Walking Bus Challenge

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[1]DEIB - Politecnico di Milano

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Problem Description

An elementary school want to setup a walking bus system for its students.

A walking bus (*pedibus* in Italian) is a form of student transport for schoolchildren who, chaperoned by two adults (usually a *driver* leads and a *conductor* follows), walk to school, in much the same way a school bus would drive them to school. Like a traditional bus, walking buses have a fixed route with designated *bus stops* in which they pick up children (The walking bus definition is courtesy of Wikipedia).

The routes of the walking bus system must serve all students joining the initiative. A route starts form a bus stop, goes through other bus stops and ends at the school. All students on the route must be picked-up. Routes can merge but cannot split after merging. No student must travel more than *alpha* times the shortest path from his bus stop to the school. The design of the routes should ensure students' safety minimizing the risk involved in the path from home to school.

It is your duty as manager of the school to define all the routes for the walking bus system taking into account all requirements and minimizing the number of chaperons involved. In other words, the number of routes composing the walking bus system must be minimized.

From a more abstract point of view: consider a complete graph $G = (N, A)$. Set $N = \{0..n\}$ is the set of nodes, node 0 is the school and all other nodes represent bus stops. Set $A = (i, j) : i \in N, j \in N$ is the set of arcs representing connections among nodes. For each pair of nodes $i \in N, j \in N : (i, j) \in A$ the length and the dangerousness of the shortest path, $c_{i,j}$, $d_{i,j}$, from node i to node j is known; $c_{0,j} = \infty \quad \forall j \in N \setminus \{0\}$.

For the purpose of this challenge we only take into account graphs in which the length of the shortest path c_{ij} is equal to the euclidean distance from node i to node j (the triangular inequality holds).

The walking bus problem can be seen as a special case of spanning tree problem. In this problem we want to find the feasible spanning tree, rooted in 0, for graph G with the minimum number of leaves (*primary objective function*). A spanning tree is consider as feasible in the walking bus problem if no node is distant from 0 more than *alpha* times the shortest path from the node to 0 (that is $c_{i,0}$). The walking bus problem takes also into account an additional objective function that is the minimization of the total dangerousness of the paths selected as routes for the walking bus (*secondary objective function*). The total dangerousness is computed as the sum of the risk (d_{ij}) associated with all the arcs composing the walking bus network. This objective function is less important than the minimization of the number of leaves and it is only used in order to differentiate among solutions with the same number of leaves.

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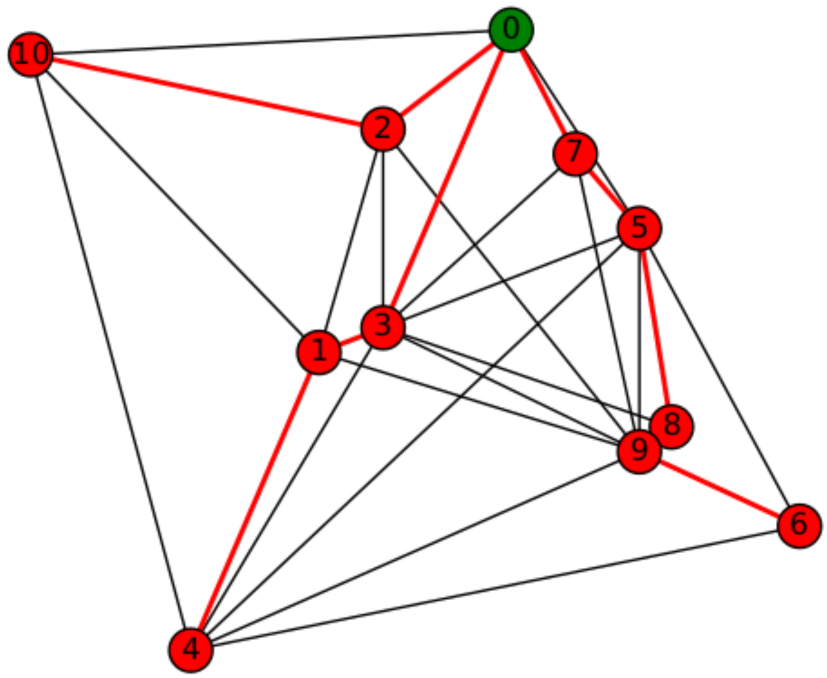

Figure 1: Walking bus solution example.
Red nodes are the students, green node is the school.
Red edges are the edges selected in the solution (the graph is not complete).

Challenge Rules

Participants are required to build their own solver in order to solve the walking bus problem. All solving approaches are accepted (mathematical models, exact algorithms and heuristic algorithms of any sort).

Students can take part in the challenge in team, **max 3 students per team**.

All teams can download from Beep:

- A set of 10 test instance to be used in order to implement end test the solver.
- A checker (a piece of software written in python 2.7) that can be used to check the feasibility of the solutions found.
- This document.
- A document describing technical requirements for the solver.

All students delivering a solver that is able to provide non trivial solution for the walking bus problem will receive from 10 to 14 points depending on the solver performance and are exempt from the lab exam and the second part of the written exam.

Deadline for the submission of the solver: 24th of February 2017.

In order to participate please **send an email** to emanuele.tresoldi@polimi.it.

What to deliver

Participants must submit:

- *Complete source code* of the solver, the solver can be written in any of the following languages: AMPL, C/C++/C#, Java, Python. Any freely available library can be used. The solver must be compilable and runnable on either Windows 10 64 Bit or Linux 64 Bit. Execution time-limit: 1 hour (for each instance).
- *Instructions* on how to compile and run the solver.
- *Small report* describing the solution approach, a couple of pages should be enough.

submissions must be sent to emanuele.tresoldi@polimi.it.

Results evaluation criteria

Solvers will be evaluated and ranked using a set of 10 instances. This evaluation set is not the same as the test set provided to the participants. However instances in the evaluation set have the same structure and size of the instances in the test set.

Three different criteria will be considered for the evaluation. From the most to the less important:

Number of leaves. Minimizing the number of adults supervisors (number of leaves) required for the walking bus is the main goal. Given two feasible solutions S_1 and S_2 for the same instance let call L_1 and L_2 the number of leaves in the spanning tree defined by S_1 and S_2 respectively. If $L1 < L2$ then S_1 is better than S_2.

Risk. If two feasible solutions S_1 and S_2 have the same number of leaves then the solution described by the less dangerous (in terms of d_{ij}) spanning three prevails. Let call D_1 and D_2 the sum of d_{ij} for all arcs (i, j) used in solutions S_1 and S_2 respectively. If $L1 = L2$ and $D_1 < D_2$ then S_1 is better than S_2.

Computational time. The faster the better. If $L1 = L2$ and $D_1 = D_2$ then the solving time is considered. Let call T_1 and T_2 the time required in order to obtain S_1 and S_2 respectively. If $L1 = L2$ and $D_1 = D_2$ and $T_1 < T_2$ then S_1 is better than S_2.

Solvers will be ranked taking into consideration criteria explained before and will be divided in five tiers. First tier solver will get 14 points, second tier 13 points, third tier 12 points, four tier 11 points and fifth tier 10 points.