Problem Instance Layout

This document specifies the format of the ten real-world school bus routing problems used in the following paper:

Lewis, R. and K. Smith-Miles (2018) "A Heuristic Algorithm for Finding Cost-Effective Solutions to Real-World School Bus Routing Problems", Journal of Discrete Algorithms, doi: 10.1016/j.jda.2018.11.001

These problem instances can be downloaded at http://rhydlewis.eu/resources/busprobs.zip and are summarised in the following table. All distances are stated in km. The geographic locations of these instances were chosen to reflect a wide range of problem features arising in the real world, including problem size (in terms of school enrolment figures and the number of bus stops in their catchment areas), urban or rural settings, coastal and inland, and organic or grid city layouts. Visualisations of all of these instances can be viewed at www.rhydlewis.eu/sols.

Location	Country / State	Number of stops, including the school ($\|V_1\|$)	Number of addresses ($\|V_2\|$)	Number of Students	Minimum Eligibility Distance (m_e)	Maximum walking distance (m_w)	Average number of stops per-address	Average number of addresses per-stop
Brisbane	Queensland	1817	438	757	3.2	1.6	79.2	19.1
Adelaide	South Australia	1118	342	565	1.6	1.6	100	28.8
Edinburgh-1	Scotland	959	409	680	1.6	1.6	84.6	36.1
Edinburgh-2	Scotland	917	190	320	1.6	1.6	256.1	53.1
Bridgend	Wales	633	221	381	4.82	1.6	45.3	15.9
Milton Keynes	England	579	149	274	4.8	1.6	64.5	16.6
Cardiff	Wales	552	90	156	4.8	1.6	63.9	10.4
Canberra	ACT	331	296	499	4.8	1	13.3	11.9
Suffolk	England	174	123	209	4.8	1.6	10.4	7.4
Porthcawl	Wales	153	42	66	3.2	1.6	53.5	14.8

These instances were generated as follows. First, the location of a school and its catchment area was identified using public records. Random residential addresses were then generated within the local area of the school, but at least m_e km from the school. Next, all bus stops in the local vicinity were added while ensuring that (a) each address had at least one stop within walking distance m_w, and (b) each stop had at least one address within walking distance m_w. The locations of these bus stops were also determined using public records. Finally, the shortest driving times and distances between each pair of bus stops, and shortest walking times and distances between all addresses and bus stops were determined using web mapping services (either Google Maps or Bing Maps). Finally, the number of students assigned to each address was generated randomly according to the following distribution: 1 (45%), 2 (40%), 3 (14%), and 4 (1%). This approximates relevant statistics in the UK and Australia.

Layout

Each problem instance is specified in a single input file with the extension **.bus**. These files can be viewed in a text editor. Items in each line of a file are separated by commas.

- The first line contains, respectively:
    - The number of stops, including the school $|V_1|$
    - The number of addresses $|V_2|$

- The number of listed walks from addresses to bus stops **x**
- The distance units (K for km, M for miles)
- The minimum eligibility distance m_e
- The maximum walking distance m_w

The remaining items on the first line give further information on the problem instance, but can be ignored.

- The second line contains the school's details: respectively,

  - An "s" indicating that this line contains a stopping location
  - The school's latitude
  - The school's longitude
  - The name of the school

Here is an example of the first two lines, taken from **Canberra.bus**

```
331, 296, 3925, K, 4.8, 1, StopBearingsNotUsed, WalkingDists=GoogleMaps, Created=01/09/2017 11:21:01
s, -35.2794, 149.14953, Campbell High School
```

- The next $|V_1| - 1$ lines in the file contain the details of each bus stop: respectively,

  - An "s" indicating that this line contains a stopping location
  - The stop's latitude
  - The stop's longitude
  - The name of the stop

Note that names of bus stops can sometimes contain commas. Here is an example of the first few bus stops in **Canberra.bus**

```
s,-35.340801,149.084457,Launceston St opp Phillip Oval.
s,-35.335697,149.081253,Theodore St before James St.
s,-35.333496,149.079742,Theodore St before 2nd James St.
s,-35.330509,149.077728,Carruthers St after Theodore St.
s,-35.327663,149.075592,Carruthers St after 2nd McCormack St.
s,-35.324566,149.075577,Carruthers St after Jennings St.
s,-35.322987,149.074814,Throssell St after Kennerley St.
s,-35.321159,149.074921,Throssell St after Jennings St.
```

- The next $|V_2|$ lines contain the details of each address: respectively,

  - An "a" indicating that this line contains an address
  - The address's latitude
  - The address's longitude
  - The number of children requiring transport to the school at this address
  - The name of the family at this address

Here is an example of the first few addresses in **Canberra.bus**

```
a,-35.2391182349441,149.143426895142,2,Fisher
a,-35.2393986437146,149.144585609436,1,James
a,-35.2408006730247,149.143212318421,3,Bradford
a,-35.2416418789767,149.142268180847,3,Davies
a,-35.2425531755781,149.142826080323,2,Nielsen
a,-35.2345843805945,149.150233914591,2,Page
```

```
a,-35.2351277020762,149.15102784846,2,Jacobson
```

- The next $|V_1|$ x $|V_1|$ lines now contain the driving distances and times between each pair of stopping points. We have, in order:

    - A "d" indicating that this line contains distance details between a pair of stopping points
    - The index of the start point
    - The index of the end point
    - The driving distance from the start point to the end point
    - The driving time (in seconds) from the start point to the end point

Note that stopping points are indexed from 0 to $|V_1|$ - 1. An index of zero corresponds to the school, the rest refer to bus stops. Here is an example of the first few addresses in **Canberra.bus**.

```
d,0,0,0,0
d,0,1,12.987,845
d,0,2,12.661,825
d,0,3,12.095,811
d,0,4,12.251,819
d,0,5,12.287,827
d,0,6,11.945,802
d,0,7,12.054,837
d,0,8,11.836,853
```

- Finally, the file contains the details of all of the **x** feasible walks in the problem instance (that is, all walks from addresses to bus stops that are less than m_w in length). Recall that **x** was specified on the first line of the input file. We have, in order:

    - A "w" indicating that this line contains details of a walk from an address to a bus stop
    - The index of the address
    - The index of the bus stop
    - The walking distance from the address to the bus stop
    - The walking time (in seconds) from the address to the bus stop

Addresses are again indexed from 0 to $|V2|$ - 1. Here is an example of the first few walks given in **Canberra.bus**.

```
w,0,174,0.854,650
w,0,204,0.993,734
w,0,206,0.787,583
w,0,207,0.721,535
w,0,208,0.587,436
w,0,209,0.594,441
w,0,210,0.736,545
w,0,211,0.647,479
w,0,212,0.716,536
w,0,213,0.682,511
w,0,303,0.759,568
w,0,306,0.668,503
```

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Please direct any queries/comments to Rhyd Lewis: web: www.rhydLewis.eu, email: LewisR9@cf.ac.uk

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R. Lewis (Last updated Tuesday, 13 November 2018)