

HW 8 Solution - ISE 754 Fall 2020

Contents

- Question 1
- Make (cut)
- (a) Hand solution
- (b) Using TSP2OPT
- Question 2
- Question 3
- (a) Hand solution
- (b) Using MINTLC
- Question 4
- Read data
- Read in data
- Get road network
- Label type of road
- Add connector roads from cities to road network
- Plot roads and customers
- Convert road distances to travel times (needs to be after ADDCONNECTOR)
- Shortest time routes
- Distance of shortest time route
- Create routing structures
- Construct & improve routes
- Add any single-shipment routes
- Plot Routes
- Display route output structure
- Plot cumsum of each route segment
- Route time and delivered/picked-up packages
- Display Gantt chart of route time spans
- Greedy route combination heuristic (not part of Matlog)
- Question 5
- Read data
- Determine shipment begining and ending location index
- Create independent shipments
- Plot independent shipments
- Consolidated shipments
- Construct and improve routes
- Make shipments not in routes into single-shipment routes
- Report results

- Question 6
- Data
- Independent transport charge
- Min incremental charge for all possible routes
- Equal charge allocation
- Equal savings allocation
- Exact Shapley allocation
- Pairwise approximate Shapley allocation
- Comparison

Question 1

Make (cut)

```

n = 6;
rng(398544)
D = ceil(rand(n)*10); D = triu(D,1) + tril(D,-1)
fhTD = @(x) locTC(x,D);
% %% Create table
% K = perms([2:n]); K = [ones(size(K,1),1) K ones(size(K,1),1)];
% for i = 1:size(K,1)
%     TD(i) = fhTD(K(i,:));
% end
% K = [K TD(:)];
% K = sortrows(K,1:7);
% mdisp(K)
% %%
rng(9739)
x0 = [1 randperm(n-1)+1 1]
fhTD(x0)
[Final_Sequence,TD,X] = tsp2optFE(x0,D);
disp('(a)')
Final_Sequence,TD
col = num2cellstr(1:n+1); col{end+1} = 'TD';
mdisp(X,[],col,'Seq')
% fprintf('Final_Sequence = '),fprintf('%d ',Final_Sequence)
% fprintf('\nTD = %d\nOrder in which sequences considered:\n',TD)
% for i=1:size(Order,1)
%     fprintf('%2d:',i),fprintf(' %d',Order(i,:)),fprintf('\n')
% end
disp('(b)')

```

D =

0	8	6	9	1	5
3	0	1	5	4	2
9	2	0	3	1	1
8	2	1	0	10	6
6	7	10	1	0	10
6	2	5	2	1	0

```
x0 =
1      5      2      6      4      3      1
```

```
ans =
```

```
22
```

(a)

```
Final_Sequence =
```

```
1      5      4      2      3      6      1
```

```
TD =
```

```
12
```

Seq:	1	2	3	4	5	6	7	TD
1:	1	5	2	6	4	3	1	22
2:	1	2	5	6	4	3	1	34
3:	1	6	2	5	4	3	1	22
4:	1	4	6	2	5	3	1	40
5:	1	5	6	2	4	3	1	28
6:	1	5	4	6	2	3	1	20
7:	1	4	5	6	2	3	1	41
8:	1	6	4	5	2	3	1	34
9:	1	2	6	4	5	3	1	41
10:	1	5	6	4	2	3	1	25
11:	1	5	2	6	4	3	1	22
12:	1	5	3	2	6	4	1	25
13:	1	5	4	2	6	3	1	20
14:	1	5	4	3	2	6	1	13
15:	1	4	5	3	2	6	1	39
16:	1	3	4	5	2	6	1	34
17:	1	2	3	4	5	6	1	38
18:	1	5	3	4	2	6	1	24
19:	1	5	2	3	4	6	1	24
20:	1	5	6	2	3	4	1	25
21:	1	5	4	2	3	6	1	12
22:	1	4	5	2	3	6	1	34
23:	1	2	4	5	3	6	1	40
24:	1	3	2	4	5	6	1	39
25:	1	5	2	4	3	6	1	21
26:	1	5	3	2	4	6	1	30
27:	1	5	6	3	2	4	1	31
28:	1	5	4	3	2	6	1	13
29:	1	5	4	6	3	2	1	18
30:	1	5	4	2	6	3	1	20

(b)

(a) Hand solution

Copy from Command into HTML set to fixed width Courier

(b) Using TSP2OPT

```
D = [
    0     8      6      9      1      5
    3     0      1      5      4      2
    9     2      0      3      1      1
    8     2      1      0     10      6
    6     7     10      1      0     10
    6     2      5      2      1      0];
loc0 = [1      5      2      6      4      3      1];
[loc,TD] = tsp2opt(loc0,D)
```

```
loc =
1      5      4      2      3      6      1
```

```
TD =
12
```

Question 2

```
T = [
0 2 2 2 1 2
2 0 3 2 3 3
2 3 0 3 2 2
2 2 3 0 3 1
1 3 2 3 0 3
2 3 2 1 3 0 ];
sh = vec2struct('b',1,'e',2:6, ...
    'temin',[9 18 9 15 21], 'temax',[12 21 18 18 24]); sdisp(sh)
tr = struct('b',1,'e',1,'tbmin',6,'temax',24); sdisp(tr)
rte = [3 1 4 2 5 3 1 4 2 5];
[TC,Xflg,out] = rteTC(rte,sh,T,tr)
```

```
sh: b e temin temax
```

```
--:-----

```

```
1: 1 2      9      12
2: 1 3      18     21
3: 1 4      9      18
4: 1 5     15     18
5: 1 6     21     24
```

```
tr: 1
```

```
-----:-----
```

```

b:    1
e:    1
tbmin:   6
temax:  24

TC =
15

Xflg =
1

out =
struct with fields:

Rte: [0 3 1 4 2 5 3 1 4 2 5 0]
Loc: [1 1 1 1 1 1 4 2 5 3 6 1]
Cost: [0 0 0 0 0 0 2 2 3 2 2 2]
Arrive: [0 8 8 8 8 8 10 12 15 17 20 23]
Wait: [0 0 0 0 0 0 0 0 0 1 1 0]
TWmin: [6 6 6 6 6 6 9 9 15 18 21 -Inf]
Start: [8 8 8 8 8 8 10 12 15 18 21 23]
LU: [0 0 0 0 0 0 0 0 0 0 0 0]
Depart: [8 8 8 8 8 8 10 12 15 18 21 23]
TWmax: [Inf Inf Inf Inf Inf Inf 18 12 18 21 24 24]
Total: [0 0 0 0 0 0 2 2 3 3 3 2]

```

Question 3

(a) Hand solution

```

D = [
      0    180    320    100    180     40
    180      0    140     80    240    140
    320    140      0    220    300    280
    100     80    220      0    240     60
    180    240    300    240      0    220
      40    140    280     60    220      0];
sh = vec2struct('b',[6 3 2],'e',[5 1 4],'f',[200 300 100],'s',[20 5 10]);
sh = vec2struct(sh,'v',[20000 5000 10000],'a',.5,'h',.3);
sdisp(sh)
rte = [2 3 2 1 3 1];
dagg = rteTC(rte,sh,D)
ash = aggshmt(sh); sdisp(ash)
ppiTL = 125;
tr = struct('r',2*(ppiTL/102.7),'Kwt',25,'Kcu',2750);
MC = mincharge(dagg,ppiTL,rte,sh)
qagg = sqrt((ash.f*max(tr.r*dagg,MC))/(ash.a*ash.v*ash.h))
q = qagg * [sh.f]/ash.f
L = rte2ldmx(rte), L{::}
k = 1

```

```

for j = 1:length(L)
    sj = sum([sh(L{j}).f])/sum([sh(L{j}).f]./[sh(L{j}).s])
    kj = min(tr.Kwt,sj*tr.Kcu/2000)/sum(q(L{j}))
    k = min(k,kj)
end
q = k*q
TLC = ash.f/sum(q)*tr.r*dagg + ash.a*ash.v*ash.h*sum(q); mdisp(TLC)

```

```

sh: b e f s v a h
---:-----
1: 6 5 200 20 20,000 0.5 0.3
2: 3 1 300 5 5,000 0.5 0.3
3: 2 4 100 10 10,000 0.5 0.3

```

dagg =

660

```

ash: 1
---:-----
b: 6.00
e: 5.00
f: 600.00
s: 7.50
v: 10,833.33
a: 0.50
h: 0.30

```

MC =

164.3135

qagg =

24.3560

q =

8.1187 12.1780 4.0593

L =

1×2 cell array

{1×2 double} {1×2 double}

ans =

2 3

```

ans =
3      1

k =
1

sj =
5.7143

kj =
0.4839

k =
0.4839

sj =
15

kj =
1.6936

k =
0.4839

q =
3.9286    5.8929    1.9643

TLC:      1
---:-----
1: 100,943.41

```

(b) Using MINTLC

```

[TLC,q] = mintLC(sh,tr,[],D,rte)
% Note: returned q in order of shmt in rte, not in shmt 1,2,3 order
rte

```

```
% To convert to 1,2,3 order:  
idx = rte2idx(rte)  
argsort(idx)  
q(argsort(idx))
```

```
TLC =  
  
1.0094e+05  
  
q =  
  
5.8929  
1.9643  
3.9286  
  
rte =  
  
2 3 2 1 3 1  
  
idx =  
  
2 3 1  
  
ans =  
  
3 1 2  
  
ans =  
  
3.9286  
5.8929  
1.9643
```

Question 4

Read data

```
close all, clear  
fn = 'HW8data.xlsx';  
inDC = table2struct(readtable(fn, 'Sheet', 'Q4-DC'));  
inC = table2struct(readtable(fn, 'Sheet', 'Q4-Customers'));
```

Read in data

```
XY = [[inDC.Lon inDC.Lat]; [inC.Lon]' [inC.Lat]'];  
pkg = [inC.Pkg]';  
TW = [inC.T_W]';
```

Get road network

```
expansionAroundXY = 0.12;
[XY2,IJD,isXY,isIJD] = subgraph(usrdnode('XY'),...
    isinrect(usrdnode('XY'),boundrect(XY,expansionAroundXY)),usrdlink('IJD'));
```

Label type of road

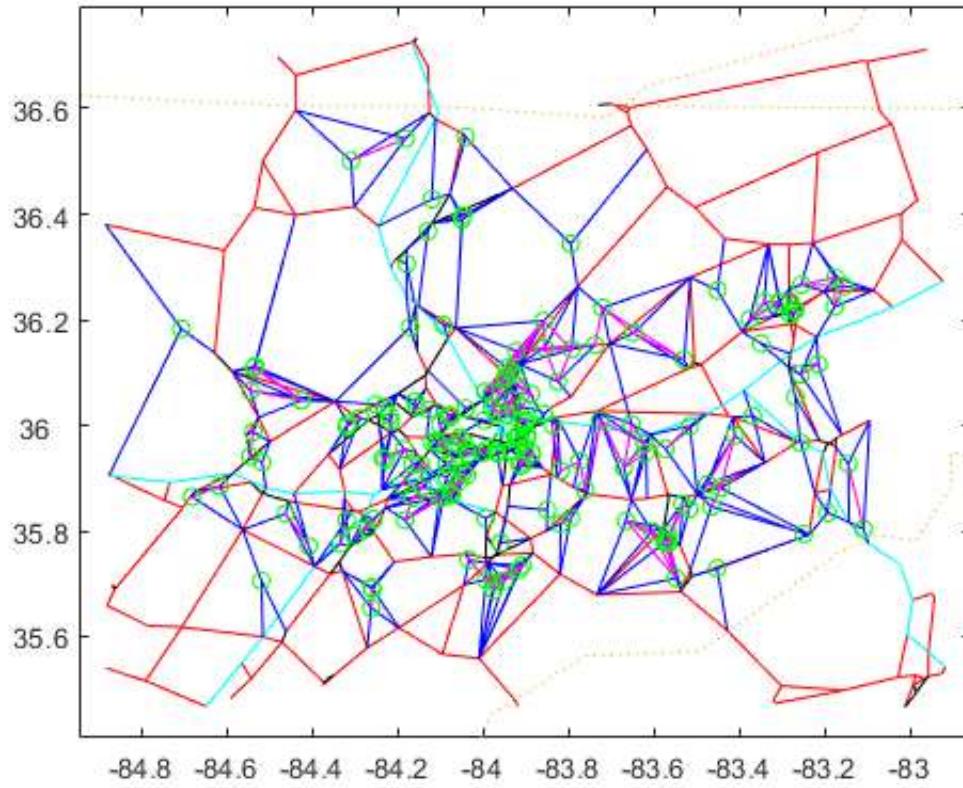
```
s = usrdlink(isIJD);
isI = s.Type == 'I'; % Interstate highways
isIR = isI & s.Urban == ' '; % Rural Interstate highways
isIU = isI & ~isIR; % Urban Interstate highways
isR = s.Urban == ' ' & ~isI; % Rural non-Interstate roads
isU = ~isI & ~isR; % Urban non-Interstate roads
```

Add connector roads from cities to road network

```
[IJD11,IJD12,IJD22] = addconnector(XY,XY2,IJD);
```

Plot roads and customers

```
makemap(XY2,0.03) % 3% expansion
h = []; % Keep handle to each plot for legend
h = [h pplot(IJD(isR,:),XY2,'r-','DisplayName','Rural Roads')];
h = [h pplot(IJD(isU,:),XY2,'k-','DisplayName','Urban Roads')];
h = [h pplot(IJD(isI,:),XY2,'c-','DisplayName','Interstate Roads')];
h = [h pplot(IJD12,[XY; XY2],'b-','DisplayName','Connector Roads')];
h = [h pplot(IJD11,[XY; XY],'m-','DisplayName','Connector Roads')];
h = [h pplot(XY,'go','DisplayName','Customers')];
```



Convert road distances to travel times (needs to be after ADDCONNECTOR)

```
IJT = IJD;
IJT(isIR,3) = IJD(isIR,3)/70; IJT(isIU,3) = IJD(isIU,3)/50;
IJT(isR,3) = IJD(isR,3)/45; IJT(isU,3) = IJD(isU,3)/20;
IJT22 = IJD22; IJT22(:,3) = IJT(:,3);
IJT12 = IJD12; IJT12(:,3) = IJD12(:,3)/15;
IJT11 = IJD11; IJT11(:,3) = IJD11(:,3)/15; % Includes residential delivery
```

Shortest time routes

```
n = size(XY,1);
[T,P] = dijk(list2adj([IJT12; IJT22]),1:n,1:n);
```

Distance of shortest time route

```
A = list2adj([IJD12; IJD22]);
D = zeros(n);
for i = 1:n, for j = 1:n, D(i,j) = locTC(pred2path(P,i,j),A); end, end
```

Create routing structures

```
tr = struct('b',1,'e',1,'Kwt',35,'maxTC',7);
temin = repmat(8,n-1,1); temin(TW == 'A') = 12; temin(TW == 'E') = 17;
temax = repmat(12,n-1,1); temax(TW == 'A') = 17; temax(TW == 'E') = 21;
```

```
sh = vec2struct('b',1,'e',2:length(T),'q',pkg,'tU',2/60,...  
'temin',temin,'temax',temax);
```

Construct & improve routes

```
rTCh = @(rte) rteTC(rte,sh,T,tr);  
IJS = pairwisesavings(rTCh,sh);  
[r,Time] = twoopt(savings(rTCh,sh,IJS,true),rTCh,true);
```

SAVINGS:

4.407606: Make Rte 1 using 43 and 175
5.058468: Add 38 to Rte 1
5.658400: Add 100 to Rte 1
9.111620: Make Rte 2 using 51 and 53
12.562217: Make Rte 3 using 39 and 136
13.263547: Add 68 to Rte 2
13.524768: Add 113 to Rte 2
16.382112: Make Rte 4 using 19 and 102
19.293893: Make Rte 5 using 13 and 49
19.853847: Add 148 to Rte 5
20.081911: Add 64 to Rte 3
18.667948: Combine Rte 3 to Rte 4
21.395961: Make Rte 6 using 50 and 131
21.787232: Add 3 to Rte 4
22.110686: Add 112 to Rte 6
22.599270: Add 66 to Rte 6
22.778701: Add 5 to Rte 6
23.085929: Add 137 to Rte 5
24.781099: Add 169 to Rte 2
28.135044: Make Rte 7 using 124 and 154
28.357768: Add 160 to Rte 5
28.578080: Add 176 to Rte 6
28.649375: Add 69 to Rte 7
29.424836: Add 163 to Rte 6
29.836976: Add 156 to Rte 1
30.518263: Add 74 to Rte 7
31.307090: Add 139 to Rte 4
31.617215: Add 126 to Rte 7
33.923302: Make Rte 8 using 17 and 128
34.269855: Add 158 to Rte 8
37.099789: Make Rte 9 using 67 and 166
37.217418: Add 129 to Rte 1
37.964250: Add 12 to Rte 9
38.553982: Add 58 to Rte 5
41.040249: Make Rte 10 using 60 and 127
39.587200: Combine Rte 6 to Rte 9
42.266732: Make Rte 11 using 54 and 101
44.320854: Make Rte 12 using 22 and 106
47.811779: Make Rte 13 using 62 and 88
50.090533: Make Rte 14 using 6 and 87
50.541308: Add 75 to Rte 11
50.752411: Add 155 to Rte 11
53.497982: Make Rte 15 using 10 and 52
53.965728: Add 95 to Rte 15

54.637391: Add 150 to Rte 15
53.300519: Combine Rte 14 to Rte 7
56.854417: Make Rte 16 using 2 and 162
57.193555: Add 1 to Rte 12
59.177951: Make Rte 17 using 11 and 78
60.358786: Add 122 to Rte 13
60.645262: Add 149 to Rte 5
60.980013: Add 121 to Rte 15
62.915927: Make Rte 18 using 117 and 174
65.157579: Make Rte 19 using 32 and 71
64.155136: Combine Rte 11 to Rte 8
66.420847: Make Rte 20 using 20 and 152
66.926520: Add 70 to Rte 16
67.676134: Add 157 to Rte 19
70.399379: Make Rte 21 using 89 and 93
73.249935: Make Rte 22 using 36 and 116
75.085642: Add 165 to Rte 22
76.619930: Add 99 to Rte 18
78.196497: Add 143 to Rte 13
78.863277: Add 107 to Rte 7
78.073590: Combine Rte 10 to Rte 8
78.756700: Add 59 to Rte 15
81.469295: Make Rte 23 using 119 and 153
81.892527: Add 63 to Rte 12
82.622232: Add 84 to Rte 16
82.930792: Add 110 to Rte 12
84.018127: Add 24 to Rte 17
84.425683: Add 104 to Rte 17
84.566811: Add 90 to Rte 21
85.044875: Add 25 to Rte 22
85.716343: Add 114 to Rte 5
87.917848: Make Rte 24 using 23 and 92
88.934429: Add 31 to Rte 19
89.209736: Add 144 to Rte 22
89.758747: Add 98 to Rte 17
93.158837: Make Rte 25 using 79 and 164
94.040674: Add 170 to Rte 17
95.704163: Make Rte 26 using 16 and 105
95.576111: Combine Rte 18 to Rte 20
95.798742: Add 177 to Rte 24
96.999287: Add 14 to Rte 19
97.303344: Add 55 to Rte 26
97.577353: Add 57 to Rte 26
97.915777: Add 77 to Rte 16
100.289709: Make Rte 27 using 8 and 94
100.551243: Add 37 to Rte 19
101.776930: Make Rte 28 using 147 and 173
103.378825: Make Rte 29 using 86 and 141
104.279872: Add 7 to Rte 22
106.201873: Make Rte 30 using 18 and 42
106.775465: Add 44 to Rte 30
106.302937: Combine Rte 21 to Rte 30
106.620789: Add 28 to Rte 30
108.004636: Make Rte 31 using 130 and 134
108.330993: Add 108 to Rte 12
108.617478: Add 33 to Rte 7
108.820008: Add 115 to Rte 29

108.287367: Combine Rte 29 to Rte 27
108.846532: Add 178 to Rte 20
109.226768: Add 161 to Rte 2
108.530224: Combine Rte 31 to Rte 12
107.710899: Combine Rte 28 to Rte 27
107.891892: Add 159 to Rte 16
108.095176: Add 81 to Rte 16
108.647587: Add 35 to Rte 27
108.837486: Add 47 to Rte 27
109.176917: Add 29 to Rte 22
109.634079: Add 140 to Rte 27
109.923006: Add 151 to Rte 7
110.620462: Add 48 to Rte 15
110.862379: Add 142 to Rte 26
111.100226: Add 27 to Rte 13
111.389502: Add 133 to Rte 27
112.013348: Add 26 to Rte 20
112.199469: Add 172 to Rte 27
112.680502: Add 9 to Rte 15
112.963636: Add 123 to Rte 22
112.820028: Combine Rte 25 to Rte 26
112.659292: Combine Rte 23 to Rte 24
113.030833: Add 46 to Rte 15
113.409705: Add 96 to Rte 24
113.479429: Add 73 to Rte 20
113.759131: Add 145 to Rte 15
114.166604: Add 91 to Rte 26
114.577704: Add 168 to Rte 17
115.533418: Make Rte 32 using 80 and 109
116.003952: Add 118 to Rte 24
116.168420: Add 138 to Rte 8
116.462531: Add 76 to Rte 12
117.472954: Make Rte 33 using 45 and 97
117.735422: Add 34 to Rte 24
117.899599: Add 83 to Rte 24
118.100568: Add 103 to Rte 33
118.556497: Add 72 to Rte 12
118.853051: Add 85 to Rte 33
119.805298: Make Rte 34 using 30 and 65
120.322909: Add 167 to Rte 26
120.567035: Add 111 to Rte 26
120.756432: Add 146 to Rte 33
121.342096: Make Rte 35 using 120 and 171
122.240872: Make Rte 36 using 179 and 180
122.315532: Add 41 to Rte 34
122.004672: Combine Rte 36 to Rte 32
122.862880: Make Rte 37 using 40 and 135
123.036552: Add 4 to Rte 32
123.105919: Add 56 to Rte 35
123.182468: Add 21 to Rte 37
123.380390: Add 15 to Rte 15
123.519857: Add 61 to Rte 33
123.300455: Combine Rte 34 to Rte 37
123.421035: Add 125 to Rte 37
123.803691: Make Rte 38 using 82 and 132
123.670253: Combine Rte 38 to Rte 32
123.507754: Combine Rte 32 to Rte 37

123.301741: Combine Rte 17 to Rte 33

TWOOPT:

123.301741: 1: 129 156 100 38 43 175 43 175 38 100 156 129
123.182583: 1: 129 156 100 38 43 175 100 38 175 43 156 129
123.182583: 1: 129 156 100 38 43 175 129 156 43 175 38 100
123.182583: 2: 161 169 113 68 53 51 51 53 68 113 169 161
123.005510: 2: 161 169 113 68 53 51 51 53 113 68 169 161
123.005510: 2: 161 169 113 68 53 51 51 68 113 53 169 161
123.005510: 3: 139 3 102 19 64 39 136 136 39 3 64 19 102 139
123.005510: 3: 139 3 102 19 64 39 136 136 64 3 39 19 102 139
123.005510: 4: 114 149 58 160 137 148 13 49 49 13 148 137 160 58 149 114
123.005510: 4: 114 149 58 160 137 148 13 49 137 148 13 49 160 58 149 114
122.989584: 4: 114 149 58 160 137 148 13 49 160 49 13 148 137 58 149 114
122.899901: 4: 114 149 58 160 137 148 13 49 149 58 137 148 13 49 160 114
122.899901: 5: 151 33 107 6 87 126 74 69 124 154 154 74 124 69 126 87 6 107 33 151
122.486889: 5: 151 33 107 6 87 126 74 69 124 154 6 87 126 69 124 74 154 107 33 151
122.181023: 5: 151 33 107 6 87 126 74 69 124 154 6 87 126 69 124 154 74 107 33 151
122.181023: 6: 138 127 60 128 17 158 155 75 54 101 54 128 158 17 155 75 127 60 101 138
121.826261: 6: 138 127 60 128 17 158 155 75 54 101 60 127 75 155 17 158 128 54 101 138
121.826261: 6: 138 127 60 128 17 158 155 75 54 101 127 60 75 155 17 158 128 54 101 138
121.826261: 7: 67 166 12 163 176 5 66 112 50 131 50 131 112 66 176 5 163 67 166 12
121.825944: 7: 67 166 12 163 176 5 66 112 131 50 131 50 112 66 176 5 163 67 166 12
121.767472: 7: 67 166 12 163 176 5 66 112 131 50 176 66 112 50 131 5 163 67 166 12
121.763133: 7: 67 166 12 163 176 5 66 112 131 50 176 66 50 112 131 5 163 67 166 12
121.754443: 7: 67 166 12 163 176 5 66 112 131 50 176 66 5 131 112 50 163 67 166 12
121.744376: 7: 67 166 12 163 176 5 66 112 131 50 176 66 112 131 5 50 163 67 166 12
121.740038: 7: 67 166 12 163 176 5 66 112 131 50 176 66 50 5 131 112 163 67 166 12
121.731347: 7: 67 166 12 163 176 5 66 112 131 50 176 66 5 50 131 112 163 67 166 12
121.723846: 7: 67 166 12 163 176 5 66 112 131 50 176 66 5 112 131 50 163 67 166 12
121.719424: 7: 67 166 12 163 176 5 66 112 50 131 112 5 66 176 50 131 163 67 166 12
121.671339: 7: 67 166 12 163 176 5 66 112 50 131 5 112 66 176 50 131 163 67 166 12
121.607472: 7: 67 166 12 163 176 5 66 112 50 131 176 66 112 5 50 131 163 67 166 12
121.603133: 7: 67 166 12 163 176 5 66 112 50 131 176 66 50 5 112 131 163 67 166 12
121.603133: 8: 72 76 134 130 108 110 63 1 106 22 22 1 106 63 110 108 134 130 76 72
121.491034: 8: 72 76 134 130 108 110 63 1 106 22 1 22 106 63 110 108 134 130 76 72
121.491034: 9: 27 143 122 62 88 88 62 143 27 122
121.491034: 9: 27 143 122 62 88 122 27 143 62 88
121.491034: 10: 15 145 46 9 48 59 121 150 95 52 10 10 150 95 52 9 48 59 121 46 145 15
121.025942: 10: 15 145 46 9 48 59 121 150 95 52 10 48 9 52 95 150 10 59 121 46 145 15
120.955288: 10: 15 145 46 9 48 59 121 10 150 95 52 9 48 10 52 95 150 59 121 46 145 15
120.843066: 10: 15 145 46 9 48 59 121 10 150 95 52 9 48 59 150 95 52 10 121 46 145 15
120.843066: 11: 81 159 77 84 70 162 2 162 2 70 84 77 159 81
120.813286: 11: 81 159 77 84 70 2 162 2 162 70 84 77 159 81
120.813286: 12: 37 14 31 157 32 71 32 14 31 157 71 37
120.745315: 12: 37 14 31 157 32 71 157 31 14 32 71 37
120.656426: 12: 37 14 31 157 32 71 31 157 14 32 71 37
120.590071: 12: 37 14 31 157 32 71 14 157 31 32 71 37
120.401153: 12: 37 14 31 157 32 71 14 31 157 32 71 37
120.401153: 13: 73 26 178 20 152 99 117 174 117 178 73 152 20 99 174 26
120.307820: 13: 73 26 178 20 152 99 117 174 99 20 152 73 178 117 174 26
120.236468: 13: 73 26 178 20 152 99 117 174 152 20 99 73 178 117 174 26
120.236468: 14: 123 29 7 144 25 165 36 116 116 25 7 144 165 36 29 123
120.208018: 14: 123 29 7 144 25 165 36 116 25 116 7 144 165 36 29 123
120.024462: 14: 123 29 7 144 25 165 36 116 7 116 25 144 165 36 29 123
119.849581: 14: 123 29 7 144 25 165 36 116 7 144 25 116 165 36 29 123
119.849581: 15: 83 34 118 96 153 119 177 23 92 92 23 118 34 96 153 119 177 83

```

119.473980: 15: 83 34 118 96 153 119 177 23 92 119 153 96 34 118 23 92 177 83
119.473980: 16: 111 167 91 79 164 142 57 55 105 16 105 167 164 79 16 57 55 142 91 111
119.324718: 16: 111 167 91 79 164 142 57 55 105 16 167 105 164 79 16 57 55 142 91 111
119.324718: 16: 111 167 91 79 164 142 57 55 105 16 167 105 164 79 57 16 55 142 91 111
119.324718: 17: 172 133 140 47 35 173 147 94 8 115 86 141 141 86 115 47 35 173 147 133 94 8 1
40 172
119.259779: 17: 172 133 140 47 35 173 147 94 8 115 86 141 115 86 141 47 35 173 147 133 94 8 1
40 172
119.259779: 17: 172 133 140 47 35 173 147 94 8 115 141 86 115 141 86 47 35 173 147 133 94 8 1
40 172
119.257575: 17: 172 133 140 47 35 173 147 94 8 115 141 86 35 47 86 141 115 173 147 133 94 8 1
40 172
119.051640: 17: 172 133 140 47 35 173 147 94 8 115 141 86 8 94 133 147 173 115 141 86 47 35 1
40 172
119.051640: 18: 28 42 18 44 90 89 93 89 93 90 42 18 44 28
118.711624: 18: 28 42 18 44 90 89 93 90 93 89 42 18 44 28
118.711624: 19: 45 97 103 85 146 61 168 170 98 104 24 78 11 78 24 98 104 11 170 168 146 45 97
103 85 61
118.444994: 19: 45 97 103 85 146 61 168 170 98 104 24 78 11 104 98 24 78 11 170 168 146 45 97
103 85 61
118.439994: 19: 45 97 103 85 146 61 168 170 98 104 24 78 11 104 98 24 78 11 170 168 61 85 103
97 45 146
118.439994: 20: 56 120 171 171 120 56
118.439994: 21: 65 30 41 21 135 40 125 82 132 4 179 180 80 109 80 109 179 180 4 40 135 21 41
65 30 125 132 82
118.401160: 21: 65 30 41 21 135 40 125 82 132 4 180 179 109 80 109 80 180 179 4 40 135 21 41
65 30 125 132 82
118.394771: 21: 65 30 41 21 135 40 125 82 132 4 180 179 109 80 4 179 180 80 109 40 135 21 41
65 30 125 132 82
118.393160: 21: 65 30 41 21 135 40 125 82 132 4 180 179 109 80 125 30 65 41 21 135 40 109 80
180 179 4 132 82
118.341160: 21: 65 30 41 21 135 40 125 82 132 4 180 179 109 80 125 30 65 41 21 135 40 4 179 1
80 80 109 132 82

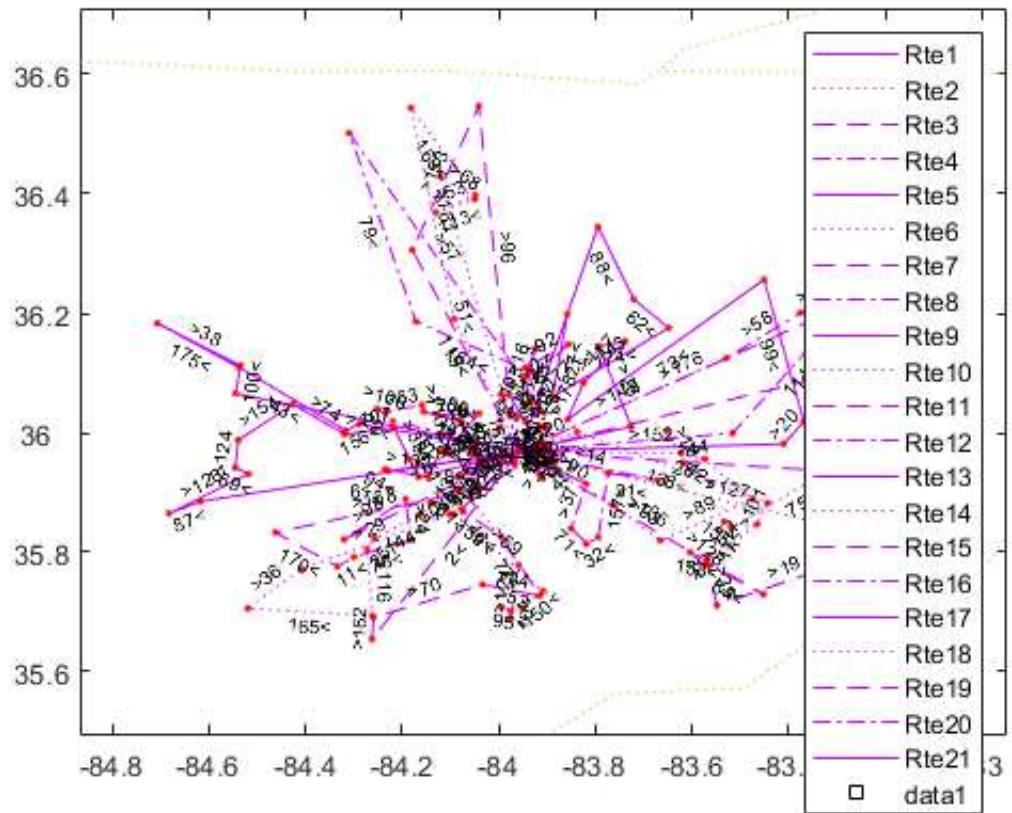
```

Add any single-shipment routes

```
[r,~,Time] = sh2rte(sh,r,rTCh);
```

Plot Routes

```
plotshmt(sh,XY,r,tr)
pplot(XY(1,:),'ks')
```



Display route output structure

```
[TC,Xflg,out] = rTCh(r);
for i = 1:length(out), sdisp(out(i),false,i), end
```

	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.00	0.00	0	-Inf	16.16	0.0000	16.16	Inf	0.00
2:	129	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
3:	156	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
4:	100	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
5:	38	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
6:	43	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
7:	175	1	0.00	16.16	0	-Inf	16.16	0.0000	16.16	Inf	0.00
8:	129	130	0.84	17.00	0	17	17.00	0.0333	17.03	21	0.87
9:	156	157	0.21	17.25	0	17	17.25	0.0333	17.28	21	0.25
10:	43	44	0.84	18.13	0	17	18.13	0.0333	18.16	21	0.88
11:	175	176	0.91	19.07	0	17	19.07	0.0333	19.10	21	0.94
12:	38	39	0.92	20.02	0	17	20.02	0.0333	20.06	21	0.96
13:	100	101	0.66	20.72	0	17	20.72	0.0333	20.75	21	0.69
14:	0	1	1.48	22.23	0	-Inf	22.23	0.0000	22.23	Inf	1.48
<hr/>											
2:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
1:	0	1	0.00	0.00	0	-Inf	14.93	0.0000	14.93	Inf	0.00
2:	161	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00

3:	169	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00
4:	113	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00
5:	68	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00
6:	53	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00
7:	51	1	0.00	14.93	0	-Inf	14.93	0.0000	14.93	Inf	0.00
8:	51	52	1.43	16.36	0	12	16.36	0.0333	16.39	17	1.47
9:	68	69	0.61	17.00	0	17	17.00	0.0333	17.03	21	0.64
10:	113	114	0.51	17.54	0	17	17.54	0.0333	17.57	21	0.54
11:	53	54	0.53	18.10	0	17	18.10	0.0333	18.13	21	0.56
12:	169	170	1.24	19.37	0	17	19.37	0.0333	19.40	21	1.27
13:	161	162	1.26	20.66	0	17	20.66	0.0333	20.69	21	1.29
14:	0	1	0.55	21.24	0	-Inf	21.24	0.0000	21.24	Inf	0.55

3:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.00	0.00	0	-Inf	14.84	0.0000	14.84	Inf	0.00
2:	139	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
3:	3	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
4:	102	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
5:	19	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
6:	64	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
7:	39	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
8:	136	1	0.00	14.84	0	-Inf	14.84	0.0000	14.84	Inf	0.00
9:	136	137	1.48	16.32	0	12	16.32	0.0333	16.35	17	1.51
10:	64	65	0.65	17.00	0	17	17.00	0.0333	17.03	21	0.68
11:	3	4	0.33	17.36	0	17	17.36	0.0333	17.40	21	0.36
12:	39	40	0.51	17.91	0	17	17.91	0.0333	17.94	21	0.54
13:	19	20	0.72	18.66	0	17	18.66	0.0333	18.69	21	0.75
14:	102	103	0.44	19.14	0	17	19.14	0.0333	19.17	21	0.48
15:	139	140	0.73	19.90	0	17	19.90	0.0333	19.93	21	0.76
16:	0	1	1.21	21.15	0	-Inf	21.15	0.0000	21.15	Inf	1.21

4:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
2:	114	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
3:	149	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
4:	58	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
5:	160	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
6:	137	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
7:	148	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
8:	13	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
9:	49	1	0.0000	16.22	0	-Inf	16.22	0.0000	16.22	Inf	0.0000
10:	149	150	0.7800	17.00	0	17	17.00	0.0333	17.03	21	0.8133
11:	58	59	0.5028	17.54	0	17	17.54	0.0333	17.57	21	0.5361
12:	137	138	0.5183	18.09	0	17	18.09	0.0333	18.12	21	0.5516
13:	148	149	0.4794	18.60	0	17	18.60	0.0333	18.63	21	0.5128
14:	13	14	0.4949	19.13	0	17	19.13	0.0333	19.16	21	0.5283
15:	49	50	0.4730	19.63	0	17	19.63	0.0333	19.67	21	0.5063
16:	160	161	0.4249	20.09	0	17	20.09	0.0333	20.13	21	0.4583
17:	114	115	0.7105	20.84	0	17	20.84	0.0333	20.87	21	0.7438
18:	0	1	0.7934	21.66	0	-Inf	21.66	0.0000	21.66	Inf	0.7934

5:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
2:	151	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000

3:	33	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
4:	107	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
5:	6	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
6:	87	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
7:	126	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
8:	74	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
9:	69	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
10:	124	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
11:	154	1	0.0000	7.07	0	-Inf	7.07	0.0000	7.07	Inf	0.0000
12:	6	7	0.9332	8.00	0	8	8.00	0.0333	8.03	12	0.9666
13:	87	88	0.3936	8.43	0	8	8.43	0.0333	8.46	12	0.4270
14:	126	127	0.5152	8.98	0	8	8.98	0.0333	9.01	12	0.5485
15:	69	70	0.1809	9.19	0	8	9.19	0.0333	9.22	12	0.2143
16:	124	125	0.3193	9.54	0	8	9.54	0.0333	9.58	12	0.3526
17:	154	155	0.7777	10.35	0	8	10.35	0.0333	10.39	12	0.8111
18:	74	75	0.6883	11.08	0	8	11.08	0.0333	11.11	12	0.7216
19:	107	108	0.5456	11.65	0	8	11.65	0.0333	11.69	12	0.5789
20:	33	34	0.4229	12.11	0	12	12.11	0.0333	12.14	17	0.4562
21:	151	152	0.3134	12.46	0	12	12.46	0.0333	12.49	17	0.3467
22:	0	1	0.4584	12.95	0	-Inf	12.95	0.0000	12.95	Inf	0.4584

6:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	6.81	0.0000	6.81	Inf	0.00
2:	138	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
3:	127	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
4:	60	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
5:	128	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
6:	17	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
7:	158	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
8:	155	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
9:	75	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
10:	54	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
11:	101	1	0.00	6.81	0	-Inf	6.81	0.0000	6.81	Inf	0.00
12:	127	128	1.19	8.00	0	8	8.00	0.0333	8.03	12	1.22
13:	60	61	0.45	8.49	0	8	8.49	0.0333	8.52	12	0.49
14:	75	76	0.59	9.11	0	8	9.11	0.0333	9.14	12	0.62
15:	155	156	0.26	9.40	0	8	9.40	0.0333	9.43	12	0.29
16:	17	18	0.51	9.94	0	8	9.94	0.0333	9.97	12	0.54
17:	158	159	0.26	10.23	0	8	10.23	0.0333	10.27	12	0.29
18:	128	129	0.34	10.61	0	8	10.61	0.0333	10.64	12	0.38
19:	54	55	0.81	11.46	0	8	11.46	0.0333	11.49	12	0.85
20:	101	102	0.56	12.05	0	12	12.05	0.0333	12.08	17	0.59
21:	138	139	0.92	13.00	0	12	13.00	0.0333	13.03	17	0.95
22:	0	1	0.28	13.31	0	-Inf	13.31	0.0000	13.31	Inf	0.28

7:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	7.15	0.0000	7.15	Inf	0.00
2:	67	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
3:	166	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
4:	12	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
5:	163	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
6:	176	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
7:	5	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
8:	66	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
9:	112	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00

10:	50	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
11:	131	1	0.00	7.15	0	-Inf	7.15	0.0000	7.15	Inf	0.00
12:	176	177	0.93	8.08	0	8	8.08	0.0333	8.12	12	0.96
13:	66	67	0.32	8.43	0	8	8.43	0.0333	8.47	12	0.35
14:	50	51	0.38	8.85	0	8	8.85	0.0333	8.88	12	0.42
15:	5	6	0.23	9.11	0	8	9.11	0.0333	9.15	12	0.26
16:	112	113	0.22	9.37	0	8	9.37	0.0333	9.40	12	0.25
17:	131	132	0.43	9.83	0	8	9.83	0.0333	9.86	12	0.46
18:	163	164	0.62	10.48	0	8	10.48	0.0333	10.52	12	0.65
19:	67	68	0.87	11.39	0	8	11.39	0.0333	11.42	12	0.91
20:	166	167	0.58	12.00	0	12	12.00	0.0333	12.03	17	0.61
21:	12	13	0.57	12.60	0	12	12.60	0.0333	12.64	17	0.60
22:	0	1	1.13	13.77	0	-Inf	13.77	0.0000	13.77	Inf	1.13

8:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
2:	72	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
3:	76	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
4:	134	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
5:	130	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
6:	108	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
7:	110	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
8:	63	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
9:	1	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
10:	106	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
11:	22	1	0.0000	15.61	0	-Inf	15.61	0.0000	15.61	Inf	0.0000
12:	1	2	0.7658	16.38	0	12	16.38	0.0333	16.41	17	0.7992
13:	22	23	0.2893	16.70	0	12	16.70	0.0333	16.73	17	0.3226
14:	106	107	0.2687	17.00	0	17	17.00	0.0333	17.03	21	0.3020
15:	63	64	0.4956	17.53	0	17	17.53	0.0333	17.56	21	0.5290
16:	110	111	0.3414	17.90	0	17	17.90	0.0333	17.94	21	0.3748
17:	108	109	0.4316	18.37	0	17	18.37	0.0333	18.40	21	0.4649
18:	134	135	0.4009	18.80	0	17	18.80	0.0333	18.84	21	0.4342
19:	130	131	0.2550	19.09	0	17	19.09	0.0333	19.12	21	0.2883
20:	76	77	0.4318	19.56	0	17	19.56	0.0333	19.59	21	0.4651
21:	72	73	0.4583	20.05	0	17	20.05	0.0333	20.08	21	0.4916
22:	0	1	0.3050	20.39	0	-Inf	20.39	0.0000	20.39	Inf	0.3050

9:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.00	0.00	0	-Inf	15.85	0.0000	15.85	Inf	0.00
2:	27	1	0.00	15.85	0	-Inf	15.85	0.0000	15.85	Inf	0.00
3:	143	1	0.00	15.85	0	-Inf	15.85	0.0000	15.85	Inf	0.00
4:	122	1	0.00	15.85	0	-Inf	15.85	0.0000	15.85	Inf	0.00
5:	62	1	0.00	15.85	0	-Inf	15.85	0.0000	15.85	Inf	0.00
6:	88	1	0.00	15.85	0	-Inf	15.85	0.0000	15.85	Inf	0.00
7:	122	123	1.15	17.00	0	17	17.00	0.0333	17.03	21	1.18
8:	27	28	0.97	18.00	0	17	18.00	0.0333	18.04	21	1.00
9:	143	144	1.02	19.05	0	17	19.05	0.0333	19.09	21	1.05
10:	62	63	0.82	19.90	0	17	19.90	0.0333	19.94	21	0.85
11:	88	89	0.99	20.93	0	17	20.93	0.0333	20.96	21	1.03
12:	0	1	1.37	22.34	0	-Inf	22.34	0.0000	22.34	Inf	1.37

10:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	7.51	0.0000	7.51	Inf	0.0000

2:	15	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
3:	145	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
4:	46	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
5:	9	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
6:	48	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
7:	59	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
8:	121	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
9:	10	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
10:	150	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
11:	95	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
12:	52	1	0.0000	7.51	0	-Inf	7.51	0.0000	7.51	Inf	0.0000
13:	9	10	0.4882	8.00	0	8	8.00	0.0333	8.03	12	0.5216
14:	48	49	0.3164	8.35	0	8	8.35	0.0333	8.38	12	0.3498
15:	59	60	0.6008	8.98	0	8	8.98	0.0333	9.02	12	0.6342
16:	150	151	0.7316	9.75	0	8	9.75	0.0333	9.78	12	0.7649
17:	95	96	0.5364	10.32	0	8	10.32	0.0333	10.35	12	0.5697
18:	52	53	0.4909	10.84	0	8	10.84	0.0333	10.88	12	0.5242
19:	10	11	0.6352	11.51	0	8	11.51	0.0333	11.54	12	0.6685
20:	121	122	0.5922	12.14	0	12	12.14	0.0333	12.17	17	0.6255
21:	46	47	0.6837	12.85	0	12	12.85	0.0333	12.89	17	0.7171
22:	145	146	0.3209	13.21	0	12	13.21	0.0333	13.24	17	0.3543
23:	15	16	0.3635	13.60	0	12	13.60	0.0333	13.64	17	0.3968
24:	0	1	0.1560	13.79	0	-Inf	13.79	0.0000	13.79	Inf	0.1560

11:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.00	0.00	0	-Inf	15.71	0.0000	15.71	Inf	0.00
2:	81	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
3:	159	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
4:	77	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
5:	84	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
6:	70	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
7:	2	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
8:	162	1	0.00	15.71	0	-Inf	15.71	0.0000	15.71	Inf	0.00
9:	2	3	1.29	17.00	0	17	17.00	0.0333	17.03	21	1.33
10:	162	163	1.06	18.10	0	17	18.10	0.0333	18.13	21	1.10
11:	70	71	0.77	18.89	0	17	18.89	0.0333	18.93	21	0.80
12:	84	85	0.61	19.54	0	17	19.54	0.0333	19.57	21	0.64
13:	77	78	0.61	20.18	0	17	20.18	0.0333	20.21	21	0.64
14:	159	160	0.31	20.53	0	17	20.53	0.0333	20.56	21	0.35
15:	81	82	0.16	20.72	0	17	20.72	0.0333	20.76	21	0.20
16:	0	1	0.43	21.19	0	-Inf	21.19	0.0000	21.19	Inf	0.43

12:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	8.11	0.0000	8.11	Inf	0.00
2:	37	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
3:	14	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
4:	31	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
5:	157	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
6:	32	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
7:	71	1	0.0000	8.11	0	-Inf	8.11	0.0000	8.11	Inf	0.00
8:	14	15	0.9591	9.07	0	8	9.07	0.0333	9.11	12	0.99
9:	31	32	0.9808	10.09	0	8	10.09	0.0333	10.12	12	1.01
10:	157	158	0.7776	10.90	0	8	10.90	0.0333	10.93	12	0.81
11:	32	33	0.5612	11.49	0	8	11.49	0.0333	11.53	12	0.59
12:	71	72	0.4741	12.00	0	12	12.00	0.0333	12.03	17	0.51

13:	37	38	0.5847	12.62	0	12	12.62	0.0333	12.65	17	0.62
14:	0	1	0.5204	13.17	0	-Inf	13.17	0.0000	13.17	Inf	0.52

	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	7.16	0.0000	7.16	Inf	0.00
2:	73	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
3:	26	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
4:	178	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
5:	20	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
6:	152	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
7:	99	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
8:	117	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
9:	174	1	0.00	7.16	0	-Inf	7.16	0.0000	7.16	Inf	0.00
10:	152	153	0.84	8.00	0	8	8.00	0.0333	8.03	12	0.87
11:	20	21	0.50	8.53	0	8	8.53	0.0333	8.57	12	0.53
12:	99	100	1.22	9.79	0	8	9.79	0.0333	9.82	12	1.25
13:	73	74	1.08	10.90	0	8	10.90	0.0333	10.94	12	1.11
14:	178	179	0.45	11.38	0	8	11.38	0.0333	11.42	12	0.48
15:	117	118	0.51	11.93	0	8	11.93	0.0333	11.96	12	0.54
16:	174	175	0.31	12.27	0	12	12.27	0.0333	12.30	17	0.34
17:	26	27	1.04	13.34	0	12	13.34	0.0333	13.38	17	1.07
18:	0	1	0.48	13.85	0	-Inf	13.85	0.0000	13.85	Inf	0.48

	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	7.26	0.0000	7.26	Inf	0.00
2:	123	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
3:	29	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
4:	7	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
5:	144	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
6:	25	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
7:	165	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
8:	36	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
9:	116	1	0.00	7.26	0	-Inf	7.26	0.0000	7.26	Inf	0.00
10:	7	8	0.74	8.00	0	8	8.00	0.0333	8.03	12	0.77
11:	144	145	0.59	8.62	0	8	8.62	0.0333	8.65	12	0.62
12:	25	26	0.28	8.93	0	8	8.93	0.0333	8.96	12	0.31
13:	116	117	0.68	9.64	0	8	9.64	0.0333	9.67	12	0.71
14:	165	166	1.43	11.11	0	8	11.11	0.0333	11.14	12	1.47
15:	36	37	1.18	12.32	0	12	12.32	0.0333	12.35	17	1.21
16:	29	30	0.72	13.08	0	12	13.08	0.0333	13.11	17	0.76
17:	123	124	0.29	13.40	0	12	13.40	0.0333	13.43	17	0.32
18:	0	1	0.40	13.83	0	-Inf	13.83	0.0000	13.83	Inf	0.40

	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	7.25	0.0000	7.25	Inf	0.00
2:	83	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
3:	34	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
4:	118	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
5:	96	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
6:	153	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
7:	119	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
8:	177	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
9:	23	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00
10:	92	1	0.00	7.25	0	-Inf	7.25	0.0000	7.25	Inf	0.00

11:	119	120	0.75	8.00	0	8	8.00	0.0333	8.03	12	0.78
12:	153	154	0.76	8.79	0	8	8.79	0.0333	8.83	12	0.79
13:	96	97	1.07	9.90	0	8	9.90	0.0333	9.93	12	1.11
14:	34	35	0.38	10.32	0	8	10.32	0.0333	10.35	12	0.42
15:	118	119	0.26	10.61	0	8	10.61	0.0333	10.64	12	0.29
16:	23	24	0.58	11.22	0	8	11.22	0.0333	11.25	12	0.61
17:	92	93	0.57	11.82	0	8	11.82	0.0333	11.85	12	0.60
18:	177	178	0.53	12.38	0	12	12.38	0.0333	12.41	17	0.56
19:	83	84	0.41	12.83	0	12	12.83	0.0333	12.86	17	0.45
20:	0	1	0.27	13.13	0	-Inf	13.13	0.0000	13.13	Inf	0.27

16:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.00	0.00	0	-Inf	13.95	0.0000	13.95	Inf	0.00
2:	111	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
3:	167	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
4:	91	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
5:	79	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
6:	164	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
7:	142	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
8:	57	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
9:	55	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
10:	105	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
11:	16	1	0.00	13.95	0	-Inf	13.95	0.0000	13.95	Inf	0.00
12:	167	168	0.33	14.28	0	12	14.28	0.0333	14.31	17	0.36
13:	105	106	0.59	14.91	0	12	14.91	0.0333	14.94	17	0.63
14:	164	165	0.83	15.77	0	12	15.77	0.0333	15.80	17	0.86
15:	79	80	1.20	17.00	0	17	17.00	0.0333	17.03	21	1.23
16:	57	58	1.38	18.41	0	17	18.41	0.0333	18.44	21	1.41
17:	16	17	0.36	18.80	0	17	18.80	0.0333	18.84	21	0.39
18:	55	56	0.38	19.21	0	17	19.21	0.0333	19.25	21	0.41
19:	142	143	0.36	19.60	0	17	19.60	0.0333	19.64	21	0.39
20:	91	92	0.46	20.09	0	17	20.09	0.0333	20.13	21	0.49
21:	111	112	0.27	20.39	0	17	20.39	0.0333	20.43	21	0.30
22:	0	1	0.29	20.71	0	-Inf	20.71	0.0000	20.71	Inf	0.29

17:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
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1:	0	1	0.0000	0.00	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
2:	172	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
3:	133	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
4:	140	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
5:	47	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
6:	35	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
7:	173	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
8:	147	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
9:	94	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
10:	8	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
11:	115	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
12:	141	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
13:	86	1	0.0000	7.21	0	-Inf	7.21	0.0000	7.21	Inf	0.0000
14:	8	9	0.7873	8.00	0	8	8.00	0.0333	8.03	12	0.8207
15:	94	95	0.7150	8.75	0	8	8.75	0.0333	8.78	12	0.7483
16:	133	134	0.6224	9.40	0	8	9.40	0.0333	9.44	12	0.6558
17:	147	148	0.2580	9.70	0	8	9.70	0.0333	9.73	12	0.2914
18:	173	174	0.1559	9.88	0	8	9.88	0.0333	9.92	12	0.1893
19:	115	116	0.3055	10.22	0	8	10.22	0.0333	10.26	12	0.3388

20:	141	142	0.3231	10.58	0	8	10.58	0.0333	10.61	12	0.3564
21:	86	87	0.3450	10.96	0	8	10.96	0.0333	10.99	12	0.3784
22:	47	48	0.4166	11.41	0	8	11.41	0.0333	11.44	12	0.4499
23:	35	36	0.2489	11.69	0	8	11.69	0.0333	11.72	12	0.2823
24:	140	141	0.2810	12.00	0	12	12.00	0.0333	12.04	17	0.3143
25:	172	173	0.2768	12.31	0	12	12.31	0.0333	12.35	17	0.3101
26:	0	1	0.3183	12.67	0	-Inf	12.67	0.0000	12.67	Inf	0.3183

18:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
2:	28	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
3:	42	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
4:	18	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
5:	44	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
6:	90	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
7:	89	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
8:	93	1	0.0000	16.42	0	-Inf	16.42	0.0000	16.42	Inf	0.0000
9:	90	91	0.5846	17.00	0	17	17.00	0.0333	17.03	21	0.6179
10:	93	94	0.4952	17.53	0	17	17.53	0.0333	17.56	21	0.5286
11:	89	90	0.7476	18.31	0	17	18.31	0.0333	18.34	21	0.7809
12:	42	43	0.8133	19.16	0	17	19.16	0.0333	19.19	21	0.8467
13:	18	19	0.5214	19.71	0	17	19.71	0.0333	19.74	21	0.5547
14:	44	45	0.5089	20.25	0	17	20.25	0.0333	20.29	21	0.5422
15:	28	29	0.4124	20.70	0	17	20.70	0.0333	20.73	21	0.4457
16:	0	1	0.5485	21.28	0	-Inf	21.28	0.0000	21.28	Inf	0.5485

19:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
2:	45	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
3:	97	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
4:	103	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
5:	85	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
6:	146	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
7:	61	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
8:	168	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
9:	170	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
10:	98	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
11:	104	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
12:	24	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
13:	78	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
14:	11	1	0.0000	14.17	0	-Inf	14.17	0.0000	14.17	Inf	0.0000
15:	104	105	0.6502	14.82	0	12	14.82	0.0333	14.85	17	0.6835
16:	98	99	0.5235	15.38	0	12	15.38	0.0333	15.41	17	0.5568
17:	24	25	0.5943	16.00	0	12	16.00	0.0333	16.04	17	0.6276
18:	78	79	0.6362	16.67	0	12	16.67	0.0333	16.71	17	0.6695
19:	11	12	0.2930	17.00	0	17	17.00	0.0333	17.03	21	0.3264
20:	170	171	0.8744	17.91	0	17	17.91	0.0333	17.94	21	0.9077
21:	168	169	0.8391	18.78	0	17	18.78	0.0333	18.81	21	0.8725
22:	61	62	0.4243	19.24	0	17	19.24	0.0333	19.27	21	0.4576
23:	85	86	0.2723	19.54	0	17	19.54	0.0333	19.58	21	0.3057
24:	103	104	0.2161	19.79	0	17	19.79	0.0333	19.83	21	0.2495
25:	97	98	0.2190	20.05	0	17	20.05	0.0333	20.08	21	0.2523
26:	45	46	0.2675	20.35	0	17	20.35	0.0333	20.38	21	0.3008
27:	146	147	0.2131	20.59	0	17	20.59	0.0333	20.63	21	0.2464
28:	0	1	0.2241	20.85	0	-Inf	20.85	0.0000	20.85	Inf	0.2241

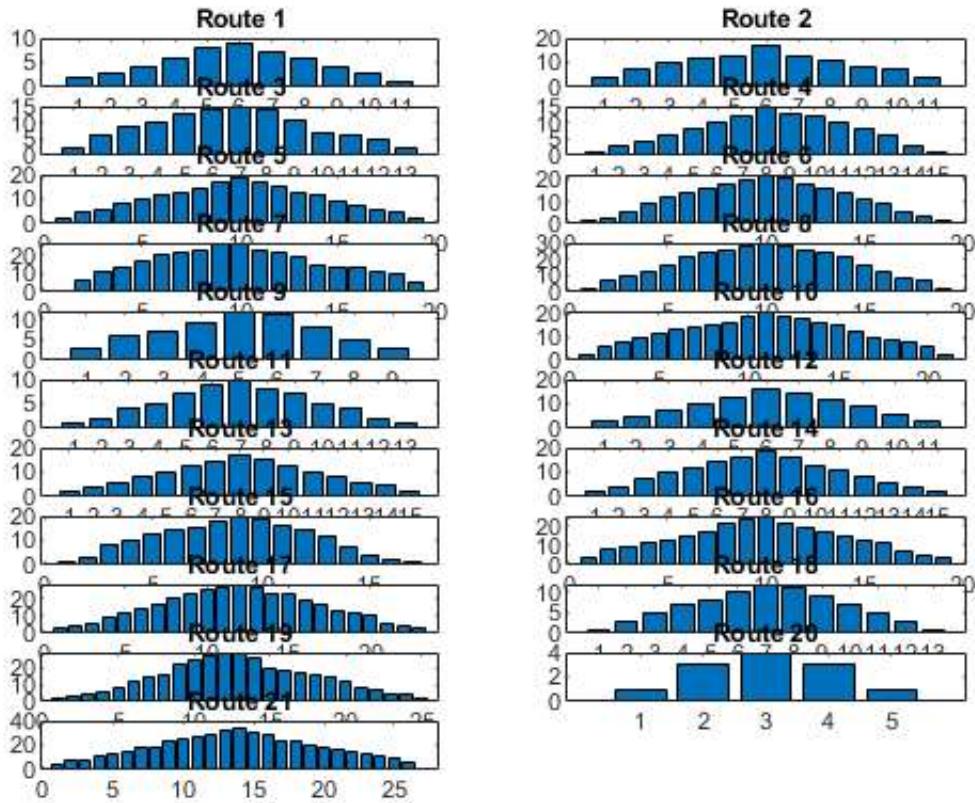
20:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
<hr/>											
1:	0	1	0.0000	0.00	0	-Inf	16.66	0.0000	16.66	Inf	0.0000
2:	56	1	0.0000	16.66	0	-Inf	16.66	0.0000	16.66	Inf	0.0000
3:	120	1	0.0000	16.66	0	-Inf	16.66	0.0000	16.66	Inf	0.0000
4:	171	1	0.0000	16.66	0	-Inf	16.66	0.0000	16.66	Inf	0.0000
5:	171	172	0.2195	16.88	0	12	16.88	0.0333	16.91	17	0.2528
6:	120	121	0.0908	17.00	0	17	17.00	0.0333	17.03	21	0.1241
7:	56	57	0.1050	17.14	0	17	17.14	0.0333	17.17	21	0.1384
8:	0	1	0.1397	17.31	0	-Inf	17.31	0.0000	17.31	Inf	0.1397
<hr/>											
21:	Rte	Loc	Cost	Arrive	Wait	TWmin	Start	LU	Depart	TWmax	Total
1:	0	1	0.0000	0.00	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
2:	65	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
3:	30	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
4:	41	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
5:	21	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
6:	135	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
7:	40	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
8:	125	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
9:	82	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
10:	132	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
11:	4	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
12:	180	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
13:	179	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
14:	109	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
15:	80	1	0.0000	8.60	0	-Inf	8.60	0.0000	8.60	Inf	0.0000
16:	125	126	0.1393	8.74	0	8	8.74	0.0333	8.77	12	0.1727
17:	30	31	0.2407	9.01	0	8	9.01	0.0333	9.05	12	0.2740
18:	65	66	0.2430	9.29	0	8	9.29	0.0333	9.32	12	0.2764
19:	41	42	0.2041	9.53	0	8	9.53	0.0333	9.56	12	0.2375
20:	21	22	0.1015	9.66	0	8	9.66	0.0333	9.70	12	0.1348
21:	135	136	0.1549	9.85	0	8	9.85	0.0333	9.88	12	0.1882
22:	40	41	0.2521	10.14	0	8	10.14	0.0333	10.17	12	0.2854
23:	4	5	0.3077	10.48	0	8	10.48	0.0333	10.51	12	0.3410
24:	179	180	0.2861	10.80	0	8	10.80	0.0333	10.83	12	0.3194
25:	180	181	0.2559	11.09	0	8	11.09	0.0333	11.12	12	0.2892
26:	80	81	0.2337	11.35	0	8	11.35	0.0333	11.39	12	0.2670
27:	109	110	0.2228	11.61	0	8	11.61	0.0333	11.64	12	0.2562
28:	132	133	0.2631	11.90	0	8	11.90	0.0333	11.94	12	0.2964
29:	82	83	0.0617	12.00	0	12	12.00	0.0333	12.03	17	0.0950
30:	0	1	0.1349	12.17	0	-Inf	12.17	0.0000	12.17	Inf	0.1349

Plot cumsum of each route segment

```

for i = 1:length(r)
    idx = rte2idx(r{i});
    segsum = rtesegsum(rtenorm(r{i}), [sh(idx).q]);
    Maxpkg(i) = max(segsum);
    subplot(ceil(length(r)/2),2,i)
    bar(segsum)
    title(['Route ' num2str(i)])
end

```



Route time and delivered/picked-up packages

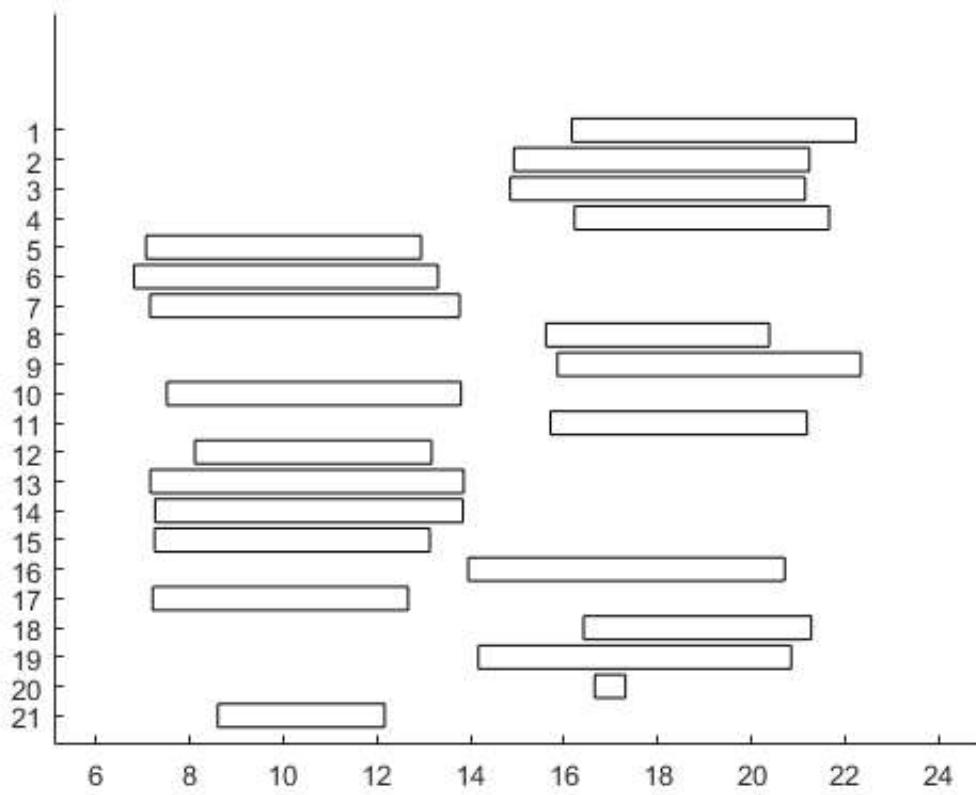
```
vdisp('Time,Maxpkg')
```

	Time	Maxpkg
1:	6.07	9
2:	6.31	17
3:	6.30	15
4:	5.44	15
5:	5.88	19
6:	6.50	22
7:	6.62	27
8:	4.78	30
9:	6.49	12
10:	6.28	21
11:	5.48	10
12:	5.06	16
13:	6.70	17
14:	6.58	19
15:	5.88	20
16:	6.76	25
17:	5.45	28
18:	4.87	12
19:	6.68	29
20:	0.66	4

Display Gantt chart of route time spans

```
b = arrayfun(@(x) (x.Start(1)),out); b = b(:);
e = arrayfun(@(x) (x.Depart(end)),out); e = e(:);
mdisp([b e])
figure
gantt([b e])
```

:	1	2
1:	16.16	22.23
2:	14.93	21.24
3:	14.84	21.15
4:	16.22	21.66
5:	7.07	12.95
6:	6.81	13.31
7:	7.15	13.77
8:	15.61	20.39
9:	15.85	22.34
10:	7.51	13.79
11:	15.71	21.19
12:	8.11	13.17
13:	7.16	13.85
14:	7.26	13.83
15:	7.25	13.13
16:	13.95	20.71
17:	7.21	12.67
18:	16.42	21.28
19:	14.17	20.85
20:	16.66	17.31
21:	8.60	12.17



Greedy route combination heuristic (not part of Matlog)

```
cmbrte = combinerte(out); cmbrte{::}
```

Question 5

Read data

```
close all, clear
fn = 'HW8data.xlsx';
in = table2struct(readtable(fn, 'Sheet', 'Q5-Data'));
sdisp(in)
```

	orig	dest	cu	wt	ud	uc
1:	28,217	28,734	0.89	0.40	6,231	1.03
2:	28,333	27,519	0.67	6.80	6,064	37.76
3:	27,407	27,701	0.67	2.29	33,557	2.50
4:	29,170	27,505	3.56	17.37	2,859	37.26
5:	27,350	27,011	1.33	14.12	3,698	42.55
6:	28,104	27,360	2.67	53.74	1,875	130.27
7:	28,670	29,450	2.67	2.55	13,500	8.43
8:	29,488	28,215	3.56	2.84	4,936	9.75
9:	28,562	27,560	1.33	37.64	2,216	37.45
10:	27,703	29,611	2.67	37.04	301	27.86
11:	29,926	28,213	1.33	2.25	10,175	25.24
12:	28,501	27,513	1.33	3.36	1,600	2.15

13:	29,108	28,079	1.33	13.61	8,512	186.42
14:	28,546	29,669	3.56	4.40	7,307	3.90
15:	29,526	28,139	3.56	59.65	144	213.79
16:	28,304	28,352	3.56	15.22	1,044	58.00
17:	27,217	29,902	1.33	19.51	516	57.17
18:	27,260	29,180	1.00	19.33	4,299	133.46
19:	28,212	29,801	0.67	3.97	10,047	126.16
20:	27,921	27,834	3.56	129.64	2,225	111.32
21:	29,118	28,173	2.67	87.71	2,103	88.67
22:	27,410	29,210	1.33	1.94	2,997	9.03
23:	28,021	28,105	1.33	4.18	600	6.65
24:	28,384	27,295	1.00	14.76	364	175.46
25:	27,028	29,403	0.89	1.39	7,586	14.49
26:	29,743	27,320	1.00	32.97	2,038	17.15
27:	27,332	27,263	0.67	6.90	7,172	4.90
28:	28,277	29,323	0.89	3.81	3,230	9.13
29:	27,244	29,710	0.67	1.33	22,427	3.03
30:	29,340	27,707	3.56	23.46	2,549	12.69
31:	27,607	28,277	1.00	1.85	12,960	7.33
32:	28,643	28,043	0.67	2.96	10,125	3.41
33:	29,687	28,311	0.67	7.55	1,140	41.00
34:	27,401	29,445	1.33	25.46	3,192	231.03
35:	29,115	27,217	0.67	1.05	14,643	4.76
36:	29,301	28,326	0.67	6.94	7,093	54.89
37:	28,510	29,541	1.33	12.10	1,616	84.33
38:	28,601	28,348	2.67	83.17	468	99.67
39:	27,542	28,655	0.89	15.61	794	259.02
40:	28,401	29,620	0.89	11.48	2,316	65.14
41:	28,056	27,705	1.33	3.62	4,392	2.15
42:	28,273	28,056	0.89	9.28	5,578	5.75
43:	28,645	27,609	3.56	11.98	8,594	14.19
44:	27,025	28,348	1.33	3.95	12,901	11.01
45:	29,924	27,892	0.67	6.69	3,443	6.63
46:	29,142	29,445	3.56	46.35	504	525.44
47:	29,745	28,314	1.00	8.82	3,543	112.77
48:	29,365	27,028	0.89	17.75	4,743	31.60
49:	29,642	28,403	1.33	8.34	4,793	72.43
50:	28,328	28,777	0.89	11.58	12,747	14.14
51:	29,412	28,748	2.67	15.97	1,483	70.86
52:	27,587	29,609	2.67	35.79	695	314.93
53:	27,330	29,115	1.00	15.04	7,977	32.36
54:	29,696	29,154	0.67	3.03	1,197	34.41
55:	27,203	29,605	3.56	7.58	8,143	58.57
56:	28,442	29,570	0.67	22.31	1,389	35.61
57:	29,464	28,613	0.67	7.48	3,124	16.45
58:	28,146	28,334	3.56	56.47	1,332	193.68
59:	28,792	27,332	3.56	41.27	764	100.13
60:	28,374	28,210	0.67	3.72	30,456	7.19
61:	27,517	29,406	1.33	30.59	5,837	85.47
62:	28,792	29,732	1.33	6.39	8,209	11.57
63:	28,207	29,445	1.33	4.64	9,525	30.37
64:	29,369	27,609	0.89	6.46	5,356	56.02

Determine shipment begining and ending location index

```
zip = unique([[in.orig]; [in.dest]]);
```

```
b = mand([in.orig],zip);
e = mand([in.dest],zip);
```

Create independent shipments

```
z = uszip5(mor(zip,uszip5('Code5')));
D = dists(z.XY,z.XY,'mi') * 1.2;
ppiTL = 131.4; % Jan 2018 (P)
ppiLTL = 179.4; % Jan 2018 (P)
tr = struct('r',2*(ppiTL/102.7),'Kwt',25,'Kcu',2750);
f = [in.wt].*[in.ud]/2000;
s = [in.wt]./[in.cu];
v = 2000*[in.uc]./[in.wt];
sh = vec2struct('b',b,'e',e,'f',f,'s',s,'v',v,'a',.5,'h',.3);
sh = vec2struct(sh,'d',diag(D([sh.b],[sh.e])));
[TLC1,q1,isLTL] = minTLC(sh,tr,ppiLTL);
sh = vec2struct(sh,'TLC1',TLC1,'q1',q1,'n1',[sh.f]./q1,...
    'cul',(2000*q1)./[sh.s],'isLTL',isLTL);
sdisp(sh)
```

sh:	b	e	f	s	v	a	h	d	TLC1	q1	n1	cul
isLTL												

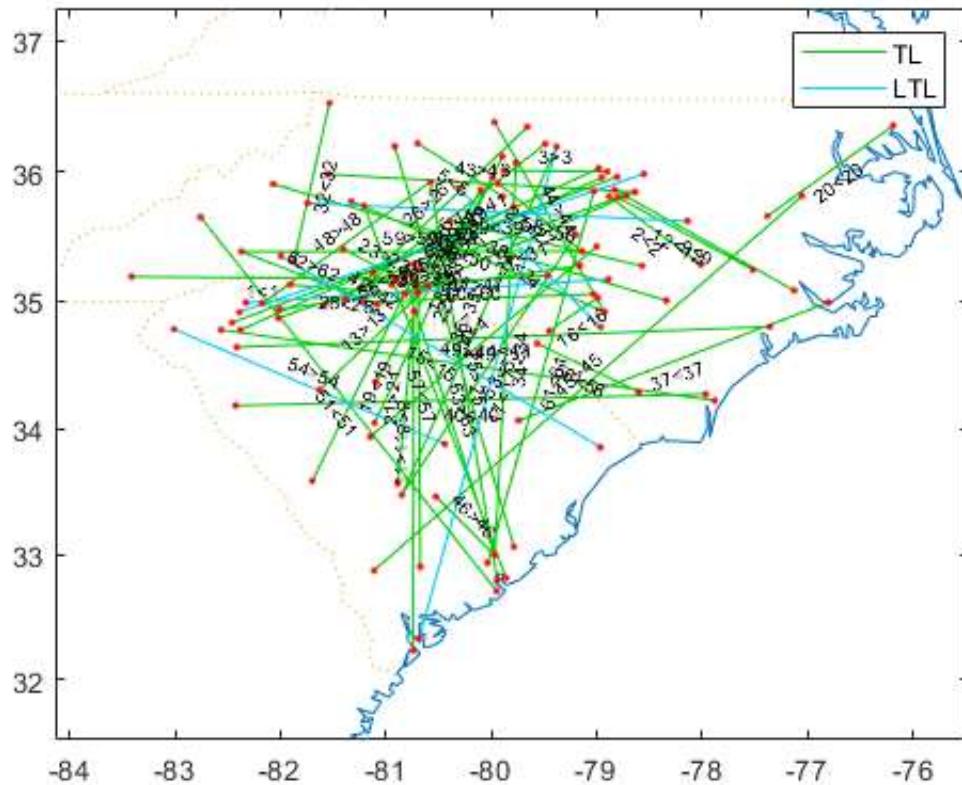
1:	48	75	1.25	0.45	5,132.04	0.5	0.3	169.55	1,351.80	0.62	2.01	2,750.00
0												
2:	56	21	20.61	10.20	11,107.68	0.5	0.3	73.10	5,069.57	1.52	13.55	298.37
0												
3:	16	27	38.44	3.44	2,182.55	0.5	0.3	65.70	2,908.96	4.44	8.65	2,585.87
0												
4:	84	18	24.84	4.89	4,289.27	0.5	0.3	191.17	5,591.69	4.35	5.72	1,778.66
0												
5:	13	1	26.10	10.59	6,027.81	0.5	0.3	63.97	3,931.07	2.17	12.01	410.60
0												
6:	38	14	50.38	20.15	4,848.33	0.5	0.3	77.31	5,384.55	3.70	13.61	367.42
0												
7:	74	96	17.21	0.96	6,614.36	0.5	0.3	270.37	10,361.08	1.31	13.09	2,750.00
0												
8:	98	47	7.02	0.80	6,856.54	0.5	0.3	193.73	4,294.92	1.10	6.38	2,750.00
0												
9:	68	23	41.70	28.23	1,990.04	0.5	0.3	131.60	4,094.90	6.86	6.08	485.96
0												
10:	28	104	5.57	13.89	1,504.30	0.5	0.3	263.71	1,842.64	4.08	1.37	587.91
0												
11:	117	46	11.45	1.69	22,424.59	0.5	0.3	252.52	9,978.39	1.48	7.72	1,757.02
0												
12:	65	19	2.69	2.52	1,280.75	0.5	0.3	98.31	720.59	1.88	1.43	1,489.55
0												
13:	79	37	57.92	10.21	27,397.99	0.5	0.3	96.88	15,363.14	1.87	30.99	366.26
0												
14:	67	107	16.07	1.24	1,773.01	0.5	0.3	344.62	8,783.69	1.70	9.45	2,750.00
0												
15:	99	40	4.30	16.78	7,167.62	0.5	0.3	240.88	2,849.35	0.42	10.33	49.58

16:0	51	59	7.94	4.28	7,622.55	0.5	0.3	37.96	1,878.55	0.82	9.67	383.87	
17:1	5	115	5.03	14.64	5,859.56	0.5	0.3	331.71	3,645.77	0.62	8.13	84.65	
18:0	7	85	41.54	19.33	13,811.59	0.5	0.3	151.38	11,547.86	2.79	14.91	288.42	
19:0	45	114	19.94	5.95	63,574.29	0.5	0.3	147.59	16,947.92	0.89	22.44	298.54	
20:0	33	31	144.22	36.46	1,717.41	0.5	0.3	98.45	6,118.82	11.88	12.14	651.46	
21:0	81	42	92.23	32.89	2,021.85	0.5	0.3	112.23	5,668.50	9.35	9.87	568.26	
22:0	17	86	2.91	1.46	9,304.48	0.5	0.3	190.27	2,811.74	1.01	2.89	1,383.87	
23:0	34	39	1.25	3.14	3,181.82	0.5	0.3	52.29	566.00	0.59	2.11	378.27	
24:1	61	9	2.69	14.76	23,780.06	0.5	0.3	127.44	2,169.06	0.12	21.99	16.55	
25:0	3	92	5.28	1.56	20,833.93	0.5	0.3	261.65	6,645.18	1.06	4.96	1,358.85	
26:0	112	10	33.60	32.97	1,040.29	0.5	0.3	160.27	2,932.71	9.40	3.58	570.01	
27:0	12	8	24.73	10.34	1,421.15	0.5	0.3	69.25	1,933.04	4.53	5.45	876.70	
28:0	50	88	6.16	4.29	4,788.13	0.5	0.3	74.14	1,832.11	1.28	4.83	594.58	
29:0	6	110	14.88	1.99	4,566.35	0.5	0.3	148.35	3,938.70	2.74	5.44	2,750.00	
30:0	89	30	29.90	6.60	1,081.81	0.5	0.3	195.38	3,119.93	9.07	3.30	2,750.00	
31:0	25	50	11.98	1.85	7,928.18	0.5	0.3	155.01	4,754.79	2.00	5.99	2,162.25	
32:0	71	35	14.97	4.44	2,305.77	0.5	0.3	103.38	2,340.95	3.38	4.42	1,525.62	
33:1	108	52	4.30	11.32	10,867.69	0.5	0.3	233.68	3,569.14	0.35	12.38	61.38	
34:0	15	95	40.63	19.09	18,149.68	0.5	0.3	254.71	16,982.08	3.12	13.03	326.69	
35:0	80	5	7.70	1.58	9,047.71	0.5	0.3	246.00	5,130.84	1.89	4.08	2,395.47	
36:0	87	54	24.61	10.41	15,817.76	0.5	0.3	195.29	10,804.48	2.28	10.81	437.44	
37:0	66	100	9.78	9.08	13,933.32	0.5	0.3	214.49	6,699.18	1.60	6.10	353.06	
38:0	69	58	19.46	31.19	2,396.71	0.5	0.3	177.04	3,560.74	4.95	3.93	317.56	
39:1	22	73	6.20	17.56	33,188.33	0.5	0.3	242.80	4,893.46	0.16	38.72	18.23	
40:0	62	105	13.29	12.91	11,350.61	0.5	0.3	305.72	8,415.08	2.47	5.38	382.77	
41:0	36	29	7.95	2.71	1,188.50	0.5	0.3	159.31	1,533.23	3.73	2.13	2,750.00	
42:0	49	36	25.89	10.44	1,239.04	0.5	0.3	14.17	1,080.91	2.25	11.52	430.38	
43:0	72	26	51.46	3.37	2,369.64	0.5	0.3	195.81	7,213.67	4.63	11.11	2,750.00	

44:	2	58	25.48	2.96	5,574.97	0.5	0.3	140.11	5,527.77	3.31	7.71	2,231.36
0												
45:	116	32	11.53	10.04	1,980.61	0.5	0.3	369.04	3,596.37	6.05	1.90	1,205.48
0												
46:	82	95	11.68	13.04	22,673.10	0.5	0.3	54.50	4,707.47	0.69	16.88	106.18
0												
47:	113	53	15.63	8.82	25,556.94	0.5	0.3	148.28	9,537.38	1.24	12.57	281.91
0												
48:	90	3	42.09	19.97	3,560.84	0.5	0.3	132.73	5,526.54	5.17	8.14	518.20
0												
49:	106	63	19.99	6.26	17,363.27	0.5	0.3	323.00	13,120.94	2.52	7.94	805.11
0												
50:	55	77	73.84	13.03	2,441.11	0.5	0.3	262.57	8,524.20	11.64	6.34	1,786.22
0												
51:	94	76	11.84	5.99	8,876.81	0.5	0.3	310.28	7,075.43	2.66	4.46	887.57
0												
52:	24	103	12.44	13.42	17,598.77	0.5	0.3	273.65	9,076.07	0.53	23.61	78.50
1												
53:	11	80	59.99	15.04	4,303.19	0.5	0.3	202.99	8,969.51	6.95	8.63	923.93
0												
54:	109	83	1.81	4.54	22,736.13	0.5	0.3	190.91	3,435.24	0.17	10.64	75.02
1												
55:	4	102	30.85	2.13	15,458.72	0.5	0.3	192.18	11,862.79	2.56	12.06	2,400.51
0												
56:	64	101	15.50	33.47	3,191.63	0.5	0.3	72.92	2,353.27	2.46	6.31	146.86
0												
57:	97	70	11.69	11.22	4,396.28	0.5	0.3	259.03	4,520.82	3.43	3.41	610.75
0												
58:	41	57	37.61	15.88	6,859.29	0.5	0.3	126.49	7,078.38	3.44	10.93	433.15
0												
59:	78	12	15.76	11.61	4,852.71	0.5	0.3	218.29	5,063.50	3.48	4.53	599.35
0												
60:	60	44	56.64	5.58	3,866.42	0.5	0.3	94.53	5,637.44	4.86	11.65	1,742.46
0												
61:	20	93	89.29	22.95	5,587.42	0.5	0.3	251.03	13,866.43	8.27	10.79	721.04
0												
62:	78	111	26.21	4.79	3,623.21	0.5	0.3	93.65	3,695.51	3.40	7.71	1,419.54
0												
63:	43	95	22.08	3.48	13,099.83	0.5	0.3	191.12	9,213.19	2.34	9.42	1,348.25
0												
64:	91	26	17.30	7.27	17,347.14	0.5	0.3	242.68	10,573.44	2.03	8.51	559.25
0												

Plot independent shipments

```
plotshmt(sh,z.XY,[],tr,true)
```



Consolidated shipments

```
rTCh = @(rte) minTLC(sh,tr,[],D,rte);
IJS = pairwisesavings(rTCh,sh,minTLC(sh,tr));
```

Construct and improve routes

```
[rc,TLCc] = twoopt(savings(rTCh,sh,IJS),rTCh);
```

Make shipments not in routes into single-shipment routes

```
[rc,idx1,TLCc] = sh2rte(sh,rc,rTCh);
```

ADD SINGLE-SHIPMENT ROUTES:

299421.236331: Added shipments 3 5 6 13 16 20 23 24 27 29 32 43 44 45 46 54

Report results

```
plotshmt(sh,z.XY,rc,tr)
[~,~,out] = rteTC(rc,sh,D,tr);
for i = 1:length(out), sdisp(out(i),false,i), end
vdisp('sum(TLC1),sum(TLCc)')
```

1:	Rte	Loc	Cost
1:	53	11	0.00
2:	61	20	30.23
3:	34	15	52.95
4:	18	7	17.69
5:	25	3	39.72
6:	7	74	31.96
7:	63	43	83.06
8:	19	45	5.44
9:	18	85	72.07
10:	19	114	76.60
11:	53	80	59.29
12:	61	93	71.98
13:	25	92	12.67
14:	34	95	16.11
15:	63	95	0.00
16:	7	96	13.87

2:	Rte	Loc	Cost
1:	62	78	0.00
2:	59	78	0.00
3:	49	106	52.08
4:	33	108	23.76
5:	48	90	10.57
6:	36	87	11.61
7:	64	91	5.70
8:	30	89	30.76
9:	62	111	34.25
10:	47	113	9.17
11:	41	36	19.66
12:	38	69	47.99
13:	48	3	51.71
14:	58	41	27.87
15:	47	53	103.40
16:	38	58	13.38
17:	33	52	21.09
18:	36	54	20.38
19:	59	12	9.31
20:	30	30	48.80
21:	41	29	6.16
22:	64	26	27.64
23:	58	57	47.56
24:	49	63	98.82

	Rte	Loc	Cost
<hr/>			
1:	37	66	0.00
2:	14	67	40.62
3:	40	62	60.21
4:	56	64	43.63
5:	56	101	72.92
6:	37	100	51.35

7: 40 105 184.40
8: 14 107 37.87

4: Rte Loc Cost

1: 11 117 0.00
2: 8 98 55.59
3: 21 81 56.70
4: 21 42 112.23
5: 8 47 27.36
6: 11 46 4.38

5: Rte Loc Cost

1: 51 94 0.00
2: 57 97 10.65
3: 15 99 105.89
4: 1 48 171.69
5: 57 70 51.27
6: 15 40 62.09
7: 51 76 57.19
8: 1 75 58.36

6: Rte Loc Cost

1: 35 80 0.00
2: 4 84 43.32
3: 26 112 90.43
4: 26 10 160.27
5: 35 5 22.34
6: 4 18 68.53

7: Rte Loc Cost

1: 17 5 0.00
2: 22 17 34.92
3: 22 86 190.27
4: 17 115 144.77

8: Rte Loc Cost

1: 9 68 0.00
2: 12 65 29.59
3: 2 56 33.73
4: 50 55 32.04
5: 39 22 52.71
6: 52 24 41.08
7: 10 28 17.21
8: 31 25 13.40
9: 12 19 5.67
10: 9 23 4.98
11: 2 21 5.52
12: 55 4 61.06
13: 31 50 89.29
14: 28 50 0.00
15: 39 73 85.46
16: 50 77 25.10

17: 28 88 65.37
18: 52 103 37.11
19: 10 104 8.28
20: 55 102 7.28

9: Rte Loc Cost

1: 60 60 0.00
2: 60 44 94.53
3: 42 49 6.14
4: 42 36 14.17

10: Rte Loc Cost

1: 3 16 0.00
2: 3 27 65.70

11: Rte Loc Cost

1: 5 13 0.00
2: 5 1 63.97

12: Rte Loc Cost

1: 6 38 0.00
2: 6 14 77.31

13: Rte Loc Cost

1: 13 79 0.00
2: 13 37 96.88

14: Rte Loc Cost

1: 16 51 0.00
2: 16 59 37.96

15: Rte Loc Cost

1: 20 33 0.00
2: 20 31 98.45

16: Rte Loc Cost

1: 23 34 0.00
2: 23 39 52.29

17: Rte Loc Cost

1: 24 61 0.00
2: 24 9 127.44

18: Rte Loc Cost

1: 27 12 0.00
2: 27 8 69.25

```
19: Rte Loc Cost
---:-----
1: 29   6   0.00
2: 29 110 148.35

20: Rte Loc Cost
---:-----
1: 32   71  0.00
2: 32   35 103.38

21: Rte Loc Cost
---:-----
1: 43   72  0.00
2: 43   26 195.81

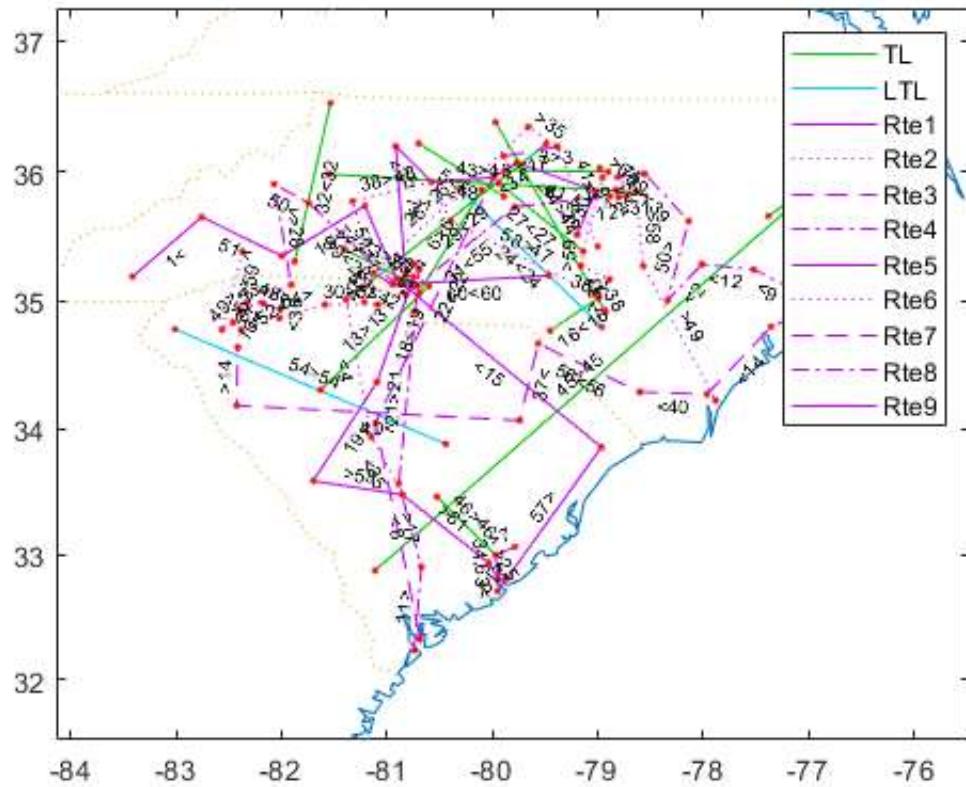
22: Rte Loc Cost
---:-----
1: 44   2   0.00
2: 44   58 140.11

23: Rte Loc Cost
---:-----
1: 45 116 0.00
2: 45   32 369.04

24: Rte Loc Cost
---:-----
1: 46   82  0.00
2: 46   95 54.50

25: Rte Loc Cost
---:-----
1: 54 109 0.00
2: 54   83 190.91

: sum(TLC1)    sum(TLCC)
---:-----
1: 384,222.44 299,421.24
```



Question 6

Data

```

clear
load shmtNC30
tr = struct('r',2,'Kwt',25,'Kcu',2750);
sh = vec2struct('b',b,'e',e,'f',f,'s',s,'v',v,'a',.5,'h',.3);
sh = vec2struct(sh,'d',diag(D([sh.b],[sh.e])));
idx = [1 3 26 5];
sh = sh(idx)
sdisp(sh,1)
r = tr.r
C = D * r;
rTCh = @(rte) rteTC(rte,sh,C);
n = length(sh)

```

sh =

1×4 struct array with fields:

b
e
f
s
v
a
h

```

d

sh:      1       2       3       4
---:-----
b:   15.00    23.00   19.00   17.00
e:   42.00    40.00   31.00   32.00
f:   2.13     6.27    3.93    6.32
s:   1.17     15.23   8.47    13.82
v: 683.19  5,843.73 331.87  2,776.55
a:   0.50     0.50    0.50    0.50
h:   0.30     0.30    0.30    0.30
d:  64.97    59.27   127.10  161.07

```

r =

2

n =

4

Independent transport charge

```
c0 = [sh.d]*r
```

c0 =

129.9440 118.5307 254.2025 322.1376

Min incremental charge for all possible routes

```

R = perms(1:n)
C = zeros(size(R));
for i = 1:size(C,1)
    for j = 1:size(C,2)
        Rj = perms(R(i,1:j)); % Try all permutations to get optimal
        TC(j) = Inf;
        for k = 1:size(Rj,1)
            [~,TCj] = insertimprove(Rj(k,:),rTCh,sh);
            if TCj < TC(j), TC(j) = TCj; end
        end
    end
    C(i,:) = TC;
    TC = diff([0 TC]);
    C(i,:) = TC(invperm(R(i,:)));
end
mdisp(C,sum(R.*repmat(10.^[n-1:-1:0],size(R,1),1),2))

```

R =

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

C:	1	2	3	4
----	---	---	---	---

4321:	32.41	17.45	80.47	322.14
4312:	35.36	14.50	80.47	322.14
4231:	32.41	73.64	24.28	322.14
4213:	28.90	73.64	27.79	322.14
4132:	78.81	14.50	37.01	322.14
4123:	78.81	23.73	27.79	322.14
3421:	32.41	17.45	254.20	148.41
3412:	35.36	14.50	254.20	148.41
3241:	32.41	26.48	254.20	139.37
3214:	26.08	26.48	254.20	145.71
3142:	17.47	14.50	254.20	166.29
3124:	17.47	35.09	254.20	145.71
2431:	32.41	118.53	24.28	277.25
2413:	28.90	118.53	27.79	277.25
2341:	32.41	118.53	162.15	139.37
2314:	26.08	118.53	162.15	145.71
2143:	74.36	118.53	27.79	231.79
2134:	74.36	118.53	113.87	145.71
1432:	129.94	14.50	37.01	271.01
1423:	129.94	23.73	27.79	271.01
1342:	129.94	14.50	141.73	166.29
1324:	129.94	35.09	141.73	145.71
1243:	129.94	62.95	27.79	231.79
1234:	129.94	62.95	113.87	145.71

Equal charge allocation

```
TCC = min(sum(C,2))
c_equal = repmat(TCC/n,1,n)
pct_reduct = round(100*(1 - c_equal./c0))
```

```
TCC =
452.4672

c_equal =
113.1168 113.1168 113.1168 113.1168

pct_reduct =
13      5      56      65
```

Equal savings allocation

```
Sn = sum(c0) - TCC
c_eq_sav = c0 - Sn/n
```

```
Sn =
372.3476

c_eq_sav =
36.8571 25.4438 161.1156 229.0507
```

Exact Shapley allocation

```
c_Shap_exact = mean(C,1)
pct_reduct = round(100*(1 - c_Shap_exact./c0))
```

```
c_Shap_exact =
62.3369 53.2033 117.1231 219.8039

pct_reduct =
52      55      54      32
```

Pairwise approximate Shapely allocation

```
[~,S2] = pairwisesavings(rTCh,sh)
c_Shap_approx = c0 - (Sn/n + sum(S2)/(n-1) - sum(sum(S2))/(n*(n-1)))
pct_reduct = round(100*(1 - c_Shap_approx./c0))
```

```
S2 =
0 55.5828 112.4757 51.1322
55.5828 0 92.0509 44.8922
112.4757 92.0509 0 173.7326
51.1322 44.8922 173.7326 0
```

```
c_Shap_approx =
52.1046 49.5796 123.3403 227.4427
```

```
pct_reduct =
60 58 51 29
```

Comparison

```
vdisp('c0,c_equal,c_eq_sav,c_Shap_exact,c_Shap_approx')
```

	c0	c_equal	c_eq_sav	c_Shap_exact	c_Shap_approx
1:	129.94	113.12	36.86	62.34	52.10
2:	118.53	113.12	25.44	53.20	49.58
3:	254.20	113.12	161.12	117.12	123.34
4:	322.14	113.12	229.05	219.80	227.44