Routecraft

Routing Algorithms for Ocean Shipping and Urban Deliveries

Programming Project II

Desenho de Algortimos

2022/2023

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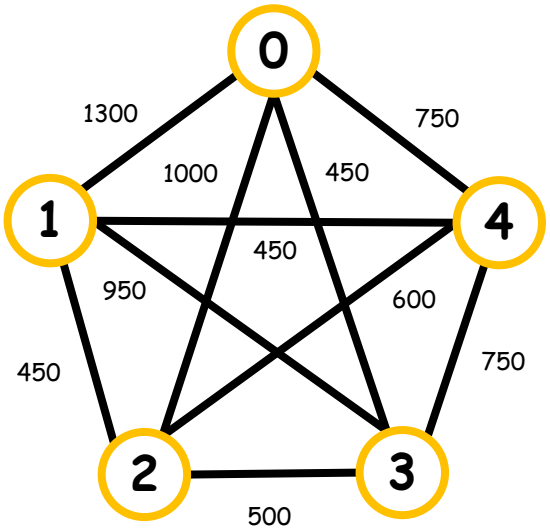
01 Backtracking using Brute Force




```
void Graph::tspBT(std::stack<Vertex*> &bestPath, double &minDist) {
    for(Vertex* v: vertexSet)
        v->setVisited(false);

    Vertex* startingNode = vertexSet[0];

    startingNode->setVisited(true);
    startingNode->setPathCost(0);
    startingNode->setPath(nullptr);

    minDist = INF;
    tspBTRec(0, 0, minDist, bestPath);
}
```

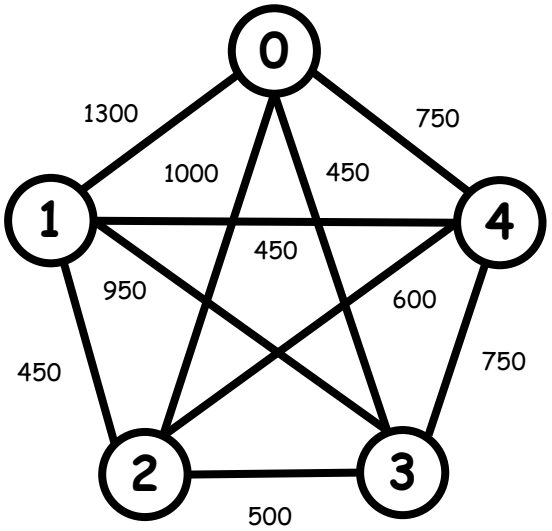
01 Backtracking using Brute Force

```
void Graph::tspBTRec(int curVertex, int curIndex,
                     double &minDist, std::stack<Vertex*> &bestPath) {
    Vertex* v1 = findVertex(curVertex);

    if (curIndex == vertexSet.size() - 1){
        double cost = v1->getPathCost();
        bool hasCon = false;
        for (auto e: v1->getAdj()) {
            if (e->getDest()->getId() == 0) {
                hasCon = true;
                cost += e->getDistance();
                break;
            }
        }
        if (hasCon && cost < minDist) {
            minDist = cost;
            bestPath = savePath(v1);
        }
        return;
    }
```

```
    for(Edge* edge : v1->getAdj()) {
        Vertex* v2 = edge->getDest();
        double distance = edge->getDistance();
        if(!v2->isVisited() && v1->getPathCost() + distance < minDist) {
            v2->setPath(edge);
            v2->setPathCost(v1->getPathCost() + distance);
            v2->setVisited(true);
            tspBTRec(v2->getId(), curIndex+1,minDist,bestPath);
            v2->setVisited(false);
        }
    }
}
```

02 Triangular Approximation




```
void Graph::triangularApproximation
 (std::queue<Vertex*> &tour, double &dist) {

    prim();

    tour = preOrderTraversal();
    tour.push(vertexSet[0]);

    std::queue<Vertex*> aux = tour;
    Vertex* cur = aux.front();
    aux.pop();
    Vertex* next = aux.front();
    while (!aux.empty()){
        dist += distance(cur, next);
        cur = next;
        aux.pop();
        next = aux.front();
    }
}
```

1. Compute MST at root (id = 0) using Prim's algorithm
2. Define a pre-order walk of the MST
3. Tour the graph using the path induced by the pre-order walk.

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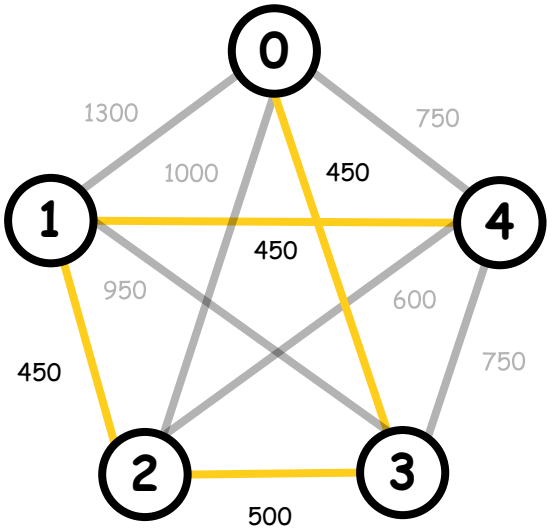


```
void Graph::prim() {
    if (vertexSet.empty()) return;
    for (auto v: vertexSet){
        v->setVisited(false);
        v->setPath(nullptr);
        v->setPathCost(INF);
        v->setMstAdj({});
        v->setDegree(0);
    }
    PriorityQueue q;

    vertexSet[0]->setPathCost(0);
    q.insert(vertexSet[0]);

    while(!q.empty()){
        auto u = q.extractMin();
        u->setVisited(true);
        if (u->getPath() != nullptr) updateMst(u);
        for (auto e : u->getAdj()){
            auto w = e->getDest();
            if (!w->isVisited()){
                auto oldDist = e->getDest()->getPathCost();
                if (e->getDistance() < oldDist){
                    w->setPathCost(e->getDistance());
                    w->setPath(e);
                    if (oldDist == INF) q.insert(w);
                    else q.decreaseKey(w);
                }
            }
        }
    }
}
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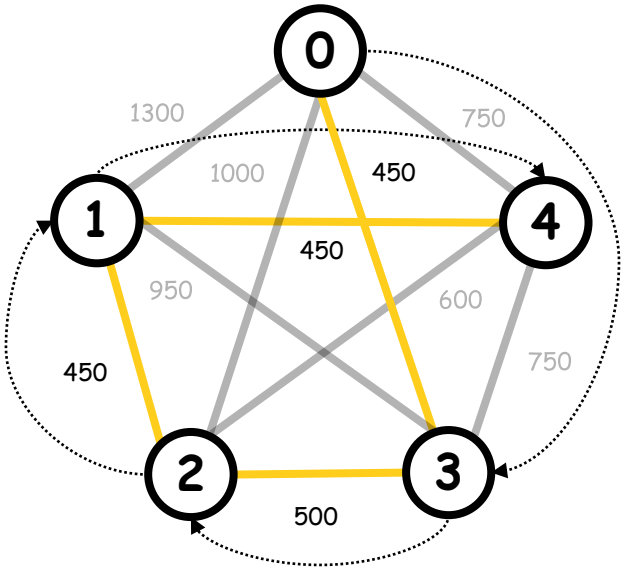


```
void Graph::preOrder
 (Vertex* vertex, std::queue<Vertex *> &l) {
    l.push(vertex);
    vertex->setVisited(true);
    for (Edge* edge : vertex->getMstAdj()) {
        Vertex* w = edge->getDest();
        if (!w->isVisited())
            preOrder(w,l);
    }
}

std::queue<Vertex *> Graph::preOrderTraversal() {
    std::queue<Vertex *> l;

    for (auto v : vertexSet)
        v->setVisited(false);

    Vertex* startingNode = vertexSet[0];

    preOrder(startingNode,l);

    return l;
}
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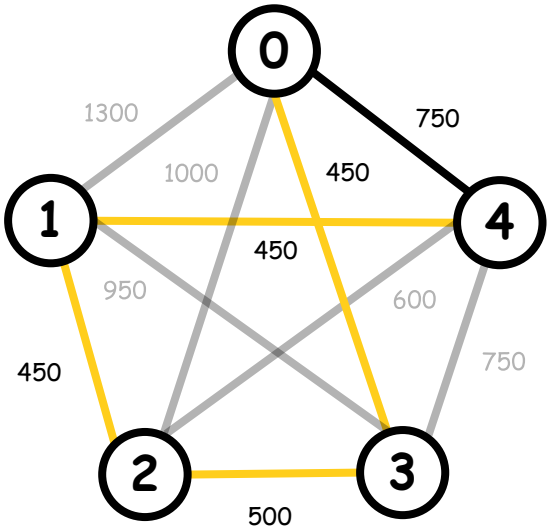


```
Path: 0 3 2 1 4 0
Distance: 2600 meters
Execution Time: 0.024375 milliseconds
```

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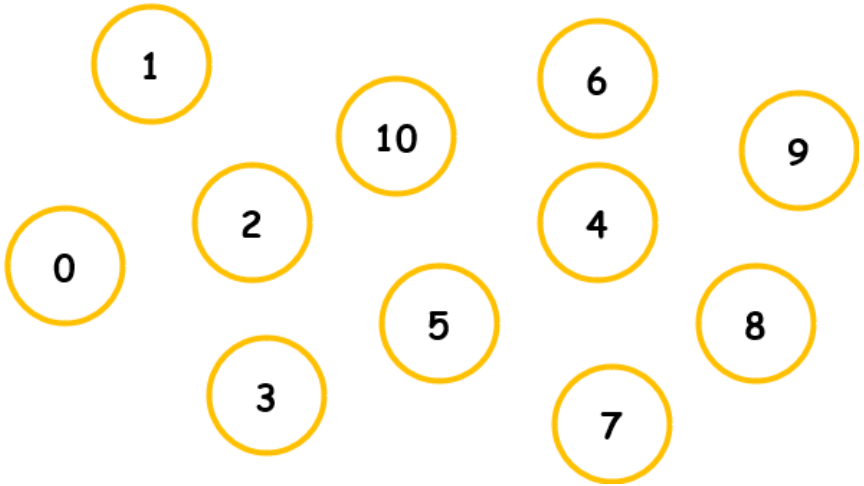
03 Christofides with 2-opt



1. Compute MST
2. Add a minimum-weight perfect matching M of the odd vertices in T
3. Find an Eulerian Circuit
4. Transform the Circuit into a Hamiltonian Cycle

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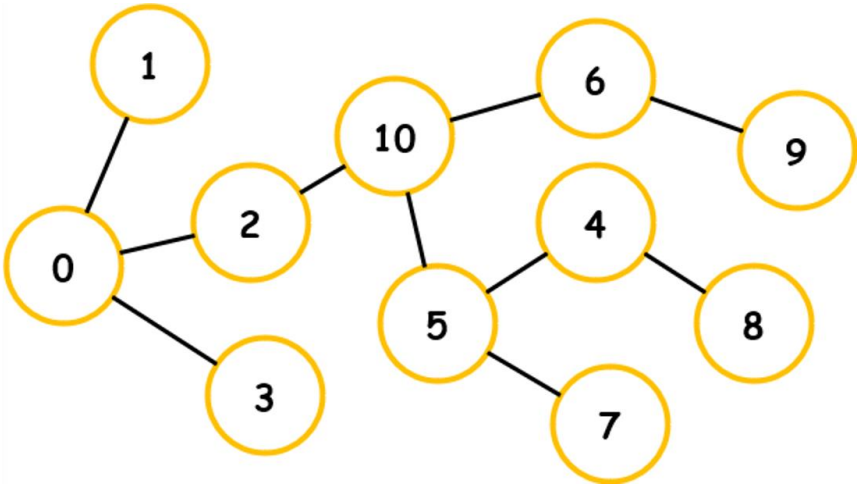

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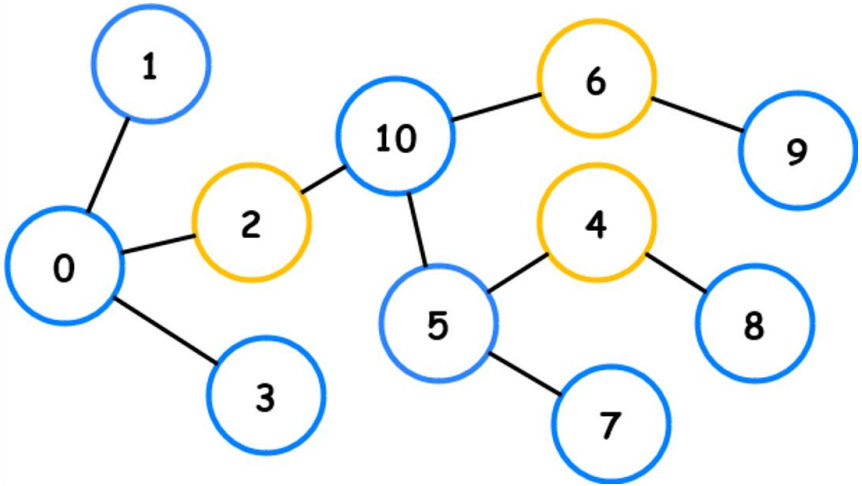

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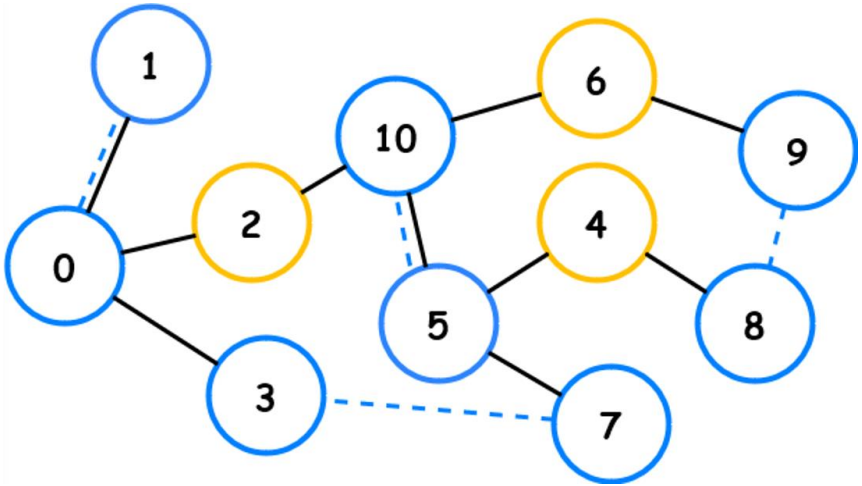

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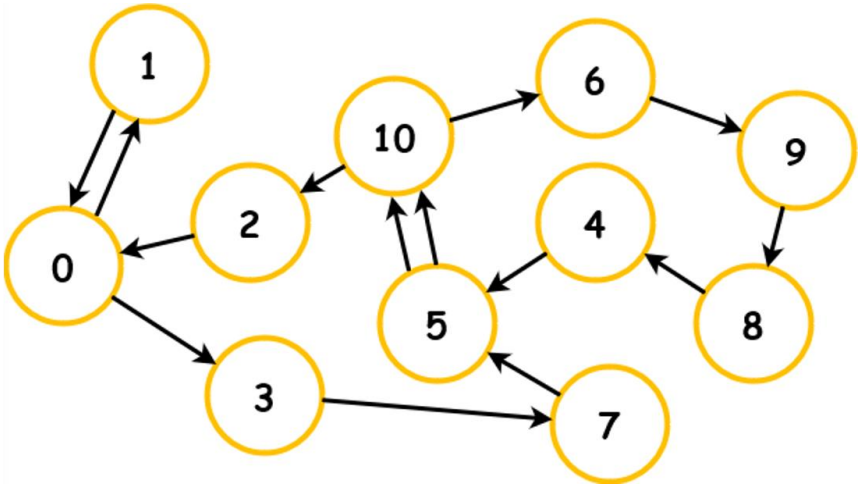

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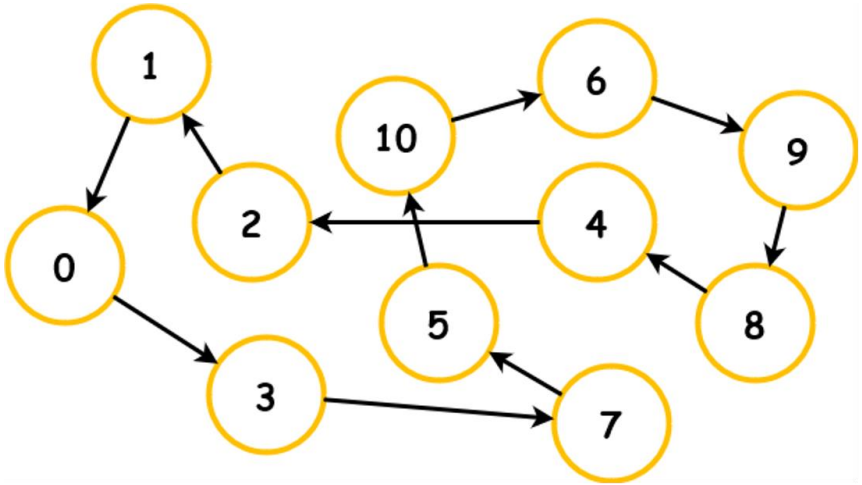

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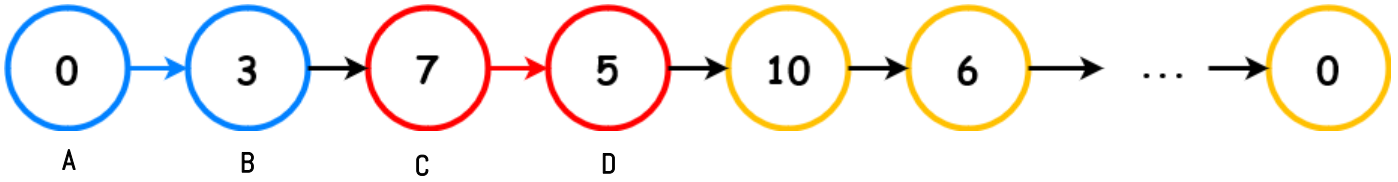
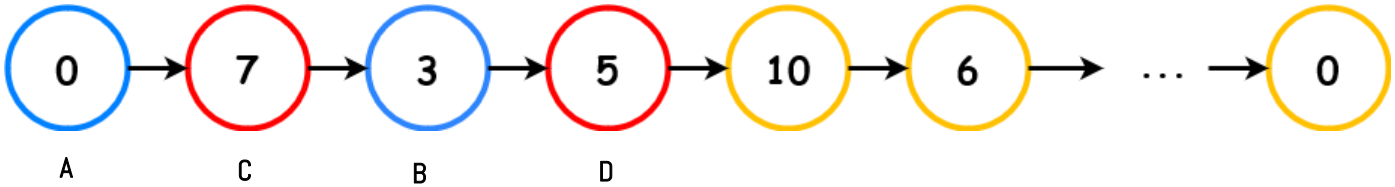
0 -> 3 -> 7 -> 5 -> 10 -> 6 -> 9 -> 8 -> 4 -> ~~5~~ -> ~~10~~ -> 2 -> ~~0~~ -> 1 -> 0

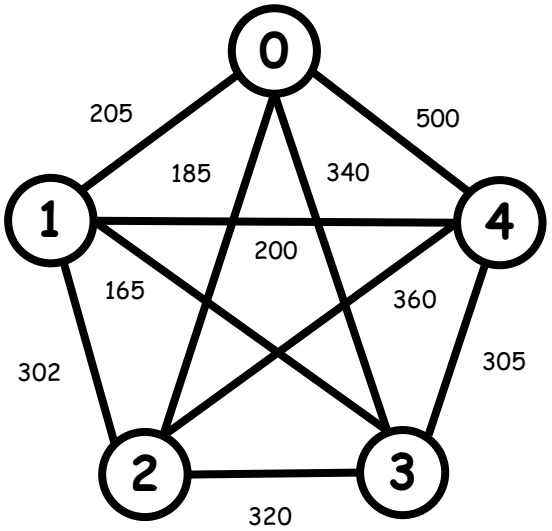
03 2-opt algorithm



If distance(A,C) + distance(B,D) < distance(A,B) + distance(C,D)



04 Nearest neighbour




```
void Graph::nearestNeighborTSP
 (std::vector<Vertex *> &tour, double &distance) {
    for (auto v : vertexSet)
        v->setVisited(false);

    Vertex* currentVertex = vertexSet[0];
    currentVertex->setVisited(true);

    while(true){
        tour.push_back(currentVertex);
        double minDist = INT_MAX;
        Vertex* nextVertex = nullptr;
        for (auto e : currentVertex->getAdj()){
            Vertex* neighbor = e->getDest();
            if (!neighbor->isVisited()){
                double dist = e->getDistance();
                if (dist < minDist){
                    minDist = dist;
                    nextVertex = neighbor;
                }
            }
        }
        if (nextVertex == nullptr) break;
        nextVertex->setVisited(true);
        distance += minDist;
        currentVertex = nextVertex;
    }

    distance += currentVertex->getAdj()[0]->getDistance();
    tour.push_back(vertexSet[0]);
}
```

1. Start at the root
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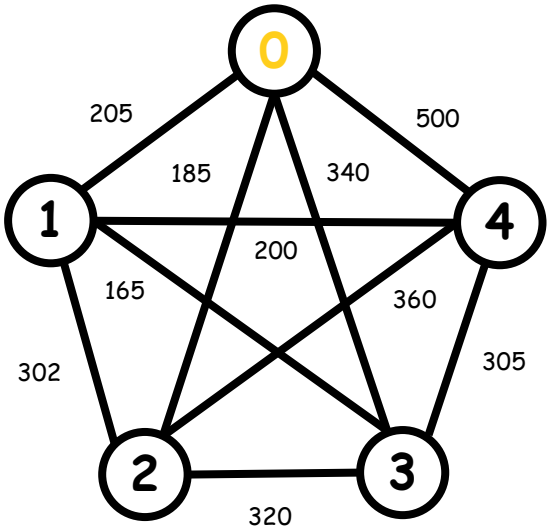


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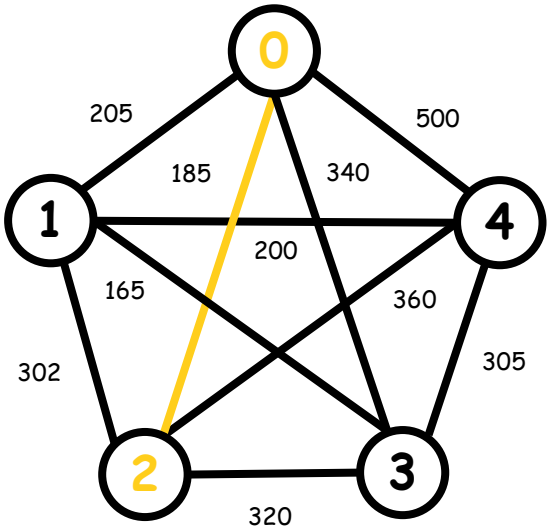


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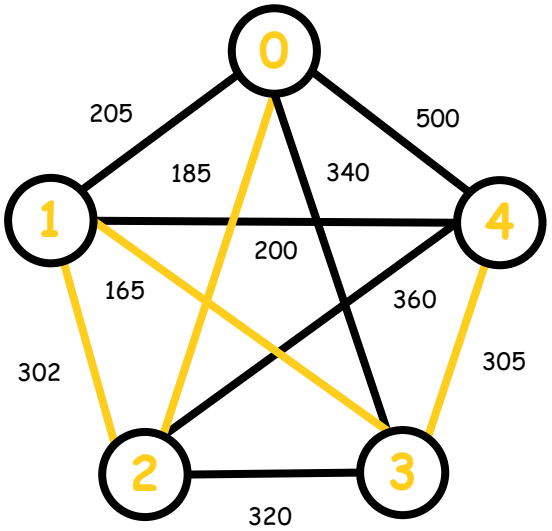


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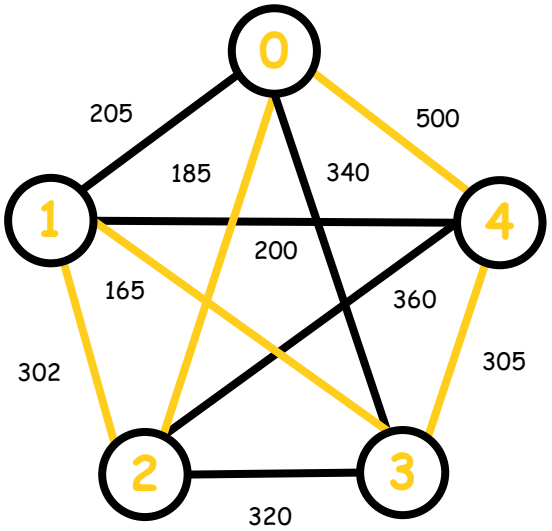


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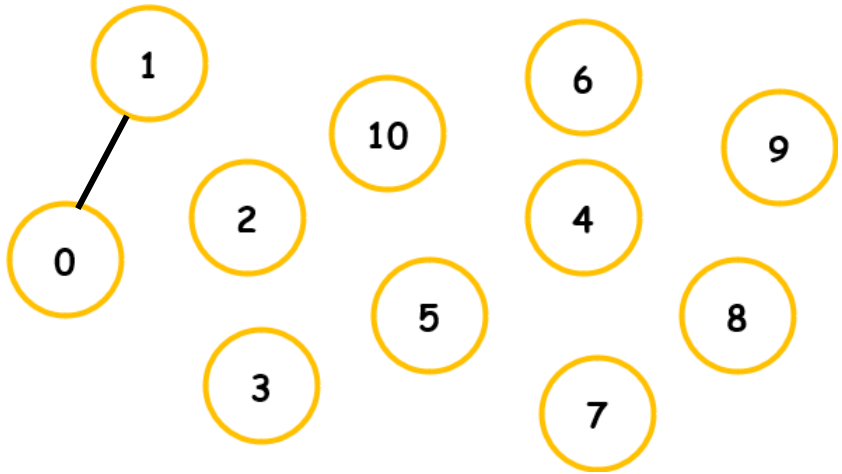
05 Nearest insertion with 2-opt



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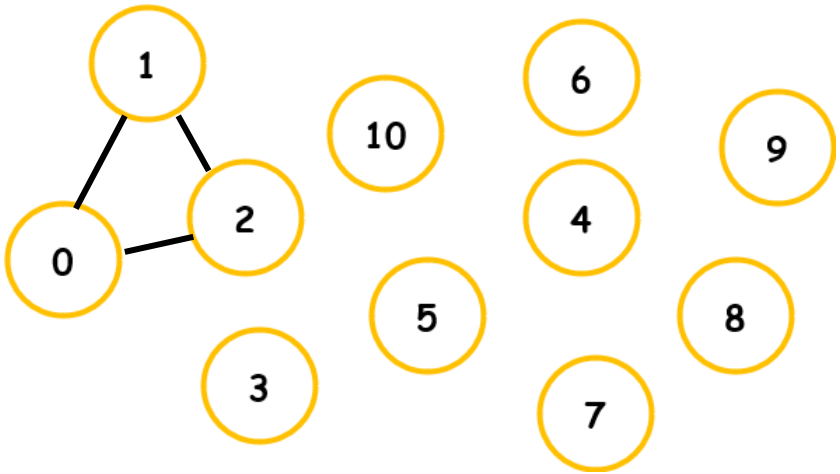

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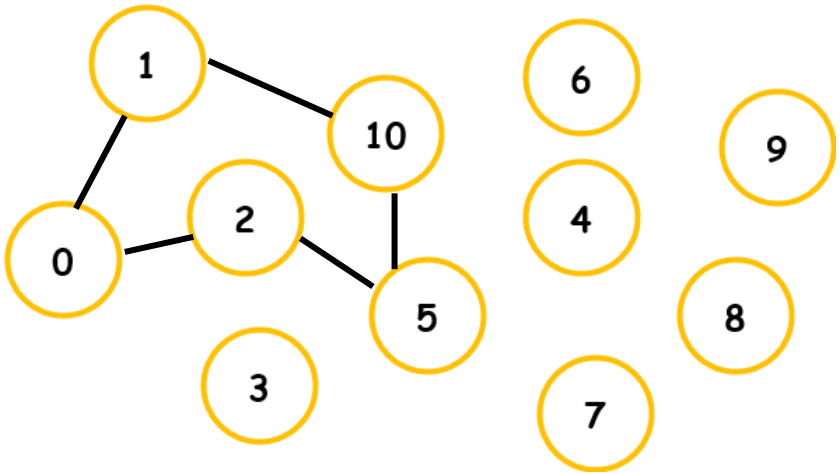

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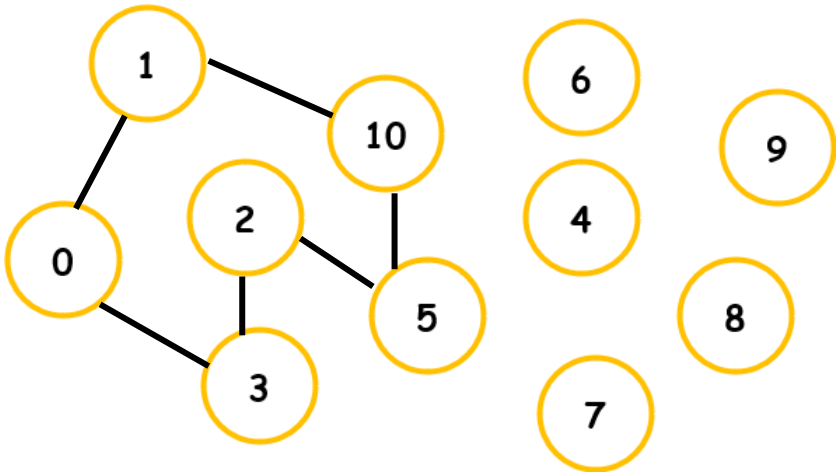

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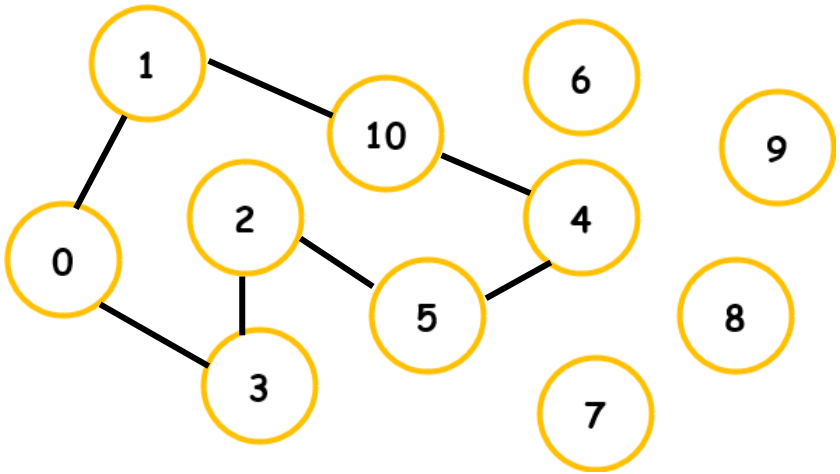

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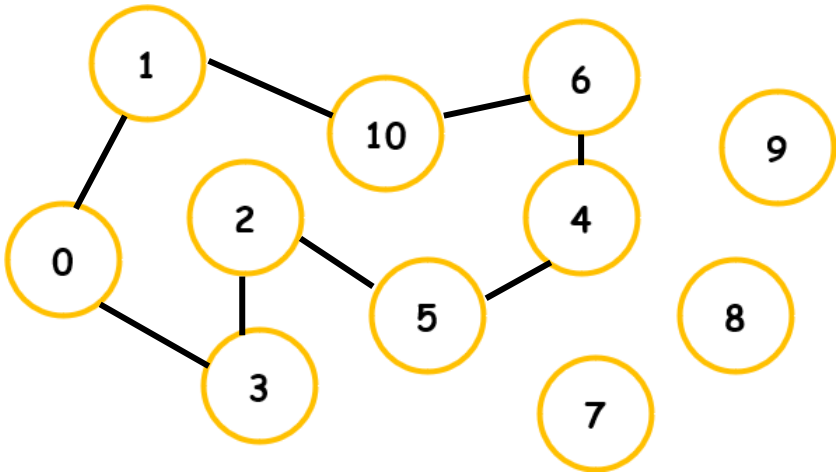

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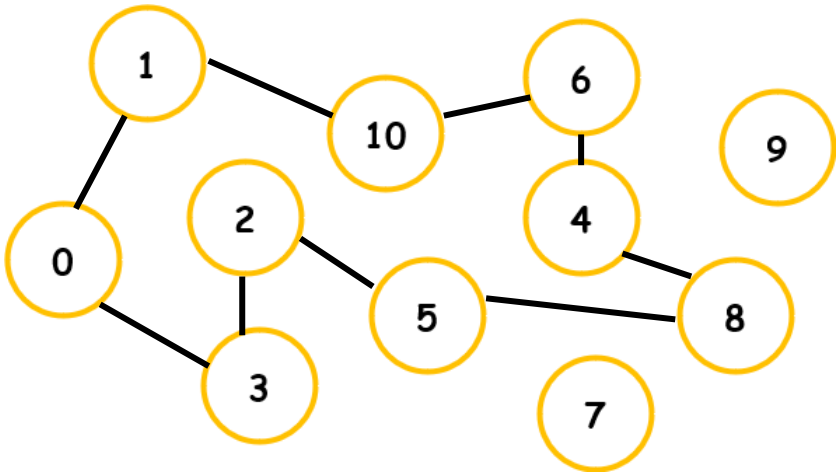

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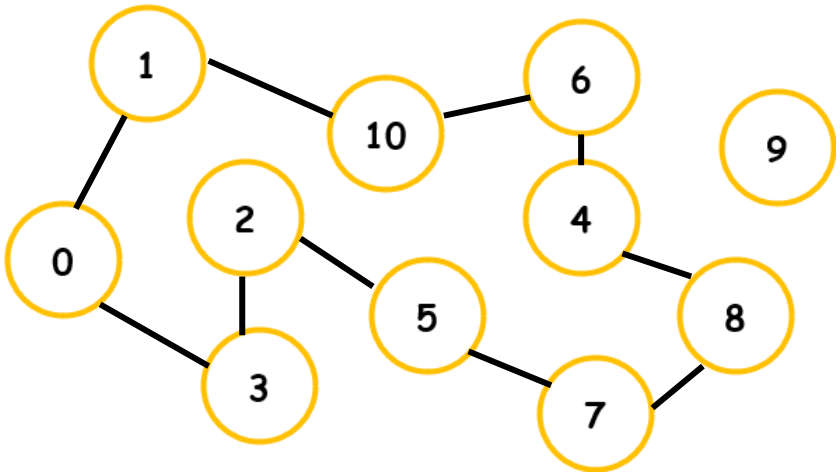

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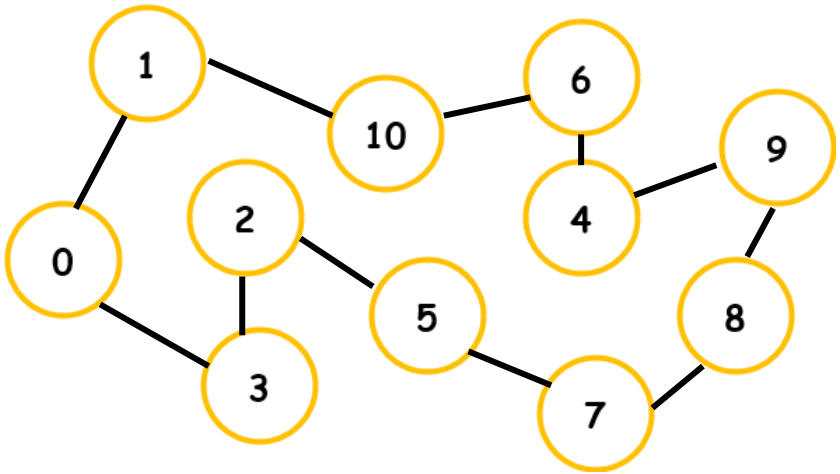

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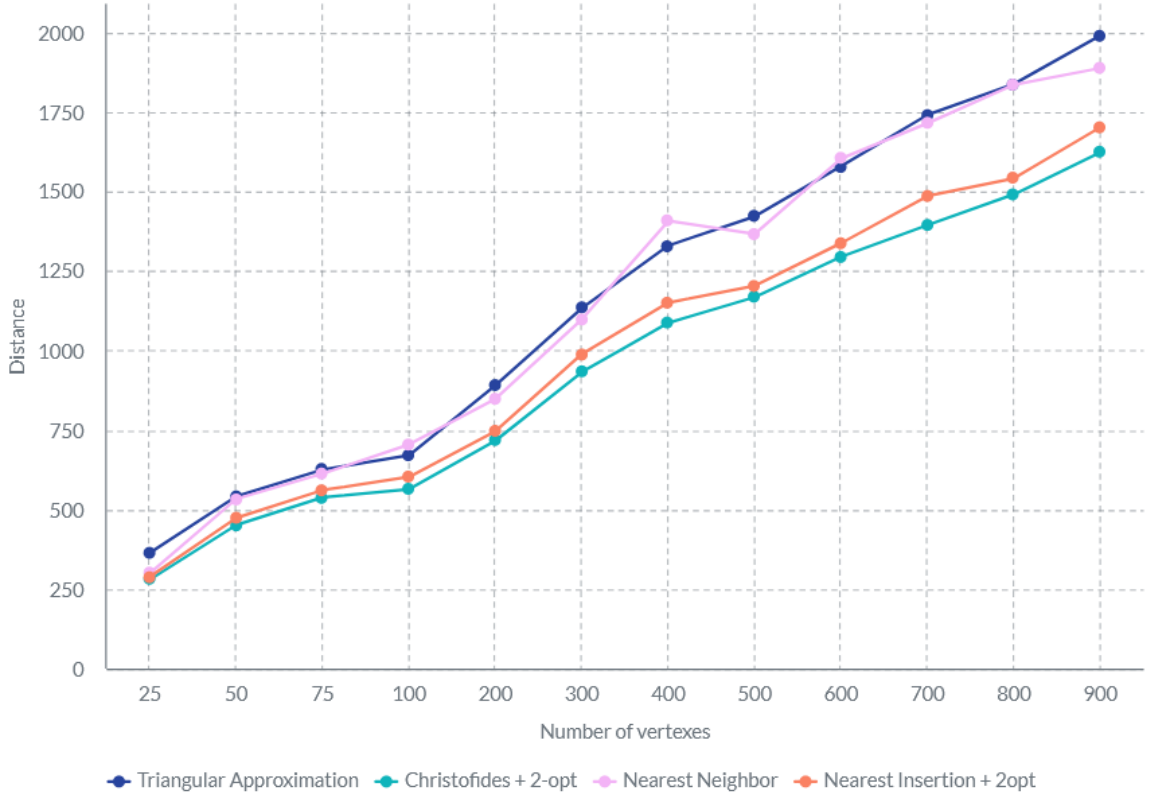
Distance comparison



Time comparison