```
 1 sets
 2 i nodes /1*5/
 3 alias (i,j,k,m,p,s) ;
 4
 5 parameter
 6 alfa discount factor for line-haul movement between hubs /0.2/
 7 pp the number of hubs to locate /2/
 8
 9 teta(i)
10 /
11 1  200
12 2  149
13 3  40
14 4  89
15 5  190/ ;
16
17 table h(i,k) demand between origin i to destination j
18         1     2    3    4    5
19 1       0    32   25   77   20
20
21 2       22    0   36   28   42
22
23 3       36   36   0   30    65
24
25 4       67    28   30   0   42
26
27 5       15    34   56   46   0   ;
28
29
30 table c(i,j) unit cost of local (non-hub to hub) movement between nodes i to »
   j
31         1       2      3    4     5
32
33   1     0       27    23    19    15
34
35   2     34      0     26    24    32
36
37   3     21      18    0     25    49
38
39   4     27      24     25    0    26
40
41   5     14      29     53    38    0;
42
43
44
45 variable
46 zz total cost;
47 positive variable
48 z(i,j,k,m);
49
50 binary variables
51 x(j) a hub is located at node j
52 y(i,j) node i is connected to a hub located at node j;
53
54
55
56 equation
57 obj
58 co1
59 co2
60 co4
```

```
61 co5
62 *co6
63 co7
64
65
66 ;
67
68 obj..           zz=e=sum((i,j,k,m),(c(i,k)+c(k,m)+c(m,j))*h(i,j)*z(i,j,k,m));
69 co1..                                  sum(k,x(k))=e=pp   ;
70 co2(i,j)$(ord(i)<>ord(j))..            sum((k,m),z(i,j,k,m))=e=1;
71 co4(i,j,k,m)$(ord(i)<>ord(j)) ..       z(i,j,k,m)=l=x(m);
72 co5(i,j,k,m)$(ord(i)<>ord(j)) ..       z(i,j,k,m)=l=x(k);
73 *co6(i,j,k,m) $(ord(i)<>ord(j))..       y(i,k)+y(j,m)-2*z(i,j,k,m)=g=0;
74 co7(i,k).. sum((m,j),h(i,j)*z(i,j,k,m))+sum((p,s),h(p,i)*z(p,i,s,k))=g=teta(k»
   )*y(i,k);
75
76
77
78
79
80 model PHL /all/;
81 option mip=cplex;
82 option optca=0;
83 option optcr=0;
84 solve PHL using mip min zz;
85 display x.l,z.l,zz.l;
86
87
```