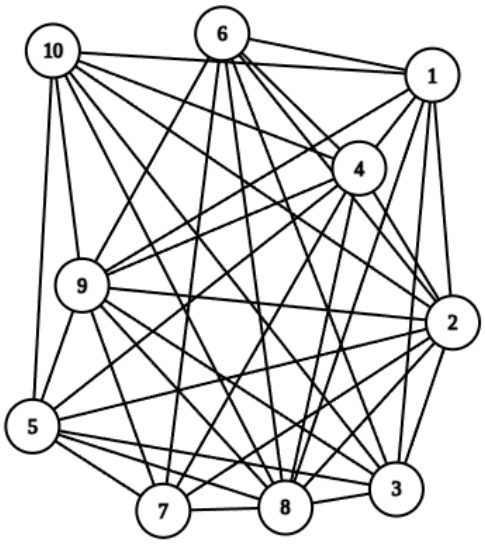
Matriz de Adjacência (10 vértices) e 65% de conectividade:

0 1 0 1 1 0 1 1 1 0
1 0 1 0 1 0 1 1 0 1
0 1 0 1 1 1 0 1 0 1
1 0 1 0 0 1 1 0 1 0
1 1 1 0 0 1 1 1 0 0
0 0 1 1 1 0 0 1 1 1
1 1 0 1 1 0 0 0 1 1
1 1 1 0 1 1 0 0 1 1
1 0 0 1 0 1 1 1 0 0
0 1 1 0 0 1 1 1 0 0



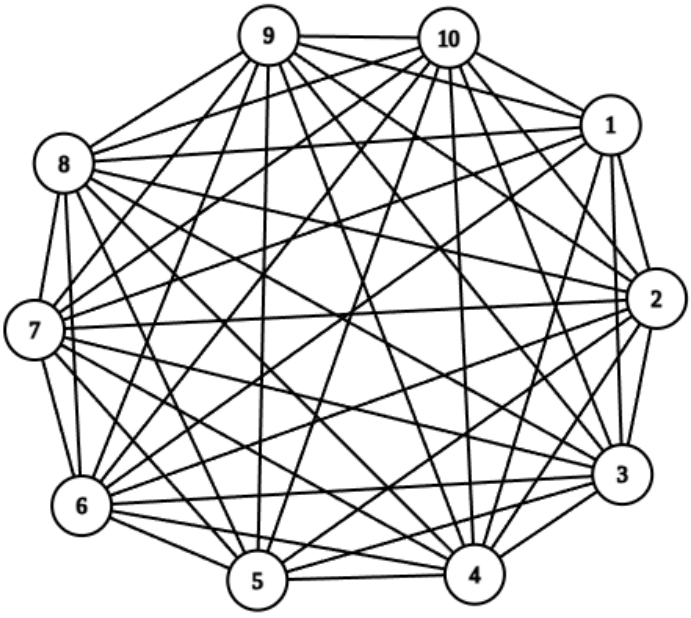
Matriz de Adjacência (10 vértices) e 85% de conectividade:

0 1 1 1 0 1 0 1 1 1
1 0 1 1 1 1 1 1 1 1
1 1 0 0 1 1 0 1 1 1
1 1 0 0 1 1 1 1 1 1
0 1 1 1 0 0 1 1 1 1
1 1 1 1 0 0 1 1 1 0
0 1 0 1 1 1 0 1 1 0
1 1 1 1 1 1 1 0 1 1
1 1 1 1 1 1 1 1 0 1
1 1 1 1 1 0 0 1 1 0



Matriz de Adjacência (10 vértices) e 100% de conectividade:

0 1 1 1 1 1 1 1 1 1
1 0 1 1 1 1 1 1 1 1
1 1 0 1 1 1 1 1 1 1
1 1 1 0 1 1 1 1 1 1
1 1 1 1 0 1 1 1 1 1
1 1 1 1 1 0 1 1 1 1
1 1 1 1 1 1 0 1 1 1
1 1 1 1 1 1 1 0 1 1
1 1 1 1 1 1 1 1 0 1
1 1 1 1 1 1 1 1 1 0



Matriz de Adjacência (50 vértices) e 25% de conectividade:

0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 0
0 0 0 0 1 0 0 0 1 0 1 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0 0 0 0
1 0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0
0 0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0
0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1 1 0 0 1 0 0
0 0 0 1 0 0 0 0 0 0 1 0 1 0 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0
1 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 1
0 1 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 1 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1
0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 0
0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 1 0 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 1
1 0 1 0 0 0 1 1 0 1 0 0 0 0 0 0 0 1 1 1 0 1 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1
0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 1 1 0 0
0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1
1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 0
1 1 0 0 0 0 0 0 1 0 0 1 0 0 1 1 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 1 1
0 0 1 0 0 0 1 1 0 0 0 0 1 0 1 0 0 0 0 0 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0 1 0 0 1 0 0 1 0
1 1 1 0 0 1 0 0 0 0 0 1 1 0 0 1 1 0 0 0 0 1 1 0 1 1 1 0 1 0 0 1 0 0 0 0 0 1 1 1 0 0 1 0 0 0 0 1 1 1
1 0 1 0 0 0 0 0 0 1 0 1 1 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0
0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 1 0 1 1 0 0 0 0 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 0 1 1 1 0 1
0 0 0 1 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 1 0 1 1 0 0
0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 1
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 0 1 0 0 0 0 0 0 0 1 1 1 0 0 1 0 1 0 1 1 0 1 0 0 0 0 0 0
0 0 1 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 1 0 1 0 0 0 0 1 0 0 1 0 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 1 1
0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 1 1 0
0 0 0 0 0 0 0 1 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0
0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0
0 0 0 1 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 1 0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 1 0
1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 1 1 0 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 0
0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0
1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 1 0 1 1 0 1 0 0 1 0 0 0 0
0 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0
0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 1 0 1 1 0 0 0 0
0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 1 1 0 0 0 0
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 0 1 0 0 0 0 0 0 0 1 1 1 0 0 1 0 1 0 1 1 0 1 0 0 0 0 0 0
0 0 1 1 1 0 1 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 1 0 1 0 0 0 0 1 0 0 1 0 0 0 0 1 1 0 1 1 0 0 0 0 0 0 0 1 1
0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 1 0 0 1 1 0
0 0 0 0 0 0 0 1 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 0
0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 1 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0
0 0 0 1 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 1 1 0
0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0
1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 1 1 1 0 1 0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 0
1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 0 1 0 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 1 1 0 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 1 0
0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0
1 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 1 0 1 1 0 1 0 0 1 0 0 0 0
0 0 1 1 0 0 0 0 0 1 0 0 1 0 0 0 0 1 1 1 0 0 0 0 1 0 1 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0
0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 1 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 1 0 1 0 1 0 1 0 1 0 0 0 1 0 1 0 1 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 1 1 0 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 1 0 0 1 0 1 0 1 0 1 0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Matriz de Adjacência (50 vértices) e 40% de conectividade:

0 0 0 0 0 0 1 0 0 1 0 1 1 0 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0
0 0 1 0 0 1 1 0 1 0 0 1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 0 1 1 0 0 0 0 0 1 0 0 0 0
0 1 0 1 0 0 0 0 0 1 0 1 1 1 0 0 0 0 0 1 1 1 1 0 0 1 1 0 0 0 0 1 1 0 0 1 0 0 0 0 1 1 0 1 0 1 1 0 0 1
0 0 1 0 1 0 0 1 0 1 0 0 1 1 1 1 0 0 0 0 1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1 0 1 1 0 0 1 0 0 0 0 0 1 0 0
0 0 0 1 0 1 1 1 0 1 1 1 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 1 0 1 0 1 1 0 0 1 1
0 1 0 0 1 0 0 0 1 0 0 0 1 1 0 1 0 1 0 0 1 0 0 0 0 0 0 1 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 1 1 0 1 1 0
1 1 0 0 1 0 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 1 0 1 1 1 0 0 0 1 1 1 0 1 0 1 1 0 1 0 0 0 1 0 0 0 0 0 1 1
0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 1 0 1 1 1 1 0 1 0 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 1 0
0 1 0 0 0 1 0 0 0 1 1 1 1 0 1 0 0 1 1 0 0 0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0 1 0 0
1 0 1 1 1 0 1 1 1 0 1 1 1 0 1 0 0 0 0 0 1 1 0 0 1 1 0 0 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 0 0 1 1 1 0 1
0 0 0 0 1 0 0 0 1 1 0 0 0 1 1 1 0 1 0 0 1 0 0 1 0 1 1 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 1 1 0 0 0 1 0 1
1 1 1 0 1 0 1 0 1 1 0 0 0 0 1 0 0 0 0 1 0 0 1 1 1 0 0 1 1 0 0 0 1 0 0 1 0 0 0 1 0 1 1 0 1 1 1 1 0 0
1 1 1 1 1 1 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 1 0 1 0 0 0 1 0 0 0 0 1 0 0 1 0
0 1 1 1 0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0 1 0 1 1 1 0 0 0 0 1 1 1 0 1 1 1 0 1 0 0 0 0 1 0 0 1 0 0 1 1
0 0 0 1 0 0 0 0 1 1 1 1 1 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 1 1 0 0 1 0 1 1 1 0 0 0 1 1 0 1 1
0 1 0 1 0 1 0 1 0 0 1 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0 1 0 1 1 1 1 1 1 0 0 0 0 0 0 1 0
0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0 1 0 0 1 1 0 0
1 0 0 0 0 1 1 1 1 0 1 0 0 1 1 0 0 0 0 0 1 1 1 1 1 1 0 1 0 1 0 1 0 0 0 1 0 0 0 0 0 0 1 1 1 1 0 1 1 0
1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 1 0 0 1 1 0 0 1 0 1 0 1 0 0 1 1 0 1 1 0 1 0 0 0 0
0 0 1 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 1 1 0 1 0 0 1 1 1 0 0 0 0 0 0 1 0 0 0 0 0
0 0 1 1 0 1 0 0 0 1 1 0 0 1 0 0 0 1 1 0 0 0 1 0 0 0 0 1 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 1 1 0 1 0
0 0 1 1 1 0 1 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 1 1 1 0 1 0 0 0 0 1 1 0 0 1 0 0 0 1 0 1 0 1 0 0 0
1 0 1 1 0 0 0 0 0 0 0 1 0 1 1 0 0 1 0 0 1 1 0 1 0 1 0 0 0 1 1 0 0 1 1 0 1 0 0 0 1 0 0 1 0 1 1 1 1 0
0 0 0 0 0 0 1 0 0 0 1 1 1 1 0 0 0 1 0 1 0 0 1 0 0 1 0 0 1 1 0 1 0 0 0 0 0 1 1 1 0 0 1 0 1 0 0 0 1 0
0 0 0 0 0 0 1 1 0 1 0 1 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1 0 1 0 1 0 0 0 1 1
0 0 1 1 1 0 1 0 0 1 1 0 1 0 0 0 1 1 1 1 0 1 1 1 0 0 1 0 0 0 1 0 1 0 0 0 1 1 0 1 1 1 1 0 0 1 0 0 0 0
0 0 1 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0 1 0 0 0 1 0 1 0 1 1 0 0 1 1 1 0 0 1 1 0
0 0 0 0 1 1 0 1 1 0 0 1 1 0 0 0 0 1 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 1 1 1 1 1 0 1 0 0 1
0 1 0 0 0 0 0 1 0 0 1 1 0 0 1 0 0 0 1 0 0 0 0 1 1 0 1 0 0 0 1 1 0 1 0 0 1 1 0 0 1 0 1 0 0 1 1 1 0 1
0 1 0 0 0 1 1 1 0 0 1 0 0 1 0 1 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 1 0 1 1 1 1 0 0 1 1 1
1 1 0 1 0 0 1 0 1 0 0 0 1 1 0 1 0 0 0 1 0 0 1 0 1 1 1 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 0 1 0 1 0
0 0 1 1 0 0 1 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 1 1 0 0 0 1 1 0 0 0 0 0 1 1 1 0 0 1 1 0 0 1 0 1 1 1 1
0 0 1 1 1 1 0 0 0 1 0 1 0 0 1 1 0 0 1 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 1 1 0 1 0 0 1
1 0 0 0 0 0 1 0 0 0 0 0 1 1 1 0 0 0 0 0 1 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 1 1 1
0 0 0 0 0 1 0 0 0 1 0 0 1 1 1 1 0 0 1 0 0 1 1 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 1 1 1 1 0 0 0
0 1 1 1 1 0 1 0 0 1 1 1 0 1 0 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 1 1 0 0 0 1 1 1 0 0 0 1 1
0 0 0 0 0 0 1 0 0 0 0 0 1 0 0 1 1 0 1 1 0 0 1 0 0 1 1 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 1 1 1 1 0 0 1 1
1 0 0 1 1 0 0 0 0 1 0 0 0 1 1 1 1 0 0 1 0 0 0 1 0 1 0 1 1 0 0 1 0 1 0 1 0 0 1 0 0 0 0 1 1 0 1 0 1 1
0 1 0 1 1 0 1 0 1 0 0 0 0 0 0 1 1 0 0 0 0 1 0 1 1 0 1 1 0 0 1 0 1 0 0 1 0 1 0 0 1 0 0 1 0 0 0 0 1 1
0 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 0 0 1 0 0 0 0 1 1 1 1 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
0 0 1 0 1 0 0 1 0 0 0 0 1 0 1 1 1 0 1 0 0 0 1 0 1 1 0 1 1 0 0 1 0 1 0 0 1 0 1 0 0 1 1 0 0 0 1 0 0 0
1 0 1 1 0 0 0 1 1 0 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 1 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 1
0 0 0 0 1 0 1 1 0 0 1 1 0 1 0 0 0 1 1 0 1 1 0 1 1 1 1 1 1 1 1 0 1 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 0 1
1 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 1 1 1 0 0 0 1 0 0 0 1 1 0 1 1 0 1 0 1 1 1 1 1 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 1 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0 1 0 1 1 0 1 1 0 1 1 1 1 0 1 1 1 1 0 0 0 1 1 0 0 1 0 0 1 0
0 1 1 0 1 1 0 1 1 1 0 1 1 1 1 0 0 1 1 0 1 0 1 0 0 1 0 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 1 1 0 1 0 0 0
0 0 1 0 0 0 0 1 0 1 0 1 0 0 1 0 1 0 0 0 1 1 1 0 0 0 0 1 1 0 1 1 1 0 1 0 0 1 0 0 1 0 0 0 0 1 0 1 0 1
0 0 0 1 0 1 0 1 1 1 1 1 0 0 0 0 1 1 0 0 0 0 1 0 0 0 1 0 1 1 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0 1
1 0 0 0 1 1 1 1 0 0 0 0 1 1 1 1 0 1 0 0 1 0 1 1 1 0 1 0 0 1 1 1 0 1 0 1 1 1 1 0 0 0 0 0 1 0 0 0 0 0
0 0 1 0 1 0 1 0 0 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 0 0 0 1 1 0 0

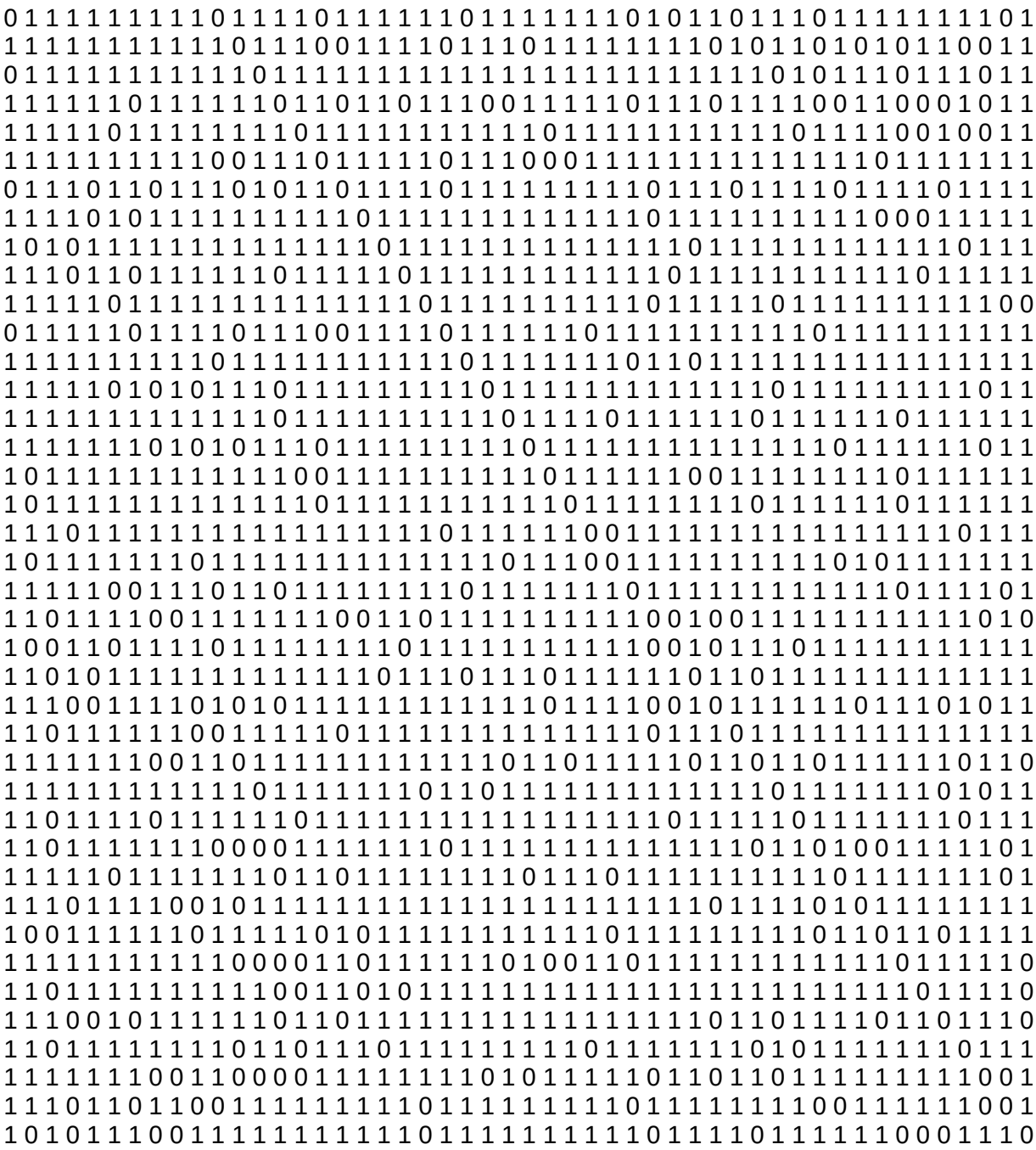
Matriz de Adjacência (50 vértices) e 65% de conectividade:

0 0 1 1 1 1 0 1 1 0 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 0 1 0 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 0
0 0 1 0 1 0 1 1 0 1 1 1 0 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 0 1 1 1 0 0 1 1 1 1 1 1 1 1 1
1 1 0 0 1 1 0 0 1 1 0 1 1 1 0 0 0 1 0 1 1 1 1 0 0 1 1 1 1 1 0 1 0 0 0 1 1 0 1 1 1 0 1 0 1 1 1 1 1 0
1 0 0 0 1 1 1 1 0 1 1 0 1 0 0 0 0 1 0 0 1 0 1 1 1 1 0 1 1 1 0 0 1 0 1 1 1 1 0 1 1 0 1 1 0 1 0 1 1 0
1 1 1 1 0 1 1 1 0 1 1 0 0 1 0 1 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1

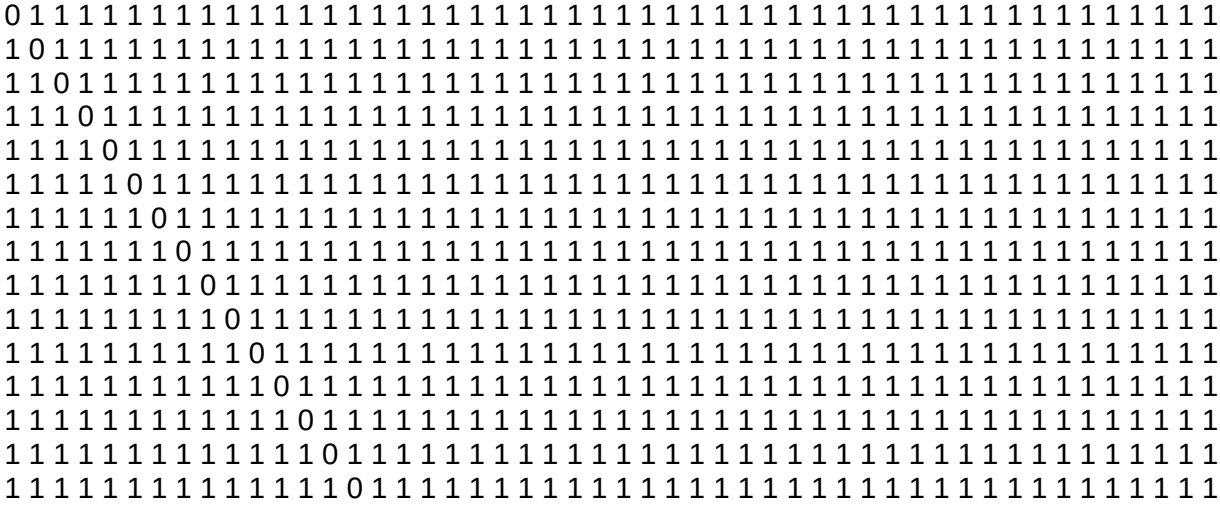
1 0 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 1 0 0 1 1 0 0 0 0 1 0 0 1 0 0
0 1 0 1 1 1 0 0 1 0 1 0 1 0 1 1 1 1 1 1 1 1 0 1 0 0 1 1 1 0 1 1 1 0 0 1 1 1 0 1 1 1 1 0 1 1 1 1 0 1 0
1 1 0 1 1 1 0 0 0 1 0 0 1 1 1 1 0 0 1 1 0 0 0 0 0 1 1 1 0 1 0 0 1 1 0 1 0 1 0 1 1 1 1 1 1 1 0 0 1 0
1 0 1 0 0 1 1 0 0 0 1 1 0 1 0 1 0 0 1 1 0 1 1 1 1 1 1 1 1 0 1 0 1 1 0 0 1 1 1 0 0 0 1 0 1 1 0 1 0 1
0 1 1 1 1 0 0 1 0 0 0 1 0 0 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1 0 0 0
0 1 0 1 1 1 1 0 1 0 0 0 1 0 0 1 1 1 1 1 1 0 0 0 0 1 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0 0 1 1
1 1 1 0 0 1 0 0 1 1 0 0 1 1 1 0 1 1 0 0 1 1 1 0 1 1 0 1 0 0 1 0 1 0 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 1
1 0 1 1 0 1 1 1 0 0 1 1 0 1 1 0 1 1 1 0 0 1 1 0 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 0 1 0
1 1 1 0 1 1 0 1 1 0 0 1 1 0 1 1 0 1 1 1 1 0 1 1 1 1 0 1 1 0 0 0 1 1 1 0 1 0 1 0 1 1 0 1 1 1 1 1 1 1
1 1 0 0 0 1 1 1 0 0 0 1 1 1 0 1 0 1 1 0 1 0 1 0 0 1 0 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1 1 0 0 1 1 1 1 0
1 0 0 0 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1 0 0 1 0 1 0 0 1 0 0 0 0 1 1 1 1 1 0 1 1 1 0 1 1 0 0 1 1 1 1 0
1 1 0 0 1 1 1 0 0 0 1 1 1 0 0 0 0 1 1 1 0 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 0 1 1 0 1 0 0 1 1 1 1 0 0
1 1 1 1 0 0 1 0 0 0 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 0 0 1 1 1 0 0 1 0 0 0 0 1 1 1 1 1 0 0 1 0 1 0 1 1
1 0 0 0 1 0 1 1 1 1 1 0 1 1 1 1 1 0 0 1 1 0 0 1 0 0 1 0 0 0 0 1 1 1 0 1 1 0 1 1 0 1 0 0 1 0 1 1 1 1
1 1 1 0 0 0 1 1 1 1 1 0 0 1 0 0 1 1 1 0 1 1 1 1 0 0 1 1 1 0 1 0 1 0 0 1 0 1 0 0 1 0 0 1 1 1 0 1 0 1
1 1 1 1 1 1 1 0 0 1 1 1 0 1 1 0 0 0 1 1 0 0 1 1 1 0 0 1 0 0 1 1 1 0 1 1 0 0 0 0 0 1 1 1 1 0 0 1 0 1
0 1 1 0 0 1 0 0 1 1 0 1 1 0 0 1 1 0 0 1 0 0 1 1 0 0 1 0 1 1 0 0 1 1 1 0 0 0 1 1 1 1 0 1 1 1 0 0 0 1
1 1 1 1 1 1 1 0 1 1 0 1 1 1 1 0 1 1 0 1 1 1 0 1 1 1 0 1 1 0 1 0 0 1 0 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 1
1 1 0 1 1 1 0 0 1 1 0 0 0 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 0 1 1 0 1 0 1 1 1 0 0 0 1 1 0 0 1 1 1 1
1 1 0 1 1 1 0 0 1 1 0 1 0 1 0 0 1 1 0 0 1 0 1 1 0 1 0 1 0 1 0 1 1 1 1 0 1 1 0 0 1 1 1 1 1 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 0 0 0 0 1 1 1 0 0 0 1 0 0 1 1 0 0 1 1 0 1 0 1 0 1 1 1 1 1 1 1 1
1 1 1 0 1 1 1 1 1 1 1 1 0 1 0 0 1 1 0 1 1 0 1 0 1 0 1 0 0 0 1 1 1 0 1 0 1 1 0 1 1 0 1 1 1 1 0 1 0 0 0 0 1
1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0 0 1 0 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 0 1 0 1 0 1 1 1 1 0 1
0 1 1 1 1 0 0 0 1 0 1 0 1 1 1 0 0 1 0 1 0 1 1 1 0 1 1 1 0 1 1 0 1 1 0 0 1 1 1 0 0 1 0 1 1 1 0 1 0 0
1 0 1 1 1 0 1 1 0 1 0 0 1 0 1 0 1 1 0 0 0 1 0 0 1 0 1 1 1 0 1 0 1 1 0 1 0 1 0 1 0 1 1 1 1 0 1 0
0 1 0 0 1 1 1 0 1 1 0 1 1 0 1 0 1 0 0 1 1 0 1 1 0 0 0 1 1 1 0 1 0 0 1 1 0 1 0 0 1 0 1 1 0 1 1 1 1 0
1 0 1 0 0 1 1 0 0 1 1 0 1 0 1 1 1 0 1 0 1 0 0 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 0 0 0 0 1 0 1 1 0 0 1
0 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 0 1 0 1 1 0 1 1 1 0 1 0 1 1 1 0 1 1 1 1
1 1 0 0 1 1 0 1 1 0 1 0 1 1 1 1 1 0 1 0 0 1 1 0 1 0 1 1 1 1 0 1 1 0 1 1 0 1 1 1 0 1 1 1 1 0 1 1 1 0
1 0 0 1 1 0 1 0 0 1 1 1 1 1 0 1 1 0 0 0 1 1 0 1 1 0 1 1 0 0 1 1 1 1 0 1 1 0 1 0 1 0 0 0 0 1 1 0 1 1
1 0 1 1 1 1 1 1 0 1 1 1 1 0 0 1 1 0 1 1 1 0 1 0 0 1 0 0 0 1 1 1 0 1 1 0 1 1 1 1 0 0 1 1 1 1 1 0 1 1
1 1 1 1 1 0 1 0 1 1 1 0 1 1 1 0 1 0 1 1 0 1 1 1 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 0 1 1
1 1 0 1 1 0 0 1 1 1 1 1 1 1 0 0 1 0 1 1 0 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 0 1 1 0
1 1 1 1 0 1 1 1 0 0 1 1 1 1 1 1 0 1 1 0 0 0 1 1 1 1 0 0 0 1 1 0 1 1 1 1 1 1 1 0 1 0 0 1 0 0 1 1 0 1
0 1 0 0 1 0 0 0 1 0 1 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 1 0 1 1 1 1 0 1 1 0 1 1 1 1 0 1 1 0

Matriz de Adjacência (50 vértices) e 85% de conectividade:

0 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 0 0 1 0 1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0
1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 0 0 1 1 0 1 0 1 0 1 1 1
1 1 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 0 1 1 0 0
1 1 1 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1
1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
1 1 0 0 1 1 0 1 1 1 1 1 1 1 1 0 1 1 1 1 0 1 0 1 1 1 1 1 1 1 0 1 1 1 1 0 1 1 1 0 1 0 1 1 1 1 1 1 1 0 1 0
1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 0
1 0 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 0 1 1 1 1 0 0 1 1 1 1 1 1 0 1



Matriz de Adjacência (50 vértices) e 100% de conectividade:



1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0

Questão 2

Busca em Largura – mostrar a árvore resultante do caminhamento; marcar tempo de execução para cada busca e a média das buscas.

A árvore utilizada para esses testes foi uma árvore de 50 vértices com 25%, 40%, 65%, 85%, 100% de conectividade :

A medida de tempo utilizada foi segundos.

Tempo BFS (25%) = 0.000019000 s
Árvore resultante da BFS:
Nível 0: 0
Nível 1: 2 7 12 16 17 19 20 36 37 39 41 44
Nível 2: 3 18 26 29 40 42 4 11 30 32 43 48 49 6 9 22 23 33 35 45 25 38 46 1 8 14 15 5 21 24 28 31 47 27 10 13
Nível 3: 34

Tempo BFS (40%) = 0.000021000 s

Árvore resultante da BFS:
Nível 0: 0
Nível 1: 6 9 11 12 17 18 22 30 33 37 41 43 48
Nível 2: 1 4 19 21 23 24 25 29 31 35 36 38 42 49 2 3 7 8 10 14 20 32 34 39 45 46 47 27 28 44 5 15 40 13 26 16

Tempo BFS (65%) = 0.000025000 s
Árvore resultante da BFS:
Nível 0: 0
Nível 1: 2 3 4 5 7 8 11 12 13 14 15 16 17 18 19 20 22 23 24 25 26 27 29 31 33 34 35 36 37 38 39 40 44 45 46 47 48
Nível 2: 1 9 21 28 42 6 10 32 43 30 41 49

Tempo BFS (85%) = 0.000017000 s
Árvore resultante da BFS:
Nível 0: 0
Nível 1: 1 2 3 4 5 6 7 8 9 11 13 14 15 17 18 19 20 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
Nível 2: 10 12 16 21

Tempo BFS (100%) = 0.000012000 s
Árvore resultante da BFS:
Nível 0: 0
Nível 1: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49

Média dos tempos: 0.0000188 s

Questão 3

Busca em em Profundidade – mostrar a sequência de vértices visitados; marcar tempo de execução para cada busca e a média das buscas.

A árvore utilizada para esses testes foi uma árvore de 50 vértices com 25%, 40%, 65%, 85%, 100% de conectividade :

A medida de tempo utilizada foi segundos.

Tempo DFS (25%) = 0.000013000 s
Sequência de vértices visitados na DFS (origem 0): 0 2 3 6 10 1 4 7 11 13 8 15 9 12 18 14 17 20 24 5 19 16 25 21 27 23 31 36 22 34 35 29 30 26 42 40 32 33 28 41 37 43 39 45 47 44 46 49 48 38

Tempo DFS (40%) = 0.000017000 s
Sequência de vértices visitados na DFS (origem 0): 0 6 1 2 3 4 5 8 9 7 15 10 13 17 14 11 19 23 12 24 18 20 22 21 16 25 26 27 35 31 28 30 38 32 42 29 34 39 33 37 43 36 40 41 44 45 46 47 49 48

Tempo DFS (65%) = 0.000021000 s
Sequência de vértices visitados na DFS (origem 0): 0 2 1 4 3 5 6 8 10 12 7 9 11 13 14 15 17 16 18 19 20 22 21 23 24 25 28 26 27 29 30 31 32 33 34 35 36 37 38 39 40 42 41 43 44 45 47 48 46 49

Tempo DFS (85%) = 0.000013000 s
Sequência de vértices visitados na DFS (origem 0): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 29 31 33 32 35 34 36 37 38 39 40 41 42 43 44 45 46 47 49 48

Tempo DFS (100%) = 0.0000100 s
Sequência de vértices visitados na DFS (origem 0): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49

Média dos tempos: 0.0000148 s

Questão 4

Todos os caminhos usando busca em profundidade – mostrar todas as sequências de vértices geradas. Usar grafos de tamanhos adequados ao exercício.

Para essa questão utilizamos apenas grafos com 5 e 7 vértices, pois o número de caminhos que percorrem todos os vértices de um grafo (como nos problemas de caminho hamiltoniano ou caixeiro viajante) cresceu exponencialmente com o número de vértices, porque a cada novo vértice adicionado, ele pode ser inserido em várias posições em cada caminho já existente, aumentando drasticamente o total de combinações possíveis. Especificamente, para N vértices, o número de possíveis caminhos é proporcional a N!, o que caracteriza um crescimento fatorial.

===== Testando com 5 vértices =====

-> Criando grafo com 60% de conexidade:
Matriz de Adjacência (5 vértices):
0 0 1 1 0
0 0 1 1 1
1 1 0 0 1
1 1 0 0 0
0 1 1 0 0

Todos os caminhos a partir do vértice 4:
4 1 2 0 3
4 1 3 0 2
4 2 0 3 1
4 2 1 3 0

-> Criando grafo com 80% de conexidade:
Matriz de Adjacência (5 vértices):
0 0 1 1 1
0 0 1 1 1
1 1 0 0 1
1 1 0 0 1
1 1 1 1 0

Todos os caminhos a partir do vértice 2:

2 0 3 1 4
2 0 3 4 1
2 0 4 1 3
2 0 4 3 1
2 1 3 0 4
2 1 3 4 0
2 1 4 0 3
2 1 4 3 0
2 4 0 3 1
2 4 1 3 0

===== Testando com 7 vértices =====

-> Criando grafo com 60% de conexidade:
Matriz de Adjacência (7 vértices):
0 0 1 0 0 1 1
0 0 1 1 0 1 1
1 1 0 1 1 0 0
0 1 1 0 1 0 1
0 0 1 1 0 0 0
1 1 0 0 0 0 1
1 1 0 1 0 1 0

Todos os caminhos a partir do vértice 5:
5 0 2 1 6 3 4
5 0 2 4 3 1 6
5 0 2 4 3 6 1
5 0 6 1 2 3 4
5 0 6 1 2 4 3
5 0 6 1 3 2 4
5 0 6 1 3 4 2
5 0 6 3 1 2 4
5 0 6 3 4 2 1
5 1 2 0 6 3 4
5 1 2 4 3 6 0
5 1 3 4 2 0 6
5 1 3 6 0 2 4
5 1 6 0 2 3 4
5 1 6 0 2 4 3
5 1 6 3 4 2 0
5 6 0 2 1 3 4
5 6 0 2 4 3 1
5 6 1 3 4 2 0

-> Criando grafo com 80% de conexidade:
Matriz de Adjacência (7 vértices):
0 1 1 1 1 0 0
1 0 1 1 1 1 1
1 1 0 1 0 0 1
1 1 1 0 0 1 1
1 1 0 0 0 1 1

0 1 0 1 1 0 1
0 1 1 1 1 1 0

Todos os caminhos a partir do vértice 1:

1 0 2 3 5 4 6
1 0 2 3 5 6 4
1 0 2 3 6 4 5
1 0 2 3 6 5 4
1 0 2 6 3 5 4
1 0 2 6 4 5 3
1 0 3 2 6 4 5
1 0 3 2 6 5 4
1 0 3 5 4 6 2
1 0 4 5 3 2 6
1 0 4 5 3 6 2
1 0 4 5 6 2 3
1 0 4 5 6 3 2
1 0 4 6 2 3 5
1 0 4 6 5 3 2
1 2 0 3 5 4 6
1 2 0 3 5 6 4
1 2 0 3 6 4 5
1 2 0 3 6 5 4
1 2 0 4 5 3 6
1 2 0 4 5 6 3
1 2 0 4 6 3 5
1 2 0 4 6 5 3
1 2 3 0 4 5 6
1 2 3 0 4 6 5
1 2 3 5 6 4 0
1 2 3 6 5 4 0
1 2 6 3 0 4 5
1 2 6 3 5 4 0
1 2 6 4 0 3 5
1 2 6 4 5 3 0
1 2 6 5 3 0 4
1 2 6 5 4 0 3
1 3 0 2 6 4 5
1 3 0 2 6 5 4
1 3 0 4 5 6 2
1 3 2 0 4 5 6
1 3 2 0 4 6 5
1 3 2 6 5 4 0
1 3 5 4 0 2 6
1 3 5 4 6 2 0
1 3 5 6 2 0 4
1 3 5 6 4 0 2
1 3 6 2 0 4 5
1 3 6 5 4 0 2
1 4 0 2 3 5 6
1 4 0 2 3 6 5
1 4 0 2 6 3 5

1 4 0 2 6 5 3
1 4 0 3 2 6 5
1 4 0 3 5 6 2
1 4 5 3 0 2 6
1 4 5 3 6 2 0
1 4 5 6 2 0 3
1 4 5 6 2 3 0
1 4 5 6 3 0 2
1 4 5 6 3 2 0
1 4 6 2 0 3 5
1 4 6 5 3 0 2
1 4 6 5 3 2 0
1 5 3 0 2 6 4
1 5 3 0 4 6 2
1 5 3 2 0 4 6
1 5 3 2 6 4 0
1 5 3 6 2 0 4
1 5 3 6 4 0 2
1 5 4 0 2 3 6
1 5 4 0 2 6 3
1 5 4 0 3 2 6
1 5 4 0 3 6 2
1 5 4 6 2 0 3
1 5 4 6 2 3 0
1 5 4 6 3 0 2
1 5 4 6 3 2 0
1 5 6 2 3 0 4
1 5 6 3 2 0 4
1 5 6 4 0 2 3
1 5 6 4 0 3 2
1 6 2 0 3 5 4
1 6 2 0 4 5 3
1 6 2 3 0 4 5
1 6 2 3 5 4 0
1 6 3 2 0 4 5
1 6 3 5 4 0 2
1 6 4 0 2 3 5
1 6 4 5 3 0 2
1 6 4 5 3 2 0
1 6 5 3 2 0 4
1 6 5 4 0 2 3
1 6 5 4 0 3 2

Questão 5

Determinar se um dado grafo possui ciclo, usando busca em profundidade. Testar diferentes grafos com e sem ciclos, de diversos tamanhos e graus de conectividade. Considerar ciclos somente de tamanho 3 ou maior (já que o grafo não é direcionado).

=== Testando com 10 vértices ===

Grau de conexidade: 25%
Matriz de adjacência com 10 vértices:
0 1 0 1 0 1 1 1 0 0
1 0 0 0 0 0 0 0 1 0
0 0 0 0 0 1 0 0 0 0
1 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 1 0 0 0
1 0 1 0 0 0 0 0 0 0
1 0 0 0 1 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0
Resultado: O grafo NÃO possui ciclo.

Grau de conexidade: 40%
Matriz de adjacência com 10 vértices:
0 1 0 0 0 0 0 1 0 0
1 0 1 0 0 0 1 1 0 0
0 1 0 0 1 0 0 0 1 0
0 0 0 0 0 1 0 0 1 1
0 0 1 0 0 1 0 1 1 0
0 0 0 1 1 0 1 1 0 1
0 1 0 0 0 1 0 1 0 1
1 1 0 0 1 1 1 0 0 0
0 0 1 1 1 0 0 0 0 0
0 0 0 1 0 1 1 0 0 0
Resultado: O grafo possui ciclo.

Grau de conexidade: 65%
Matriz de adjacência com 10 vértices:
0 1 0 0 0 0 0 0 0 1
1 0 1 0 0 1 1 0 0 0
0 1 0 1 0 0 0 1 0 0
0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0
0 1 0 0 1 0 0 0 1 0
0 1 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0
1 0 0 0 0 0 0 0 0 0
Resultado: O grafo NÃO possui ciclo.

Grau de conexidade: 85%
Matriz de adjacência com 10 vértices:
0 1 1 1 1 1 1 1 1 1
1 0 1 1 1 1 1 1 1 1
1 1 0 1 1 1 0 1 0 0
1 1 1 0 1 1 1 1 0 1
1 1 1 1 0 1 0 1 1 1
1 1 1 1 1 0 1 0 1 1
1 1 0 1 0 1 0 1 1 1

1 1 1 1 1 0 1 0 0 1
1 1 0 0 1 1 1 0 0 1
1 1 0 1 1 1 1 1 1 0
Resultado: O grafo possui ciclo.

Grau de conexidade: 100%
Matriz de adjacência com 10 vértices:
0 1 1 1 0 0 0 0 1 0
1 0 0 0 0 0 0 0 0 0
1 0 0 0 0 1 0 1 0 0
1 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0
0 0 1 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 1 0
0 0 1 0 0 0 0 0 0 0
1 0 0 0 1 0 1 0 0 0
0 0 0 0 0 1 0 0 0 0
Resultado: O grafo NÃO possui ciclo

=== Testando com 20 vértices ===

Grau de conexidade: 25%
Matriz de adjacência com 20 vértices:
0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0
0 0 0 0 0 1 0 0 0 0 1 1 0 0 1 0 0 0 0 0
0 0 0 0 1 0 0 0 1 0 0 1 0 1 1 1 1 0 0 0
0 0 0 0 0 1 0 1 0 1 0 0 0 0 0 1 0 0 0 1
1 0 1 0 0 0 0 0 0 1 0 0 0 1 1 1 1 1 0 0
0 1 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1
0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 1 0
0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 1 0 1 0
0 0 1 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0
0 0 0 1 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0
0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 1 0 0 0 1
0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0
0 0 1 0 1 1 0 0 0 0 1 0 0 0 1 0 0 0 0 0
1 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1
0 0 1 1 1 0 0 0 0 0 1 1 0 0 0 0 1 0 1 0
0 0 1 0 1 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0 1
0 0 0 1 0 1 0 0 0 0 1 0 0 0 1 0 0 0 1 0
Resultado: O grafo possui ciclo.

Grau de conexidade: 40%
Matriz de adjacência com 20 vértices:
0 1 1 0 0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0
1 0 0 1 1 0 1 1 1 1 0 0 1 1 1 0 0 1 1 0
1 0 0 0 0 0 0 1 0 0 1 1 1 1 0 1 1 0 0 0
0 1 0 0 0 0 1 0 0 1 0 0 0 0 0 0 1 0 0 0
0 1 0 0 0 0 0 1 1 0 0 1 1 0 0 1 1 0 1 0

0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 1 1 0 0
1 1 0 1 0 0 0 0 1 0 1 1 1 0 0 0 0 1 0 0
0 1 1 0 1 1 0 0 0 0 1 1 1 0 0 1 1 0 0 0
1 1 0 0 1 1 1 0 0 1 1 0 0 0 0 0 0 0 1 1
0 1 0 1 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 1
0 0 1 0 0 1 1 1 1 0 0 0 1 0 0 0 1 1 0 1
1 0 1 0 1 0 1 1 0 1 0 0 0 0 0 0 1 1 0 0
0 1 1 0 1 0 1 1 0 0 1 0 0 0 0 0 1 0 0 0
0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0
0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 1
0 0 1 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0 1 0
0 0 1 1 1 1 0 1 0 0 1 1 1 1 0 0 0 0 1 1
1 1 0 0 0 1 1 0 0 1 1 1 0 1 1 0 0 0 0 0
0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 1 1 0 0 1
0 0 0 0 0 0 0 0 1 1 1 0 0 0 1 0 1 0 1 0
Resultado: O grafo possui ciclo.

Grau de conexidade: 65%
Matriz de adjacência com 20 vértices:
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 0 0 0 1 1 0 0 0 0 0 0 1 0 0 0 1 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 1 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 1 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
1 0 1 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0
Resultado: O grafo NÃO possui ciclo.

Grau de conexidade: 85%
Matriz de adjacência com 20 vértices:
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0
0 0 0 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0
Resultado: O grafo NÃO possui ciclo.

Grau de conexidade: 100%
Matriz de adjacência com 20 vértices:
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
Resultado: O grafo possui ciclo.

Há diferença significativa de uso de memória entre a busca em largura e a busca em profundidade?

Sim, há uma diferença significativa de uso de memória entre a busca em largura (BFS) e a busca em profundidade (DFS) em grafos. A BFS utiliza uma fila para armazenar os vértices a serem explorados, e isso pode exigir muita memória em grafos com alta ramificação, já que todos os vizinhos de um nível precisam ser mantidos na fila ao mesmo tempo. Por outro lado, a DFS utiliza uma pilha, que pode ser implementada de forma explícita ou usando recursão, e geralmente armazena apenas os vértices do caminho atual em profundidade, o que tende a consumir menos memória em muitos casos. Portanto, embora ambas tenham complexidade de memória O(V) no pior caso, na prática, a BFS costuma demandar mais memória que a DFS em grafos amplos.