QAPLIB-Problem Instances and Solutions

R.E. BURKARD, E. ÇELA, S.E. KARISCH and F. RENDL

Complete List

- R.E. Burkard and J. Offermann
- N. Christofides and E. Benavent
- A.N. Elshafei
- B. Eschermann and H.J. Wunderlich
- S.W. Hadley, F. Rendl and H. Wolkowicz
- J. Krarup and P.M. Pruzan
- Y. Li and P.M. Pardalos
- C.E. Nugent, T.E. Vollmann and J. Ruml
- C. Roucairol
- M. Scriabin and R.C. Vergin
- J. Skorin-Kapov
- L. Steinberg
- E.D. Taillard
- U.W. Thonemann and A. Bölte
- M.R. Wilhelm and T.L. Ward

Compressed Data and Solutions

Data: qapdata.tar.gz (453187 KB). Solutions: qapsoln.tar.gz (9836 KB). (“gunzip qap*xxxx*.tar.gz” and “tar xf qap*xxxx*.tar”. This should result in 136 instances and 111 solutions.)

Description

The instances are listed in alphabetical order by the names of

their authors. We shortly characterize the examples by indicating their

generation. All the instances in the current version are pure quadratic.

If not stated otherwise the examples are symmetric.

The format of the problem data is

n

A

B

where n is the size of the instance, and A and

B are either

flow or distance matrix.

This corresponds to a QAP of the form

```
          ---  ---

          \    \

    min   /    /    a    b

     p    ---  ---   ij   p(i),p(j)

           i    j
```

where p is a permutation.

We quote the filename under which it is stored in the library and report

the size of the problem. Then the objective function value of the best

known feasible solution is given. In parentheses we indicate whether

this solution is optimal or derived by a heuristic. The heuristics that are

used are

- ant systems: (ANT) [Stuetzle:97].

- genetic hybrids: (GEN) [FlFe:94],(GEN-2) [OsRu:96],(GEN-3) [TaGa:97], and (GEN-4) [Mise:04].
- a greedy randomized adaptive search procedure: (GRASP) [LiPaRe:94],
- scatter search: (ScS) [CuMaMiTa:97],
- simulated annealing: (SIM-1) [BuRe:84],(SIM-2)[ThBo:94] and(SIM-3) [Mise:03], and
- simulated jumping: (SIMJ) [Amin:98].
- tabu search:parallel adaptive tabu search (PA-TS)[TaHaGe:97],reactive tabu search (Re-TS) [BaTe:94],robust tabu search (Ro-TS) [Taillard:91,Taillard:94],strict tabu search (S-TS) [Skorin:90], (TS-1) [Iriyama:97], (TS-2) [Mise:05] and (ITS) [Mise:08]

If available we give a link to a solution for the instances. The format

of these files is

```
        n    sol


        p
```

where *n* gives the size of the instance, *sol* is the

objective function value and *p* a corresponding permutation,

i.e.

```
            ---  ---


            \    \


       sol =  /    /    a    b         .


            ---  ---   ij   p(i),p(j)


             i    j
```

For optimal solutions we enclose the optimal permutation while for nonoptimal solutions lower bounds are given. We also give explicit reference who solved hard instances of size n>15 first. The lower bounds given in the tables are

- the Gilmore-Lawler bound: (GLB)[Gilmore:62,Lawler:63],
- the elimination bound: (ELI) [HaReWo:92],
- an interior point based linear programming bound: (IPLP) [ReRaDr:94]
- a triangle decomposition bound: (TDB) [KaRe:95a],
- a semidefinite programming bound: (SDP)[ZhKaReWo:96],
- a bound based on a dual procedure: (DP)[HaGr:95],
- a bound based on a cutting plane approach: (CUT)[Kaibel:97],
- a dual framework based bound: (DFB)[KaCeClEs:98],
- a lift-and-project relaxation bound: (L&P)[http://www.optimization-online.org/DB_HTML/2004/06/890.html],
- a level-2 RLT bound: (RLT2)[HHJGSR:01],
- a semidefinite programming bound: (SDP1)[DKSo:07], and
- a semidefinite relaxation-matrix splitting bound: (SDRMS)[http://www.optimization-online.org/DB_HTML/2009/02/2220.html],

When lower bounds are included we also give the relative gap between best feasible soltion and best known lower bound in percent, i.e.

*gap = (solution – bound)/(solution)**100 %.

R.E. Burkard and J. Offermann [BuOf:77]

The data of the first matrix correspond to the typing-time of an average stenotypist, while the second matrix describes the frequency of pairs of letters in different languages taken over 100,000 pairs for examples a-f and over 187,778 pairs for examples g-h. (Note that the solutions are not scaled for a flow matrix of 100,000 pairs anymore.)

One also distinguishes between two types of typewriter keyboards.

The instances are asymmetric.

```
name     n      feas. solution          bound          gap
```

```
-------------------------------------------------------------

* Bur26a  26    5426670 (OPT)    (26 15 11 7 4 12 13 2 6 18 1 5 9 21 8
14 3 20 19 25 17 10 16 24 23 22)

* Bur26b  26    3817852 (OPT)    (17 11 26 7 4 14 6 22 23 18 5 9 1 21
8 12 3 19 20 15 10 25 24 16 13 2)

* Bur26c  26    5426795 (OPT)    (12 3 2 13 16 25 11 15 10 9 18 19 8
20 4 21 1 5 14 24 22 6 23 7 26 17)

* Bur26d  26    3821225 (OPT)    (3 22 11 2 16 26 8 15 21 9 19 12 18
20 23 25 14 5 1 6 13 24 4 7 17 10)

* Bur26e  26    5386879 (OPT)    (14 4 13 7 16 25 26 17 1 15 12 20 18
19  3 8 21 9 5 24 6 10 22 2 23 11)

* Bur26f  26    3782044 (OPT)    (7 2 13 17 16 26 23 1 10 15 19 20 18
12 14 25 21 5 9 3 6 24 22 4 11 8)

* Bur26g  26   10117172 (OPT)    (22 11 2 23 13 25 24 8 1 21 20 4 7 18
12 15 9 19 5 26 16 6 14 3 17 10)

* Bur26h  26    7098658 (OPT)    (22 16 3 12 6 24 17 1 8 21 20 4 7 18
14 15 9 5 19 2 11 13 23 26 25 10)
```

N. Christofides and E. Benavent [ChBe:89]

One matrix is the adjacency matrix of a weighted tree the other that of a complete graph.

```
   name    n      solution      permutation

   ------------------------------------------------------------------------
--------------------------------

   Chr12a  12      9552 (OPT)    (7,5,12,2,1,3,9,11,10,6,8,4)

   Chr12b  12      9742 (OPT)    (5,7,1,10,11,3,4,2,9,6,12,8)

   Chr12c  12     11156 (OPT)    (7,5,1,3,10,4,8,6,9,11,2,12)

   Chr15a  15      9896 (OPT)    (5,10,8,13,12,11,14,2,4,6,7,15,3,1,9)

   Chr15b  15      7990 (OPT)    (4,13,15,1,9,2,5,12,6,14,7,3,10,11,8)

   Chr15c  15      9504 (OPT)    (13,2,5,7,8,1,14,6,4,3,15,9,12,11,10)

   Chr18a  18     11098 (OPT)
(3,13,6,4,18,12,10,5,1,11,8,7,17,14,9,16,15,2)

   Chr18b  18      1534 (OPT)
(1,2,4,3,5,6,8,9,7,12,10,11,13,14,16,15,17,18)

   Chr20a  20      2192 (OPT)
(3,20,7,18,9,12,19,4,10,11,1,6,15,8,2,5,14,16,13,17)
```

```
   Chr20b  20     2298 (OPT)
(20,3,9,7,1,12,16,6,8,14,10,4,5,13,17,2,18,11,19,15)


   Chr20c  20    14142 (OPT)
(12,6,9,2,10,11,3,4,15,18,7,13,16,5,14,17,19,1,8,20)


   Chr22a  22     6156 (OPT)
(15,2,21,8,16,1,7,18,14,13,5,17,6,11,3,4,20,19,9,22,10,12)


   Chr22b  22     6194 (OPT)
(10,19,3,1,20,2,6,4,7,8,17,12,11,15,21,13,9,5,22,14,18,16)


   Chr25a  25     3796 (OPT)
(25,12,5,3,18,4,16,8,20,10,14,6,15,23,24,19,13,1,21,11,17,2,22,7,9)
```

A.N. Elshafei [Elshafei:77]

The data describe the distances of 19 different facilities of a hospital and the flow of patients between those locations. The optimal solution was first found by [Mautor:92].

```
   name    n     solution        permutation


   ----------------------------------------------------------------------
-----------


   Els19   19   17212548 (OPT)
(9,10,7,18,14,19,13,17,6,11,4,5,12,8,15,16,1,2,3)
```

B. Eschermann and H.J. Wunderlich [EsWu:90]

These examples stem from an application in computer science, from the testing of self-testable sequential circuits. The amount of additional hardware for the testing should be minimized. The optimal solutions are due to [ClPe:94] (*n*=16) and [BrClMaPe:96] (*n*=32).

```
   name    n    feas.sol.     permutation/bound      gap

   ----------------------------------------------------------------------
----------

   Esc16a  16     68  (OPT)     (2,14,10,16,5,3,7,8,4,6,12,11,15,13,9,1)

   Esc16b  16    292  (OPT)     (6,3,7,5,13,1,15,2,4,11,9,14,10,12,8,16)

   Esc16c  16    160  (OPT)     (11,14,10,16,12,8,9,3,13,6,5,7,15,2,1,4)

   Esc16d  16     16  (OPT)     (14,2,12,5,6,16,8,10,3,9,13,7,11,15,4,1)

   Esc16e  16     28  (OPT)     (16,7,8,15,9,12,14,10,11,2,6,5,13,4,3,1)

   Esc16f  16      0  (OPT)     (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16)

   Esc16g  16     26  (OPT)     (8,11,9,12,15,16,14,10,7,6,2,5,13,4,3,1)

   Esc16h  16    996  (OPT)     (13,9,10,15,3,11,4,16,12,7,8,5,6,2,1,14)
```

Esc16i 16 14 (OPT) (13,9,11,3,7,5,6,2,1,15,4,14,12,10,8,16)

Esc16j 16 8 (OPT) (8,3,16,14,2,12,10,6,9,5,13,11,4,7,15,1)

* Esc32a 32 130 (OPT)
(11,3,7,23,19,27,15,14,20,17,28,9,12,4,8,2,26,24,32,13,22,25,6,18,29,10,30,21,1,5,16,31)

* Esc32b 32 168 (OPT)
(15,31,7,8,23,24,16,32,14,10,30,26,5,6,13,9,2,1,21,22,29,25,18,17,12,27,20,11,3,19,28,4)

* Esc32c 32 642 (OPT)
(15,12,27,13,22,8,24,23,20,19,4,2,1,7,6,3,5,18,17,21,14,29,16,32,26,11,31,30,28,10,25,9)

* Esc32d 32 200 (OPT)
(18,29,10,2,25,32,22,20,24,17,30,9,1,26,31,21,19,23,27,16,13,6,3,11,15,7,8,5,14,4,12,28)

Esc32e 32 2 (OPT)
(1,2,5,6,8,16,13,19,9,32,7,22,24,20,4,12,3,

17,29,21,11,25,27,18,30,31,23,28,14,15,26,10)

Esc32g 32 6 (OPT)
(14,15,16,12,11,26,30,10,25,8,29,22,31,28,

13,1,19,9,17,32,24,18,4,2,20,5,21,3,7,6,23,27)

* Esc32h 32 438 (OPT)
(1,19,29,22,12,4,30,25,9,7,27,11,21,6,5,13,14,

31,10,28,8,3,23,26,17,2,32,15,24,18,20,16)

* Esc64a 64 116 (OPT)
(1,2,9,50,3,61,4,62,5,54,64,6,7,52,56,8,55,10,63,18,11,51,12,13,14,15,20,43,16,41,17,47,23,19,24,21,53,22,28,25,26,27,29,60,30,59,31,32,33,34,35,36,37,38,39,40,42,44,45,46,48,49,57,58)

* Esc128 128 64 (OPT) (1,2,3,4,117,5,6,7,8,9,10,11,12,73,13,89,

14,15,16,17,18,19,20,21,22,23,24,53,25,26,102,

27,104,28,118,120,29,30,31,80,32,111,112,34,35,

36,97,98,38,39,100,40,99,41,42,43,44,45,46,47,

48,33,49,37,51,121,52,54,122,55,123,56,124,57,

125,58,126,59,127,128,81,60,61,62,63,64,113,

105,66,67,68,69,70,65,71,72,74,75,76,77,78,79,

```
82,83,84,85,86,87,88,90,50,91,114,92,93,94,95,

96,101,103,106,107,108,109,110,115,116,119)
```

S.W. Hadley, F. Rendl and H. Wolkowicz [HaReWo:92]

The first matrix represents Manhattan distances of a connected cellular complex in the plane while the entries in the flow matrix are drawn uniformly from the interval [1,*n*]. The proof of optimality of the solution for *n=16* is due to [HaGrHa:96], for *n=18* and *n=20* due to [BrClMaPe:96]

```
   name   n    solution      permutation

   -------------------------------------------------------------------
----

   Had12  12   1652 (OPT)    (3,10,11,2,12,5,6,7,8,1,4,9)

   Had14  14   2724 (OPT)    (8,13,10,5,12,11,2,14,3,6,7,1,9,4)

   Had16  16   3720 (OPT)    (9,4,16,1,7,8,6,14,15,11,12,10,5,3,2,13)

   Had18  18   5358 (OPT)
(8,15,16,6,7,18,14,11,1,10,12,5,3,13,2,17,9,4)
```

```
   Had20  20   6922 (OPT)
(8,15,16,14,19,6,7,17,1,12,10,11,5,20,2,3,4,9,18,13)
```

J. Krarup and P.M. Pruzan [KrPr:78]

The instances contain real world data and were used to plan the

Klinikum Regensburg in Germany.

```
   name    n    feas. solution      permutation/bound       gap


   ---------------------------------------------------------


*   Kra30a  30   88900 (OPT)
(23,10,28,29,21,7,13,24,20,8,9,19,25,27,15,



4,22,12,6,5,16,11,3,2,17,1,30,26,18,14)


*   Kra30b  30   91420 (OPT)
(23,26,19,25,20,22,11,8,9,14,27,30,12,6,28,



24,21,18,1,7,10,29,13,5,2,17,3,15,4,16)


*   Kra32   32   88700 (OPT)
(31,23,18,21,22,19,10,11,15,9,30,29,14,12,17,26,



27,28,1,7,6,25,5,3,8,24,32,13,2,20,4,16)
```

Y. Li and P.M. Pardalos [LiPa:92]

These instances come from problem generators described in [LiPa:92].

The generators provide asymmetric instances with known optimal solutions.

```
name     n      solution
---------------------------
Lipa20a  20       3683 (OPT)
Lipa20b  20      27076 (OPT)
Lipa30a  30      13178 (OPT)
Lipa30b  30     151426 (OPT)
Lipa40a  40      31538 (OPT)
Lipa40b  40     476581 (OPT)
Lipa50a  50      62093 (OPT)
Lipa50b  50    1210244 (OPT)
Lipa60a  60     107218 (OPT)
```

```
Lipa60b  60   2520135 (OPT)

Lipa70a  70    169755 (OPT)

Lipa70b  70   4603200 (OPT)

Lipa80a  80    253195 (OPT)

Lipa80b  80   7763962 (OPT)

Lipa90a  90    360630 (OPT)

Lipa90b  90  12490441 (OPT)
```

C.E. Nugent, T.E. Vollmann and J. Ruml [NuVoRu:68]

The following problem instances are probably the most used. The distance

matrix contains Manhattan distances of rectangular grids. The instances

of size n = {14,16,17,18,21,22,24,25} were constructed out of

the larger instances by deleting certain rows and columns, see Clausen and

Perregaard [ClPe:94]. The optimal solutions

are also due to [ClPe:94]. For Nug21 and

Nug22 optimality was proved by [BrClMaPe:96],

for Nug24 by [CEKPT:96].

The instances of size n =27 and n =28 were constructed out of the instance of

size n =30 by deleting the three or two last facilities, respectively,

and were solved by Anstreicher, Brixius, Goux, and Linderoth.

Aslo Nug 30 was solved by these authors.

The solution was found by applying a

branch and bound algorithm, see Anstreicher and Brixius

[AnBr2:00].

The involved bound was based on convex quadratic programming, see

Anstreicher and Brixius

[AnBr1:00].

```
   name    n    feas.sol.     permutation/bound      gap


   ---------------------------------------------------------------------
----------------------



   Nug12   12     578  (OPT)     (12,7,9,3,4,8,11,1,5,6,10,2)


   Nug14   14    1014  (OPT)     (9,8,13,2,1,11,7,14,3,4,12,5,6,10)


   Nug15   15    1150  (OPT)     (1,2,13,8,9,4,3,14,7,11,10,15,6,5,12)


   Nug16a  16    1610  (OPT)     (9,14,2,15,16,3,10,12,8,11,6,5,7,1,4,13)


   Nug16b  16    1240  (OPT)     (16,12,13,8,4,2,9,11,15,10,7,3,14,6,1,5)


   Nug17   17    1732  (OPT)
(16,15,2,14,9,11,8,12,10,3,4,1,7,6,13,17,5)
```

```
   Nug18   18   1930 (OPT)
(10,3,14,2,18,6,7,12,15,4,5,1,11,8,17,13,9,16)


   Nug20   20   2570 (OPT)
(18,14,10,3,9,4,2,12,11,16,19,15,20,8,13,17,5,7,1,6)


   Nug21   21   2438 (OPT)
(4,21,3,9,13,2,5,14,18,11,16,10,6,15,20,19,8,7,1,12,17)


   Nug22   22   3596 (OPT)
(2,21,9,10,7,3,1,19,8,20,17,5,13,6,12,16,11,22,18,14,15)


   Nug24   24   3488 (OPT)
(17,8,11,23,4,20,15,19,22,18,3,14,1,10,7,9,16,21,24,12,6,13,5,2)


   Nug25   25   3744 (OPT)
(5,11,20,15,22,2,25,8,9,1,18,16,3,6,19,24,21,14,7,10,17,12,4,23,13)


*  Nug27   27   5234 (OPT)
(23,18,3,1,27,17,5,12,7,15,4,26,8,19,20,2,24,21,14,10,9,13,22,25,6,16,1
1)


*  Nug28   28   5166 (OPT)
(18,21,9,1,28,20,11,3,13,12,10,19,14,22,15,2,25,16,4,23,7,17,24,26,5,27
,8,6)


*  Nug30   30   6124 (OPT)    (5 12 6 13 2 21 26 24 10 9 29 28 17 1 8 7
19 25 23 22 11 16 30 4 15 18 27 3 14 20)
```

C. Roucairol [Roucairol:87]

The entries of the matrices are chosen from the interval [1,100].

```
   name    n      feas.sol.       permutation


   --------------------------------------------------------------------
-------


   Rou12  12   235528 (OPT)     (6,5,11,9,2,8,3,1,12,7,4,10)

   Rou15  15   354210 (OPT)     (12,6,8,13,5,3,15,2,7,1,9,10,4,14,11)

   Rou20  20   725522 (OPT)
(1,19,2,14,10,16,11,20,9,5,7,4,8,18,15,3,12,17,13,6)
```

M. Scriabin and R.C. Vergin [ScVe:75]

The distances of these problems are rectangular. The optimal solution for

the instanze of size *n*=20 was found by [Mautor:92].

```
   name    n       solution      permutation


   --------------------------------------------------------------------
-----------


   Scr12  12     31410 (OPT)   (8,6,3,2,10,1,5,9,4,7,12,11)

   Scr15  15     51140 (OPT)   (15,7,11,8,1,4,3,2,12,6,13,5,14,10,9)
```

```
   Scr20  20   110030 (OPT)
(20,7,12,6,4,8,3,2,14,11,18,9,19,15,16,17,13,5,10,1)
```

J. Skorin-Kapov [Skorin:90]

The distances of these problems are rectangular and the entries in flow

matrices are pseudorandom numbers.

```
   name      n       feas.sol.         bound        gap

   --------------------------------------------------------

   Sko42      42     15812  (Ro-TS)     14934  (TDB)    5.56 %

   Sko49      49     23386  (Ro-TS)     22004  (TDB)    5.91 %

   Sko56      56     34458  (Ro-TS)     32610  (TDB)    5.37 %

   Sko64      64     48498  (Ro-TS)     45736  (TDB)    5.70 %

   Sko72      72     66256  (Ro-TS)     62691  (TDB)    5.38 %

   Sko81      81     90998  (GEN)       86072  (TDB)    5.41 %

*  Sko90      90    115534  (Ro-TS)    109030  (SDRMS-SUM)    5.63 %
*  Sko100a  100    152002  (GEN)      143846  (SDRMS-SUM)    5.37 %
```

```
*   Sko100b  100   153890 (GEN)      145522 (SDRMS-SUM)    5.44 %

*   Sko100c  100   147862 (GEN)      139881 (SDRMS-SUM)    5.54 %

*   Sko100d  100   149576 (GEN)      141289 (SDRMS-SUM)    5.54 %

*   Sko100e  100   149150 (GEN)      140893 (SDRMS-SUM)    5.54 %

*   Sko100f  100   149036 (GEN)      140691 (SDRMS-SUM)    5.60 %
```

L. Steinberg [Steinberg:61]

The three instances model the backboard wiring problem. The distances in the first one are Manhattan, in the second squared Euclidean, and in the third one Euclidean distances (multiplied by 1000).

```
   name      n         feas.sol.          permutation/bound      gap



   --------------------------------------------------------------------
--------------



*   Ste36a   36        9526 (OPT)
(35,5,6,12,11,27,26,25,24,9,4,1,13,20,14,23,21,22,2,8,10,7,28,19,32,34,
33,17,18,3,15,16,29,30,31,36)



*   Ste36b   36       15852 (OPT)
(35,31,30,29,28,1,15,9,16,33,34,32,19,20,7,10,18,17,26,25,23,14,12,13,4
,8,2,24,22,21,27,11,6,5,3,36)



*   Ste36c   36     8239110 (OPT)
(3,19,29,21,30,31,13,20,2,12,32,23,22,24,4,1,10,11,15,14,26,27,25,36,35
,34,33,5,6,7,8,16,18,17,28,9)
```

E.D. Taillard

[Taillard:91,Taillard:94]

The instances Tai*xx*a are uniformly generated and were proposed in [Taillard:91]. The other problems were introduced in [Taillard:94]. Problems Tai*xx*b are asymmetric and randomly generated. Instances Tai*xx*c occur in the generation of grey patterns. The optimality of the solutions for Tai17a and Tai20a was proved by [BrClMaPe:96], while the method of [HaGrHa:96] proved optimality of Tai20b and the Tai25a. Giovannetti [Giovannetti:97] showed the optimality of Tai25b.

Drezner [Drez:06] proved the optimality of the Tai64c. Drezner's method is branch and bound. His bound exploits the special structure of the problem.

name	n	feas.sol.	permutation/bound	gap
Tai12a	12	224416 (OPT)	(8,1,6,2,11,10,3,5,9,7,12,4)	
Tai12b	12	39464925 (OPT)	(9,4,6,3,11,7,12,2,8,10,1,5)	
Tai15a	15	388214 (OPT)	(5,10,4,13,2,9,1,11,12,14,7,15,3,8,6)	
Tai15b	15	51765268 (OPT)	(1,9,4,6,8,15,7,11,3,5,2,14,13,12,10)	
Tai17a	17	491812 (OPT)	(12,2,6,7,4,8,14,5,11,3,16,13,17,9,1,10,15)	

Tai20a 20 703482 (OPT)
(10,9,12,20,19,3,14,6,17,11,5,7,15,16,18,2,4,8,13,1)

* Tai20b 20 122455319 (OPT)
(8,16,14,17,4,11,3,19,7,9,1,15,6,13,10,2,5,20,18,12)

* Tai25a 25 1167256 (OPT)
(9,4,6,11,5,1,15,10,14,3,17,12,19,18,23,8,21,2,22,7,16,20,24,25,13)

* Tai25b 25 344355646 (OPT)
(4,15,10,9,13,5,25,19,7,3,17,6,18,20,16,2,22,23,8,11,21,24,14,12,1)

Tai30a 30 1818146 (Ro-TS) 1706855 (L&P) 6.12 %

* Tai30b 30 637117113 (OPT) (4 8 11 15 17 20 21 5 14 30 2 13 6 29 10 26 27 24 28 22 12 9 7 23 19 18 25 16 1 3)

Tai35a 35 2422002 (Ro-TS) 2216627 (L&P) 8,48 %

* Tai35b 35 283315445 (Ro-TS) 242172800 (SDRMS-SUM) 14.52 %

Tai40a 40 3139370 (Ro-TS) 2843274 (L&P) 9.43 %

* Tai40b 40 637250948 (Ro-TS) 564428353 (SDRMS-SUM) 11.43 %

```
*  Tai50a    50      4938796 (ITS)       4390920 (L&P)           11.09
%

*  Tai50b    50    458821517 (Ro-TS)   395543467 (SDRMS-SUM)     13.79
%

*  Tai60a    60      7205962 (TS-2)      5578356 (SDRMS)
22.59 %

*  Tai60b    60    608215054 (Ro-TS)   542376603 (SDRMS-SUM)     10.82
%

   Tai64c    64      1855928 (BandB)
(1,3,5,15,17,20,30,35,40,45,49,51,55,2,4,6,7,8,9,10,11,12,13,14,16,18,1
9,21,22,23,24,25,26,27,28,29,31,32,33,34,36,37,38,39,41,42,43,44,46,47,
48,50,52,53,54,56,57,58,59,60,61,62,63,64)

*  Tai80a    80     13499184 (ITS)      10501941 (DP)            22.20
%

*  Tai80b    80    818415043 (Ro-TS)   717907288 (SDRMS-SUM)     12.28
%

*  Tai100a  100     21052466 (ITS)      15844731 (SDRMS)
24.86 %

*  Tai100b  100   1185996137 (Ro-TS)  1058131796 (SDRMS-SUM)     10.78
%

*  Tai150b  150    498896643 (GEN-3)   441786736 (SDRMS-SUM)     11.45
%

*  Tai256c  256     44759294 (ANT)      43849646 (SDRMS)          2.03
%
```

U.W. Thonemann and A. Bölte [ThBo:94]

The distances of these instances are rectangular.

```
   name      n        feas.sol.         bound         gap

   ----------------------------------------------------------

*  Tho30     30    149936 (OPT)
(8,6,20,17,19,12,29,15,1,2,30,11,13,28,23,

                            27,16,22,10,21,25,24,26,18,3,14,7,5,9,4)

   Tho40     40    240516 (SIM-2)     224414 (L&P)         6.69 %

*  Tho150   150   8133398 (SIM-3)    7620628 (TDB)    6.30 %
```

M.R. Wilhelm and T.L. Ward [WiWa:87]

The distances of these problems are rectangular.

```
   name      n        feas.sol.         bound         gap

   ----------------------------------------------------------

   Wil50     50    48816 (SIM-2)    47098 (TDB)      3.52 %
```

```
*  Wil100  100   273038 (GEN)    264442 (SDRMS-SUM) 3.15 %
```

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