Compact Formulations from the Literature

The Compact Formulation of Avriel and Penn (1993). The first formulation for the CSPP is owed to Avriel and Penn (1993). It was proposed for both full-loading and non-full-loading transportation matrices. The version provided in the following is slightly simplified with respect to the one found in Avriel and Penn (1993) to exploit the full-loading assumption. This translates into a formulation with fewer variables and fewer constraints.

Let $\theta^{rc}_{ijk} \in \{0,1\}$ be a binary variable equal to 1 if there is a container in tier $r \in R$ of stack $c \in C$ loaded on board in port $i \in P_1^{n-1}$ with final destination $j \in P_{i+1}^{n}$, and unloaded in port $k \in P_{i+1}^{j}$ (0 otherwise). Avriel and Penn (1993) formulated the CSPP as follows:

$$z_{\text{AP}} = \min \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \sum_{k=i+1}^{j-1} \sum_{r \in R} \sum_{c \in C} \theta^{rc}_{ijk} \tag{EC.1}$$

$$\text{s.t.} \sum_{r \in R} \sum_{c \in C} \left(\sum_{k=i+1}^{j} \theta^{rc}_{ijk} - \sum_{k=1}^{i-1} \theta^{rc}_{kji} \right) = t_{ij} \qquad (i,j) \in \mathcal{W} \tag{EC.2}$$

$$\sum_{k=1}^{i} \sum_{j=i+1}^{n} \sum_{v=i+1}^{j} \theta^{rc}_{kjv} = 1 \qquad i \in P_1^{n-1} \quad r \in R \quad c \in C \tag{EC.3}$$

$$\sum_{i=1}^{j-1} \sum_{k=j}^{n} \theta^{rc}_{ikj} + \sum_{i=1}^{j-1} \sum_{k=j+1}^{n} \sum_{v=j+1}^{k} \theta^{r+1\,c}_{ikv} \leq 1 \qquad j \in P_2^{n} \quad r \in R^{-} \quad c \in C \tag{EC.4}$$

$$\theta^{rc}_{ijk} \in \{0,1\} \qquad i \in P_1^{n-1} \quad j \in P_{i+1}^{n} \quad k \in P_{i+1}^{j} \quad r \in R \quad c \in C \tag{EC.5}$$

The objective function (EC.1) aims to minimize the total number of shifts. Constraints (EC.2) state that, for each pair $(i,j) \in \mathcal{W}$, the difference between the number of j-containers unloaded in any port $k = i+1, \ldots, j$ minus the number of j-containers originated from $k = 1, \ldots, i-1$, and unloaded at i must be equal to t_{ij}. Constraints (EC.3) stipulate that exactly one container has to be stowed in tier $r \in R$ of stack $c \in C$ upon leaving each port $i \in P_1^{n-1}$. Constraints (EC.4) allow to count the number of shifts: if the container stowed in tier $r \in R^{-}$ of stack $c \in C$ at port $j \in P_2^{n}$ is unloaded, then even the container stowed in tier $r+1$ must be unloaded at port j. Integrality on the variables is imposed with constraints (EC.5).

The relationship between the optimal value of (1)-(5) and the optimal value z_{AP} of formulation (EC.1)-(EC.5) is $z_{\text{AP}} = z_{\text{RP}} - nCont$ as the number of discharges (i.e., $nCont$), which are included in the costs $\tilde{c}_s$ of stack plans, is constant.

A weakness of formulation (EC.1)-(EC.5) is that its linear relaxation has optimal value zero (see Avriel et al. (1998)).

The Compact Formulation of Ding and Chou (2015). An alternative compact formulation has been introduced by Ding and Chou (2015), in the online supplement of their paper. As in Avriel and Penn (1993), the formulation was proposed for both full-loading and non-full-loading

transportation matrices. In the following, we report a slightly simplified version of the original formulation of Ding and Chou (2015), where the objective function has been adapted and a set of constraints has been removed thanks to the full-loading assumption.

Consider the two sets of binary variables: $\mu_{ij}^{rc} \in \{0,1\}$ and $\phi_{ij}^{rc} \in \{0,1\}$, where μ_{ij}^{rc} equals 1 if, upon leaving port i, a j-container (with $(i,j) \in \mathcal{W}$) is stowed in tier $r \in R$ of stack $c \in C$ (0 otherwise), and ϕ_{ij}^{rc} equals 1 if, before any loading operation at port $i \in P_2^{n-1}$ begins, a j-container ($j \in P_{i+1}^n$) is stowed in tier $r \in R$ of stack $c \in C$ (0 otherwise). The CSPP can be formulated as:

$$z_{\text{DC}} = \max \sum_{i=2}^{n-1} \sum_{j=i+1}^{n} \sum_{r \in R} \sum_{c \in C} \phi_{ij}^{rc} \tag{EC.6}$$

$$\text{s.t.} \sum_{r \in R} \sum_{c \in C} \mu_{1j}^{rc} = t_{1j} \qquad j \in P_2^n \tag{EC.7}$$

$$\sum_{r \in R} \sum_{c \in C} \left(\mu_{ij}^{rc} - \mu_{i-1,j}^{rc}\right) = t_{ij} \qquad i \in P_2^{n-1} \quad j \in P_{i+1}^n \tag{EC.8}$$

$$\sum_{j=i+1}^{n} \mu_{ij}^{rc} = 1 \qquad i \in P_1^{n-1} \quad r \in R \quad c \in C \tag{EC.9}$$

$$\sum_{j=i+1}^{n} \phi_{ij}^{rc} \leq 1 \qquad i \in P_2^{n-1} \quad r \in R \quad c \in C \tag{EC.10}$$

$$\sum_{j=i+1}^{n} \left(\phi_{ij}^{rc} - \phi_{ij}^{r+1,c}\right) \geq 0 \qquad i \in P_2^{n-1} \quad r \in R^- \quad c \in C \tag{EC.11}$$

$$\phi_{ij}^{rc} \leq \mu_{ij}^{rc} \qquad i \in P_2^{n-1} \quad j \in P_{i+1}^n \quad r \in R \quad c \in C \tag{EC.12}$$

$$\phi_{i+1,j}^{rc} \leq \mu_{ij}^{rc} \qquad i \in P_1^{n-2} \quad j \in P_{i+2}^n \quad r \in R \quad c \in C \tag{EC.13}$$

$$\mu_{ij}^{rc} \in \{0,1\} \qquad (i,j) \in \mathcal{W} \quad r \in R \quad c \in C \tag{EC.14}$$

$$\phi_{ij}^{rc} \in \{0,1\} \qquad i \in P_2^{n-1} \quad j \in P_{i+1}^n \quad r \in R \quad c \in C \tag{EC.15}$$

The objective function (EC.6) maximizes the number of containers still on board after all unloading operations have taken place in each port; notice that the total number of shifts (i.e., the optimal value z_{AP} of (EC.1)-(EC.5)) can be derived as $z_{\text{AP}} = (n-1) \cdot \overline{r} \cdot \overline{c} - z_{\text{DC}} - nCont$, where $(n-1) \cdot \overline{r} \cdot \overline{c}$ is the total (constant) number of containers stowed upon leaving the first $n-1$ ports. Constraints (EC.7) stipulate that all transports originated from port 1 have to be satisfied. Constraints (EC.8) stipulate that, upon leaving port $i \in P_2^{n-1}$, the number of j-containers ($j \in P_{i+1}^n$) on board has to be equal to the number of j-containers on board upon leaving port $i-1$ plus the transport t_{ij}. Constraints (EC.9) ensure that exactly one container is stowed in tier $r \in R$ of stack $c \in C$ upon leaving port $i \in P_1^{n-1}$. Constraints (EC.10) guarantee that no more than one container is stowed in tier $r \in R$ of stack $c \in C$ before loading operations take place in port $i \in P_2^{n-1}$. Constraints (EC.11) stipulate that all containers on-board before any loading operations in port $i \in P_2^{n-1}$ have to be stowed at the bottom of the stacks. Constraints (EC.12) and (EC.13) link variables $\boldsymbol{\mu}$ and $\boldsymbol{\phi}$ by

stating that if, at port $i \in P_2^{n-1}$, there is a j-container ($j \in P_{i+1}^n$) stowed in tier $r \in R$ of stack $c \in C$ before any loading operations, then even upon leaving port i there has to be a j-container in tier r of stack c, and that there can be a j-container ($j \in P_{i+2}^n$) stowed in tier $r \in R$ of stack $c \in C$ before loading operations start at port $i+1$ if and only if there was a j-container in tier r of stack c upon leaving port $i \in P_1^{n-2}$. Integrality on the decision variables is imposed with constraints (EC.14)-(EC.15).

Detailed Description of the Lower Bounding Procedure

Algorithm 1 Lower Bounding Procedure

```
1: procedure LowerBoundingProcedure
2:     LB_0 ← CombinatorialLB()                          ▷ See §5.2
3:     solveY ← false
4:     if LB_0 > 0 then
5:         callHeuX2 ← true
6:     else
7:         callHeuX2 ← false
8:     InitializeRMP()                                   ▷ See §5.3
9:     while true do
10:        z_RMP = SolveRMP()
11:        if z_RMP ≤ LB_0 then
12:            break
13:        (u, v) = GetDualRMPSolution()
14:        cardS ← |Ŝ|
15:        HeuX1(v)                                      ▷ See §5.4.1
16:        if callHeuX2 then
17:            HeuX2(v)                                  ▷ See §5.4.2
18:        if cardS = |Ŝ| then
19:            solveY ← true
20:        if solveY then
21:            cardL ← Σ_{i=1}^{n-1} |L̂_i|
22:            for i = 1, ..., n − 2 do
23:                HeuY(i, u, v)                         ▷ See §5.4.3
24:            if cardL = Σ_{i=1}^{n-1} |L̂_i| then
25:                for i = 1, ..., n − 2 do
26:                    ExactY(i, u, v)                   ▷ See §4.2
27:        if cardS = |Ŝ| ∧ cardL = Σ_{i=1}^{n-1} |L̂_i| then
28:            ExactX(u)                                 ▷ See §4.1
29:        if cardS = |Ŝ| ∧ cardL = Σ_{i=1}^{n-1} |L̂_i| then
30:            break
31:    LB = max{LB_0, ⌈z_RMP⌉}
32:    return LB
```

A pseudo-code of the lower bounding procedure outlined in §5 is provided in Algorithm 1.

First, the combinatorial lower bound LB_0 described in §5.2 is computed (see Line 2). Then, the two parameters *solveY* and *callHeuX2* are initialized (see Lines 3-7); *solveY* indicates whether or not the $\boldsymbol{y}$ variables are priced out, and *callHeuX2* indicates if Procedure *HeuX2* (see §5.4.2) will be used.

Procedure *InitializeRMP()* (see Line 8) initializes the subsets $\hat{\mathcal{S}}$ and $\hat{\mathcal{L}}_i$ with the variables of a solution that is obtained via a greedy algorithm that, for the sake of conciseness, is not described; furthermore, additional columns are added to RMP in order to stabilize the column generation procedure (see §5.3).

The main loop of the bounding procedure is given in Lines 9-30. The optimal value of RMP, z_{RMP}, is computed with a general purpose linear programming solver. If z_{RMP} is less than or equal to LB_0, the main loop terminates. Otherwise, the optimal RMP dual solution $(\boldsymbol{u}, \boldsymbol{v})$ is retrieved and used

to generate negative reduced cost columns. The cardinality, $cardS$, of the current set $\hat{\mathcal{S}}$ is stored. Negative reduced cost stack plans are generated and added to RMP by mean of Procedures *HeuX1* and *HeuX2* (see Lines 15-17 and §§5.4.1-5.4.2). Parameter $solveY$ is set to *true* (see Lines 18-19) at the very first iteration when both *HeuX1* and *HeuX2* do not generate any negative reduced cost stack plans. Lines 20-26 correspond to the port layouts pricing phase. The cardinality, $cardL$, of the current sets $\hat{\mathcal{L}}_i$ is stored, and negative reduced cost port layouts are generated via Procedure $HeuY$ (see §5.4.3) and by solving the exact pricing MIP (see §4.2). Whenever no negative reduced cost columns have been found at the current iteration, the exact MIP described in §4.1 is called to solve the stack plans pricing problem to optimality (see Lines 27-28). The main loop terminates if no negative reduced cost column exists (see Lines 29-30). The final lower bound returned by the bounding procedure is the best between LB_0 and $\lceil z_{\text{RMP}} \rceil$.

Detailed Computational Results

We report detailed computational results achieved by the compact formulation of Avriel and Penn (1993) (hereafter called AP93), the compact formulation of Ding and Chou (2015) (hereafter DC15), and the solution method proposed in this paper. We summarized these results in §7 of the main manuscript. We report three tables for each of the five types of instances: one table for the six-port instances, one for the eight-port instances, and another one for the ten-port instances. Tables EC.1-EC.3 regard `Long` instances, Tables EC.4-EC.6 `Mixed` instances, Tables EC.7-EC.9 `Short` instances, Tables EC.10-EC.12 `Authentic` instances, and Tables EC.13-EC.15 `Required` instances.

For each of the 405 test instances, the following information is reported:

General features

- number of tiers per stack ($\bar{r}$)
- number of stacks ($\bar{c}$)
- instance number (no, which can be 1, 2 or 3)
- total number of containers transported (nCont)

Formulation of Avriel and Penn (1993)

- number of constraints (Rows) and of variables (Cols)
- final lower (LB) and upper (UB) bound upon termination
- computing time to achieve upper bound UB (T_{ub})
- total computing time (T_{tot})

Formulation of Ding and Chou (2015)

- number of constraints (Rows) and of variables (Cols)
- final lower (LB) and upper (UB) bound upon termination
- computing time to achieve upper bound UB (T_{ub})
- total computing time (T_{tot})

Solution method of this paper

- combinatorial lower bound described in §5.2 (LB_0) - the constant number nCont is subtracted
- value of the solution found by the greedy heuristic to initial the RMP (UB_0)
- total number of inequalities (20), (21), (22) added to stabilized column generation (nDOI)
- number of variables in the final RMP (Vars)
- number of column generation iterations (Iter)
- final lower bound (LB) - the constant number nCont is subtracted
- computing time of the bounding procedure (T_{lb})
- number of constraints (Rows) and variables (Cols) in the final MIP to find an optimal solution
- final upper bound (UB) - the constant number nCont is subtracted - a dash indicates that no feasible solution was found
- total computing time (T_{tot})

Table EC.1 Computational results on `Long` instances with six ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1447	5515	21000	0	0	1	1	19415	15000	0	0	10	10	0	6	209	318	5	0	0	1715	2100	0	0
6	100	2	1432	5515	21000	0	0	1	1	19415	15000	0	0	3	3	0	3	169	275	2	0	0	1712	1800	0	0
6	100	3	1655	5515	21000	0	0	1	1	19415	15000	0	0	19	19	0	5	213	323	6	0	0	1715	2100	0	0
6	300	1	3219	16515	63000	0	0	3	3	58215	45000	0	0	19	19	0	9	200	512	8	0	0	5115	6300	0	0
6	300	2	4354	16515	63000	0	0	4	4	58215	45000	0	0	19	19	0	9	194	504	6	0	0	5115	6300	0	0
6	300	3	4814	16515	63000	0	0	4	4	58215	45000	0	0	183	183	0	4	193	501	4	0	0	5115	6300	0	0
6	500	1	7417	27515	105000	0	0	4	4	97015	75000	0	0	43	43	0	6	150	659	5	0	0	8512	9000	0	0
6	500	2	6975	27515	105000	0	0	8	8	97015	75000	0	0	122	122	0	7	191	698	3	0	0	8515	10500	0	0
6	500	3	3003	27515	105000	0	0	1	1	97015	75000	0	0	16	16	0	0	115	620	1	0	0	8505	5500	0	0
8	100	1	1997	7515	28000	0	0	2	2	26015	20000	0	0	11	11	0	6	413	523	6	0	0	1715	2100	0	0
8	100	2	1885	7515	28000	0	0	4	4	26015	20000	0	0	9	9	0	8	397	508	7	0	0	1713	1900	0	0
8	100	3	2495	7515	28000	0	0	2	2	26015	20000	0	0	12	12	0	5	417	526	5	0	0	1715	2100	0	0
8	300	1	6553	22515	84000	0	0	8	8	78015	60000	0	0	414	414	0	6	374	684	6	0	0	5115	6300	0	0
8	300	2	6093	22515	84000	0	0	11	11	78015	60000	0	0	533	533	0	4	427	734	3	0	0	5115	6300	0	0
8	300	3	5690	22515	84000	0	0	8	8	78015	60000	0	0	498	498	0	11	437	747	6	0	0	5115	6300	0	0
8	500	1	9795	37515	140000	0	0	27	27	130015	100000	0	0	2039	2039	0	11	396	904	4	0	0	8515	10500	0	1
8	500	2	9745	37515	140000	0	0	38	38	130015	100000	0	0	943	943	0	9	419	926	3	0	0	8515	10500	0	1
8	500	3	11248	37515	140000	0	0	35	35	130015	100000	0	0	2016	2016	0	6	396	904	4	0	0	8515	10500	0	0
10	100	1	2729	9515	35000	0	0	4	4	32615	25000	0	0	28	28	0	12	606	717	7	0	0	1713	1900	0	0
10	100	2	2344	9515	35000	0	0	4	4	32615	25000	0	0	104	104	0	14	684	799	11	0	0	1715	2100	0	0
10	100	3	2058	9515	35000	0	0	4	4	32615	25000	0	0	31	31	0	15	645	768	19	0	0	1715	2100	0	0
10	300	1	7417	28515	105000	0	0	8	8	97815	75000	0	0	70	70	0	6	506	815	5	0	0	5112	5400	0	0
10	300	2	6975	28515	105000	0	0	16	16	97815	75000	0	0	615	615	0	5	652	959	3	0	0	5115	6300	0	0
10	300	3	3003	28515	105000	0	0	2	2	97815	75000	0	0	13	13	0	0	403	708	1	0	0	5105	3300	0	0
10	500	1	12475	47515	175000	0	0	106	106	163015	125000	0	23	3398	3600	0	3	645	1152	3	0	0	8515	10500	0	0
10	500	2	12016	47515	175000	0	0	1172	1172	163015	125000	0	0	931	931	0	10	648	1158	6	0	0	8515	10500	0	0
10	500	3	11689	47515	175000	0	0	107	107	163015	125000	0	0	1653	1653	0	9	659	1166	3	0	0	8515	10500	0	1
Avg									59						517							0				0
Solved									27						26											27

Table EC.2 Computational results on `Long` instances with eight ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1308	7728	50400	0	0	15	15	36028	29400	0	0	254	254	0	16	396	526	24	0	0	3727	4200	0	1
6	100	2	1560	7728	50400	0	0	7	7	36028	29400	0	0	47	47	0	6	338	455	11	0	0	3724	3900	0	0
6	100	3	1456	7728	50400	0	0	3	3	36028	29400	0	0	103	103	0	8	302	431	23	0	0	3716	3100	0	0
6	300	1	4599	23128	151200	0	0	14	14	108028	88200	0	0	166	166	0	11	303	617	8	0	0	11121	10800	0	1
6	300	2	5633	23128	151200	0	0	48	48	108028	88200	0	0	2181	2181	0	8	382	697	9	0	0	11127	12600	0	1
6	300	3	5489	23128	151200	0	0	111	111	108028	88200	0	0	1819	1819	0	8	404	717	7	0	0	11126	12300	0	8
6	500	1	7293	38528	252000	0	0	95	95	180028	147000	0	0	2065	2065	0	12	289	802	7	0	0	18521	18000	0	2
6	500	2	9717	38528	252000	0	0	106	106	180028	147000	0	34	3010	3600	0	9	396	913	11	0	0	18528	21500	0	11
6	500	3	11151	38528	252000	0	0	84	84	180028	147000	0	24	2980	3600	0	5	376	888	6	0	0	18526	20500	0	7
8	100	1	1996	10528	67200	0	0	5	5	48228	39200	0	0	320	320	0	14	708	830	16	0	0	3722	3700	0	0
8	100	2	2019	10528	67200	0	0	36	36	48228	39200	0	0	541	541	0	18	741	875	28	0	0	3726	4100	0	0
8	100	3	3090	10528	67200	0	0	15	15	48228	39200	0	0	551	551	0	17	805	926	15	0	0	3726	4100	0	0
8	300	1	9353	31528	201600	0	0	77	77	144628	117600	0	0	2707	2707	0	14	710	1020	4	0	0	11125	12000	0	1
8	300	2	6653	31528	201600	0	0	46	46	144628	117600	0	0	1213	1213	0	16	653	969	10	0	0	11120	10500	0	0
8	300	3	9291	31528	201600	0	0	68	68	144628	117600	0	0	2717	2717	0	19	705	1021	10	0	0	11126	12300	0	2
8	500	1	13679	52528	336000	0	0	212	212	241028	196000	0	13823	690	3600	0	17	715	1228	7	0	0	18524	19500	0	4
8	500	2	12206	52528	336000	0	0	522	522	241028	196000	0	15794	755	3600	0	14	695	1208	7	0	0	18525	20000	0	3
8	500	3	13364	52528	336000	0	0	227	227	241028	196000	0	14636	976	3600	0	13	744	1256	6	0	0	18527	21000	0	6
10	100	1	3099	13328	84000	0	0	54	54	60428	49000	0	0	1100	1100	0	16	1298	1418	14	0	0	3726	4100	0	0
10	100	2	3145	13328	84000	0	0	23	23	60428	49000	0	0	1272	1272	0	18	1156	1274	12	0	0	3724	3900	0	0
10	100	3	3589	13328	84000	0	0	45	45	60428	49000	0	0	608	608	0	22	1160	1281	15	0	0	3724	3900	0	1
10	300	1	7293	39928	252000	0	0	86	86	181228	147000	0	0	1412	1412	0	20	981	1299	12	0	0	11121	10800	0	1
10	300	2	9717	39928	252000	0	0	437	437	181228	147000	0	11283	651	3600	0	29	1322	1640	12	0	0	11128	12900	0	3
10	300	3	11151	39928	252000	0	0	195	195	181228	147000	0	210	2590	3600	0	15	1254	1570	10	0	0	11126	12300	0	3
10	500	1	13371	66528	420000	0	0	281	281	302028	245000	0	21131	2111	3600	0	27	1283	1806	17	0	0	18527	21000	0	6
10	500	2	19514	66528	420000	0	0	706	706	302028	245000	0	15486	1731	3600	0	23	1333	1847	8	0	0	18528	21500	0	5
10	500	3	15281	66528	420000	0	0	499	499	302028	245000	0	19719	1431	3600	0	18	1123	1635	6	0	0	18524	19500	0	4
Avg									149						2040							0				3
Solved									27						17											27

Table EC.3 Computational results on `Long` instances with ten ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	928	9945	99000	0	0	5	5	57445	48600	0	0	36	36	0	11	444	570	18	0	0	6523	5100	0	0
6	100	2	1458	9945	99000	0	0	8	8	57445	48600	0	0	252	252	0	17	496	622	18	0	0	6525	5300	0	0
6	100	3	1173	9945	99000	0	0	6	6	57445	48600	0	0	288	288	0	14	489	619	22	0	0	6525	5300	0	1
6	300	1	7348	29745	297000	0	0	96	96	172245	145800	0	94	1926	3600	0	26	569	890	13	0	0	19540	20400	0	6
6	300	2	8555	29745	297000	0	0	99	99	172245	145800	0	118	1807	3600	0	14	513	829	8	0	0	19536	19200	0	8
6	300	3	8120	29745	297000	0	0	417	417	172245	145800	0	167	3139	3600	0	23	586	911	17	0	0	19540	20400	0	6
6	500	1	12388	49545	495000	0	0	814	814	287045	243000	0	14114	1324	3600	0	20	548	1072	16	0	0	32534	31000	0	12
6	500	2	12148	49545	495000	0	0	1066	1066	287045	243000	0	14852	2151	3600	0	21	621	1147	18	0	0	32543	35500	0	20
6	500	3	7590	49545	495000	0	0	675	675	287045	243000	0	18912	2002	3600	0	17	581	1112	23	0	0	32531	29500	0	7
8	100	1	3280	13545	132000	0	0	32	32	76845	64800	0	0	1293	1293	0	20	982	1122	32	0	0	6527	5500	0	0
8	100	2	3147	13545	132000	0	0	230	230	76845	64800	0	8	273	3600	0	28	1179	1311	24	0	0	6529	5700	0	0
8	100	3	2101	13545	132000	0	0	15	15	76845	64800	0	0	876	876	0	13	882	1014	24	0	0	6522	5000	0	1
8	300	1	8247	40545	396000	0	0	1011	1011	230445	194400	0	13055	1679	3600	0	34	1212	1535	15	0	0	19539	20100	0	9
8	300	2	4377	40545	396000	0	0	44	44	230445	194400	0	0	1009	1009	0	23	926	1258	24	0	0	19529	17100	0	3
8	300	3	11551	40545	396000	0	0	345	345	230445	194400	0	10049	1307	3600	0	36	1237	1564	19	0	0	19543	21300	0	18
8	500	1	14045	67545	660000	0	0	1545	1545	384045	324000	0	21457	2736	3600	0	29	974	1493	11	0	0	32533	30500	0	6
8	500	2	15207	67545	660000	0	0	1275	1275	384045	324000	0	20295	3600	3600	0	41	1154	1675	13	0	0	32539	33500	0	62
8	500	3	17102	67545	660000	0	0	1696	1696	384045	324000	0	18400	3600	3600	0	26	1166	1691	17	0	0	32539	33500	0	43
10	100	1	3937	17145	165000	0	0	376	376	96245	81000	0	53	3235	3600	0	35	1975	2106	23	0	0	6542	7000	0	4
10	100	2	4048	17145	165000	0	0	182	182	96245	81000	0	0	1184	1184	0	30	1596	1734	30	0	0	6532	6000	0	1
10	100	3	4173	17145	165000	0	0	232	232	96245	81000	0	120	3452	3600	0	31	1761	1893	24	0	0	6536	6400	0	2
10	300	1	12388	51345	495000	0	0	726	726	288645	243000	0	14314	1481	3600	0	30	1778	2104	18	0	0	19534	18600	0	14
10	300	2	12148	51345	495000	0	0	1473	1473	288645	243000	0	14852	2306	3600	0	43	2034	2354	12	0	0	19543	21300	0	16
10	300	3	7590	51345	495000	0	0	388	388	288645	243000	0	19112	1620	3600	0	25	1890	2227	29	0	0	19531	17700	0	8
10	500	1	11496	85545	825000	0	0	2170	2170	481045	405000	0	33006	3600	3600	0	34	1887	2412	17	0	0	32539	33500	0	15
10	500	2	20195	85545	825000	0	24805	244	3600	481045	405000	0	24307	3600	3600	0	31	1958	2485	19	0	0	32537	32500	0	19
10	500	3	10790	85545	825000	0	0	1465	1465	481045	405000	0	33712	3600	3600	0	20	1535	2064	21	0	0	32529	28500	0	19
Avg									740						2850							0				11
Solved									26						7											27

Table EC.4 Computational results on `Mixed` instances with six ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1864	5515	21000	0	0	1	1	19415	15000	0	0	8	8	0	1	206	312	2	0	0	1715	2100	0	0
6	100	2	2000	5515	21000	0	0	1	1	19415	15000	0	0	3	3	0	5	220	328	4	0	0	1715	2100	0	0
6	100	3	2135	5515	21000	0	0	1	1	19415	15000	0	0	3	3	0	4	223	332	5	0	0	1715	2100	0	0
6	300	1	5071	16515	63000	0	0	4	4	58215	45000	0	0	33	33	0	5	197	508	7	0	0	5115	6300	0	0
6	300	2	5550	16515	63000	0	0	5	5	58215	45000	0	0	24	24	0	5	207	515	4	0	0	5115	6300	0	0
6	300	3	4908	16515	63000	0	0	3	3	58215	45000	0	0	206	206	0	5	202	509	3	0	0	5115	6300	0	0
6	500	1	7892	27515	105000	0	0	7	7	97015	75000	0	0	898	898	0	4	192	699	3	0	0	8515	10500	0	0
6	500	2	8621	27515	105000	0	0	17	17	97015	75000	0	0	874	874	0	6	202	710	4	0	0	8515	10500	0	0
6	500	3	8254	27515	105000	0	0	13	13	97015	75000	0	0	703	703	0	4	187	695	4	0	0	8515	10500	0	0
8	100	1	3006	7515	28000	0	0	2	2	26015	20000	0	0	8	8	0	8	408	516	4	0	0	1715	2100	0	0
8	100	2	2954	7515	28000	0	0	2	2	26015	20000	0	0	30	30	0	9	414	521	3	0	0	1715	2100	0	0
8	100	3	2567	7515	28000	0	0	3	3	26015	20000	0	0	52	52	0	5	422	529	3	0	0	1715	2100	0	0
8	300	1	8648	22515	84000	0	0	8	8	78015	60000	0	0	266	266	0	3	386	694	4	0	0	5115	6300	0	0
8	300	2	7637	22515	84000	0	0	12	12	78015	60000	0	0	358	358	0	8	410	717	3	0	0	5115	6300	0	0
8	300	3	8496	22515	84000	0	0	10	10	78015	60000	0	0	64	64	0	4	436	745	5	0	0	5115	6300	0	0
8	500	1	12579	37515	140000	0	0	38	38	130015	100000	0	0	1423	1423	0	6	401	908	3	0	0	8515	10500	0	1
8	500	2	14258	37515	140000	0	0	23	23	130015	100000	0	0	2174	2174	0	8	406	913	3	0	0	8515	10500	0	0
8	500	3	12308	37515	140000	0	0	22	22	130015	100000	0	0	2132	2132	0	4	409	916	3	0	0	8515	10500	0	0
10	100	1	2945	9515	35000	0	0	3	3	32615	25000	0	0	145	145	0	7	660	767	3	0	0	1715	2100	0	0
10	100	2	2757	9515	35000	0	0	4	4	32615	25000	0	0	73	73	0	6	714	821	3	0	0	1715	2100	0	0
10	100	3	2988	9515	35000	0	0	3	3	32615	25000	0	0	97	97	0	11	691	799	4	0	0	1715	2100	0	0
10	300	1	7892	28515	105000	0	0	17	17	97815	75000	0	0	583	583	0	10	647	954	3	0	0	5115	6300	0	0
10	300	2	8621	28515	105000	0	0	27	27	97815	75000	0	0	691	691	0	15	680	988	4	0	0	5115	6300	0	1
10	300	3	8254	28515	105000	0	0	18	18	97815	75000	0	0	604	604	0	12	645	951	2	0	0	5115	6300	0	0
10	500	1	16049	47515	175000	0	0	78	78	163015	125000	0	0	3212	3212	0	12	697	1203	2	0	0	8515	10500	0	0
10	500	2	15591	47515	175000	0	0	66	66	163015	125000	0	0	3365	3365	0	12	689	1197	4	0	0	8515	10500	0	1
10	500	3	16561	47515	175000	0	0	41	41	163015	125000	0	0	1874	1874	0	15	715	1222	3	0	0	8515	10500	0	1
Avg									16						737							0				0
Solved									27						27											27

Table EC.5 Computational results on `Mixed` instances with eight ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1831	7728	50400	0	0	5	5	36028	29400	0	0	36	36	0	16	381	501	14	0	0	3727	4200	0	0
6	100	2	2102	7728	50400	0	0	5	5	36028	29400	0	0	134	134	0	13	331	447	10	0	0	3724	3900	0	0
6	100	3	2255	7728	50400	0	0	8	8	36028	29400	0	0	198	198	0	12	379	494	9	0	0	3727	4200	0	0
6	300	1	7423	23128	151200	0	0	21	21	108028	88200	0	0	772	772	0	9	293	605	6	0	0	11124	11700	0	1
6	300	2	6743	23128	151200	0	0	30	30	108028	88200	0	0	1664	1664	0	9	395	706	5	0	0	11128	12900	0	4
6	300	3	5812	23128	151200	0	0	44	44	108028	88200	0	0	2373	2373	0	15	392	703	5	0	0	11128	12900	0	2
6	500	1	10874	38528	252000	0	0	63	63	180028	147000	0	0	2721	2721	0	14	337	851	8	0	0	18525	20000	0	4
6	500	2	10427	38528	252000	0	0	106	106	180028	147000	0	10573	609	3600	0	11	376	887	5	0	0	18528	21500	0	4
6	500	3	11433	38528	252000	0	0	120	120	180028	147000	0	25	1766	3600	0	19	355	874	13	0	0	18527	21000	0	4
8	100	1	3045	10528	67200	0	0	19	19	48228	39200	0	0	378	378	0	15	761	878	11	0	0	3727	4200	0	2
8	100	2	2445	10528	67200	0	0	31	31	48228	39200	0	0	376	376	0	12	804	922	12	0	0	3726	4100	0	0
8	100	3	3162	10528	67200	0	0	12	12	48228	39200	0	0	307	307	0	11	717	829	6	0	0	3723	3800	0	0
8	300	1	9109	31528	201600	0	0	64	64	144628	117600	0	0	2967	2967	0	7	664	975	5	0	0	11123	11400	0	1
8	300	2	9289	31528	201600	0	0	106	106	144628	117600	0	11	2429	3600	0	6	814	1130	10	0	0	11127	12600	0	2
8	300	3	10183	31528	201600	0	0	82	82	144628	117600	0	0	2303	2303	0	17	707	1021	8	0	0	11125	12000	0	1
8	500	1	14395	52528	336000	0	0	182	182	241028	196000	0	13605	518	3600	0	19	675	1186	5	0	0	18524	19500	0	6
8	500	2	15810	52528	336000	0	0	170	170	241028	196000	0	12190	948	3600	0	22	796	1309	7	0	0	18528	21500	0	4
8	500	3	15912	52528	336000	0	0	161	161	241028	196000	0	81	2501	3600	0	14	671	1183	6	0	0	18522	18500	0	1
10	100	1	3459	13328	84000	0	0	19	19	60428	49000	0	0	700	700	0	31	1287	1404	11	0	0	3728	4300	0	1
10	100	2	3738	13328	84000	0	0	80	80	60428	49000	0	0	898	898	0	18	1278	1390	6	0	0	3727	4200	0	0
10	100	3	4048	13328	84000	0	0	38	38	60428	49000	0	0	943	943	0	30	1251	1368	11	0	0	3726	4100	0	1
10	300	1	10874	39928	252000	0	0	115	115	181228	147000	0	1	2610	2610	0	22	1116	1432	10	0	0	11125	12000	0	2
10	300	2	10427	39928	252000	0	0	347	347	181228	147000	0	10573	847	3600	0	32	1274	1585	5	0	0	11128	12900	0	2
10	300	3	11433	39928	252000	0	0	261	261	181228	147000	0	172	3386	3600	0	23	1215	1532	11	0	0	11127	12600	0	3
10	500	1	18883	66528	420000	0	0	444	444	302028	245000	0	15619	3034	3600	0	17	1328	1840	6	0	0	18527	21000	0	4
10	500	2	19612	66528	420000	0	0	550	550	302028	245000	0	15388	1507	3600	0	24	1305	1817	6	0	0	18528	21500	0	2
10	500	3	19702	66528	420000	0	0	360	360	302028	245000	0	15298	1895	3600	0	24	1346	1861	9	0	0	18528	21500	0	5
Avg									128						2184							0				2
Solved									27						15											27

Table EC.6 Computational results on `Mixed` instances with ten ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	2431	9945	99000	0	0	14	14	57445	48600	0	0	750	750	0	17	556	679	15	0	0	6534	6200	0	1
6	100	2	2505	9945	99000	0	0	15	15	57445	48600	0	0	2102	2102	0	12	545	665	12	0	0	6535	6300	0	2
6	100	3	2661	9945	99000	0	0	26	26	57445	48600	0	0	1470	1470	0	14	551	673	14	0	0	6533	6100	0	1
6	300	1	7901	29745	297000	0	0	214	214	172245	145800	0	8299	361	3600	0	27	536	858	14	0	0	19540	20400	0	7
6	300	2	9595	29745	297000	0	0	123	123	172245	145800	0	8	2214	3600	0	19	523	844	13	0	0	19536	19200	0	5
6	300	3	9251	29745	297000	0	0	77	77	172245	145800	0	0	3458	3458	0	16	540	859	11	0	0	19536	19200	0	8
6	500	1	12468	49545	495000	0	0	146	146	287045	243000	0	309	3528	3600	0	23	502	1025	15	0	0	32533	30500	0	15
6	500	2	12611	49545	495000	0	0	505	505	287045	243000	0	14389	1541	3600	0	25	561	1082	13	0	0	32540	34000	0	79
6	500	3	10748	49545	495000	0	0	731	731	287045	243000	0	15754	1832	3600	0	22	627	1151	16	0	0	32537	32500	0	10
8	100	1	3568	13545	132000	0	0	29	29	76845	64800	0	0	1842	1842	0	23	1072	1193	13	0	0	6532	6000	0	1
8	100	2	3008	13545	132000	0	0	107	107	76845	64800	0	14	2563	3600	0	34	1316	1447	23	0	0	6537	6500	0	3
8	100	3	3705	13545	132000	0	0	23	23	76845	64800	0	0	678	678	0	18	1069	1189	12	0	0	6532	6000	0	1
8	300	1	12422	40545	396000	0	0	160	160	230445	194400	0	8880	528	3600	0	30	1095	1415	12	0	0	19536	19200	0	10
8	300	2	10823	40545	396000	0	0	262	262	230445	194400	0	10479	737	3600	0	26	1104	1428	16	0	0	19537	19500	0	6
8	300	3	12944	40545	396000	0	0	164	164	230445	194400	0	334	3356	3600	0	25	1019	1339	12	0	0	19535	18900	0	9
8	500	1	18545	67545	660000	0	0	1052	1052	384045	324000	0	16957	2801	3600	0	28	1175	1692	9	0	0	32539	33500	0	26
8	500	2	20504	67545	660000	0	0	648	648	384045	324000	0	15087	2249	3600	0	32	1111	1629	10	0	0	32539	33500	0	15
8	500	3	17483	67545	660000	0	0	858	858	384045	324000	0	18019	3058	3600	0	29	1222	1754	24	0	0	32541	34500	0	36
10	100	1	4538	17145	165000	0	0	109	109	96245	81000	0	415	1737	3600	0	46	1935	2064	21	0	0	6538	6600	0	2
10	100	2	4835	17145	165000	0	0	189	189	96245	81000	0	0	1824	1824	0	23	1732	1855	15	0	0	6536	6400	0	1
10	100	3	4674	17145	165000	0	0	147	147	96245	81000	0	82	2713	3600	0	25	1685	1814	21	0	0	6535	6300	0	1
10	300	1	12468	51345	495000	0	0	473	473	288645	243000	0	14234	945	3600	0	32	1635	1958	15	0	0	19533	18300	0	6
10	300	2	12611	51345	495000	0	0	1991	1991	288645	243000	0	14389	1461	3600	0	44	1861	2183	14	0	0	19540	20400	0	9
10	300	3	10748	51345	495000	0	0	524	524	288645	243000	0	15954	1836	3600	0	41	2059	2393	26	0	1	19537	19500	0	13
10	500	1	22761	85545	825000	0	0	1557	1557	481045	405000	0	21741	2676	3600	0	27	1828	2348	12	0	0	32538	33000	0	19
10	500	2	18709	85545	825000	0	0	2405	2405	481045	405000	0	25793	3600	3600	0	37	1852	2375	15	0	1	32537	32500	0	23
10	500	3	19296	85545	825000	0	0	1646	1646	481045	405000	0	25206	3600	3600	0	43	2133	2660	19	0	1	32541	34500	0	15
Avg									526						3116							0				12
Solved									27						7											27

Table EC.7 Computational results on `Short` instances with six ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	2245	5515	21000	0	0	1	1	19415	15000	0	0	5	5	0	8	182	294	8	0	0	1715	2100	0	0
6	100	2	2168	5515	21000	0	0	1	1	19415	15000	0	0	4	4	0	4	202	312	6	0	0	1715	2100	0	0
6	100	3	2244	5515	21000	0	0	2	2	19415	15000	0	0	4	4	0	4	198	310	8	0	0	1714	2000	0	0
6	300	1	5294	16515	63000	0	0	3	3	58215	45000	0	0	30	30	0	4	202	511	5	0	0	5115	6300	0	0
6	300	2	5640	16515	63000	0	0	5	5	58215	45000	0	0	35	35	0	8	184	492	4	0	0	5115	6300	0	0
6	300	3	6370	16515	63000	0	0	3	3	58215	45000	0	0	23	23	0	7	196	507	7	0	0	5114	6000	0	0
6	500	1	11071	27515	105000	0	0	9	9	97015	75000	0	0	88	88	0	11	214	723	5	0	0	8515	10500	0	1
6	500	2	10610	27515	105000	0	0	8	8	97015	75000	0	0	50	50	0	7	189	696	3	0	0	8515	10500	0	1
6	500	3	11470	27515	105000	0	0	5	5	97015	75000	0	0	78	78	0	3	193	702	5	0	0	8515	10500	0	1
8	100	1	2577	7515	28000	0	0	2	2	26015	20000	0	0	9	9	0	6	386	498	8	0	0	1715	2100	0	0
8	100	2	3341	7515	28000	0	0	1	1	26015	20000	0	0	6	6	0	4	422	530	4	0	0	1715	2100	0	0
8	100	3	2996	7515	28000	0	0	2	2	26015	20000	0	0	8	8	0	10	402	512	6	0	0	1715	2100	0	0
8	300	1	9170	22515	84000	0	0	7	7	78015	60000	0	0	41	41	0	10	401	710	5	0	0	5115	6300	0	0
8	300	2	9585	22515	84000	0	0	8	8	78015	60000	0	0	34	34	0	9	386	694	4	0	0	5115	6300	0	0
8	300	3	9458	22515	84000	0	0	7	7	78015	60000	0	0	39	39	0	9	410	722	8	0	0	5115	6300	0	0
8	500	1	12897	37515	140000	0	0	29	29	130015	100000	0	0	2000	2000	0	11	389	896	3	0	0	8515	10500	0	0
8	500	2	13337	37515	140000	0	0	24	24	130015	100000	0	0	641	641	0	9	398	905	3	0	0	8514	10000	0	0
8	500	3	10725	37515	140000	0	0	40	40	130015	100000	0	0	1195	1195	0	8	416	924	4	0	0	8515	10500	0	0
10	100	1	3584	9515	35000	0	0	4	4	32615	25000	0	0	15	15	0	11	691	801	6	0	0	1715	2100	0	0
10	100	2	3599	9515	35000	0	0	8	8	32615	25000	0	0	52	52	0	8	663	773	6	0	0	1715	2100	0	0
10	100	3	2993	9515	35000	0	0	5	5	32615	25000	0	0	85	85	0	4	684	793	5	0	0	1715	2100	0	0
10	300	1	11071	28515	105000	0	0	14	14	97815	75000	0	0	129	129	0	12	693	1002	5	0	0	5115	6300	0	0
10	300	2	10610	28515	105000	0	0	23	23	97815	75000	0	0	496	496	0	14	647	954	3	0	0	5115	6300	0	0
10	300	3	11470	28515	105000	0	0	21	21	97815	75000	0	0	616	616	0	5	661	969	4	0	0	5115	6300	0	0
10	500	1	15886	47515	175000	0	0	68	68	163015	125000	0	0	3545	3545	0	8	704	1212	4	0	0	8515	10500	0	1
10	500	2	18987	47515	175000	0	0	40	40	163015	125000	0	0	1990	1990	0	5	680	1187	3	0	0	8515	10500	0	0
10	500	3	20973	47515	175000	0	0	86	86	163015	125000	0	0	1100	1100	0	12	686	1193	3	0	0	8515	10500	0	0
Avg									16						456							0				0
Solved									27						27											27

Table EC.8 Computational results on `Short` instances with eight ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	2630	7728	50400	0	0	7	7	36028	29400	0	0	143	143	0	9	397	516	13	0	0	3726	4100	0	0
6	100	2	3111	7728	50400	0	0	3	3	36028	29400	0	0	11	11	0	11	339	459	14	0	0	3723	3800	0	0
6	100	3	2590	7728	50400	0	0	14	14	36028	29400	0	0	125	125	0	9	393	512	13	0	0	3728	4300	0	0
6	300	1	8677	23128	151200	0	0	35	35	108028	88200	0	0	114	114	0	22	374	689	9	0	0	11128	12900	0	1
6	300	2	8117	23128	151200	0	0	25	25	108028	88200	0	0	1135	1135	0	11	388	700	6	0	0	11127	12600	0	2
6	300	3	8516	23128	151200	0	0	77	77	108028	88200	0	0	736	736	0	11	369	688	13	0	0	11127	12600	0	1
6	500	1	12226	38528	252000	0	0	77	77	180028	147000	0	95	1854	3600	0	7	420	930	4	0	0	18528	21500	0	6
6	500	2	12050	38528	252000	0	0	94	94	180028	147000	0	155	1340	3600	0	16	405	918	7	0	0	18528	21500	0	4
6	500	3	13138	38528	252000	0	0	77	77	180028	147000	0	0	453	453	0	11	372	887	9	0	0	18527	21000	0	3
8	100	1	3763	10528	67200	0	0	14	14	48228	39200	0	0	281	281	0	18	720	845	19	0	0	3726	4100	0	0
8	100	2	3096	10528	67200	0	0	15	15	48228	39200	0	0	597	597	0	26	795	910	9	0	0	3725	4000	0	0
8	100	3	2883	10528	67200	0	0	13	13	48228	39200	0	0	559	559	0	10	789	909	14	0	0	3727	4200	0	0
8	300	1	9773	31528	201600	0	0	78	78	144628	117600	0	0	3444	3444	0	17	722	1039	11	0	0	11126	12300	0	2
8	300	2	12708	31528	201600	0	0	42	42	144628	117600	0	0	1849	1849	0	12	755	1070	9	0	0	11128	12900	0	2
8	300	3	9535	31528	201600	0	0	83	83	144628	117600	0	0	2807	2807	0	16	779	1095	10	0	0	11128	12900	0	1
8	500	1	16835	52528	336000	0	0	258	258	241028	196000	0	11165	674	3600	0	13	771	1287	10	0	0	18528	21500	0	4
8	500	2	16908	52528	336000	0	0	220	220	241028	196000	0	11092	657	3600	0	17	796	1308	6	0	0	18528	21500	0	4
8	500	3	19633	52528	336000	0	0	155	155	241028	196000	0	13	1213	3600	0	16	781	1297	10	0	0	18528	21500	0	3
10	100	1	4968	13328	84000	0	0	14	14	60428	49000	0	0	85	85	0	12	998	1113	9	0	0	3722	3700	0	0
10	100	2	4604	13328	84000	0	0	16	16	60428	49000	0	0	590	590	0	20	1334	1455	15	0	0	3724	3900	0	0
10	100	3	4271	13328	84000	0	0	27	27	60428	49000	0	0	1005	1005	0	18	1271	1389	12	0	0	3728	4300	0	1
10	300	1	12226	39928	252000	0	0	186	186	181228	147000	0	8774	488	3600	0	18	1335	1647	6	0	0	11128	12900	0	3
10	300	2	12050	39928	252000	0	0	171	171	181228	147000	0	147	2738	3600	0	17	1348	1663	9	0	0	11128	12900	0	1
10	300	3	13138	39928	252000	0	0	228	228	181228	147000	0	5	621	3600	0	23	1269	1590	15	0	0	11127	12600	0	2
10	500	1	24410	66528	420000	0	0	628	628	302028	245000	0	10590	1921	3600	0	13	1297	1808	5	0	0	18528	21500	0	4
10	500	2	20795	66528	420000	0	0	395	395	302028	245000	0	14205	1680	3600	0	21	1320	1833	7	0	0	18528	21500	0	6
10	500	3	22122	66528	420000	0	0	367	367	302028	245000	0	12878	1012	3600	0	13	1291	1804	7	0	0	18528	21500	0	4
Avg									123						1983							0				2
Solved									27						16											27

Table EC.9 Computational results on `Short` instances with ten ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	3409	9945	99000	0	0	8	8	57445	48600	0	0	133	133	0	10	442	559	9	0	0	6531	5900	0	0
6	100	2	3441	9945	99000	0	0	31	31	57445	48600	0	34	2637	3600	0	17	674	805	23	0	0	6542	7000	0	1
6	100	3	3414	9945	99000	0	0	62	62	57445	48600	0	0	314	314	0	16	597	727	22	0	0	6539	6700	0	2
6	300	1	10243	29745	297000	0	0	120	120	172245	145800	0	0	3253	3253	0	20	625	949	16	0	0	19543	21300	0	9
6	300	2	9981	29745	297000	0	0	236	236	172245	145800	0	22	1809	3600	0	21	645	970	17	0	0	19542	21000	0	4
6	300	3	9956	29745	297000	0	0	320	320	172245	145800	0	52	1256	3600	0	27	643	963	12	0	0	19544	21600	0	5
6	500	1	16917	49545	495000	0	0	291	291	287045	243000	0	10083	1105	3600	0	28	597	1118	13	0	0	32543	35500	0	14
6	500	2	15763	49545	495000	0	0	528	528	287045	243000	0	111	3206	3600	0	19	664	1185	13	0	0	32543	35500	0	17
6	500	3	17155	49545	495000	0	0	131	131	287045	243000	0	9347	922	3600	0	20	563	1084	13	0	0	32538	33000	0	23
8	100	1	3538	13545	132000	0	0	51	51	76845	64800	0	2	2875	3600	0	25	1243	1376	25	0	0	6539	6700	0	1
8	100	2	4670	13545	132000	0	0	65	65	76845	64800	0	0	3482	3482	0	26	1287	1417	22	0	0	6541	6900	0	1
8	100	3	4687	13545	132000	0	0	31	31	76845	64800	0	0	1875	1875	0	22	1069	1197	20	0	0	6539	6700	0	1
8	300	1	11972	40545	396000	0	0	1102	1102	230445	194400	0	9628	1318	3600	0	21	1290	1613	15	0	0	19545	21900	0	13
8	300	2	14041	40545	396000	0	0	179	179	230445	194400	0	7559	555	3600	0	35	1219	1541	14	0	0	19540	20400	0	6
8	300	3	12516	40545	396000	0	0	1323	1323	230445	194400	0	8786	817	3600	0	27	1287	1615	20	0	0	19543	21300	0	6
8	500	1	21188	67545	660000	0	0	2871	2871	384045	324000	0	14314	3447	3600	0	18	1317	1839	14	0	0	32544	36000	0	19
8	500	2	19100	67545	660000	0	0	1666	1666	384045	324000	0	16402	2183	3600	0	33	1279	1806	19	0	0	32543	35500	0	18
8	500	3	22408	67545	660000	0	0	2271	2271	384045	324000	0	13094	3160	3600	0	28	1305	1828	15	0	1	32544	36000	0	33
10	100	1	5434	17145	165000	0	0	90	90	96245	81000	0	468	3135	3600	0	46	2008	2135	19	0	0	6541	6900	0	1
10	100	2	6244	17145	165000	0	0	36	36	96245	81000	0	0	1480	1480	0	32	1674	1804	22	0	0	6536	6400	0	1
10	100	3	5173	17145	165000	0	0	606	606	96245	81000	0	0	2895	2895	0	41	2097	2229	24	0	1	6541	6900	0	2
10	300	1	16917	51345	495000	0	0	660	660	288645	243000	0	10083	1204	3600	0	30	2022	2343	13	0	0	19543	21300	0	11
10	300	2	15763	51345	495000	0	0	1656	1656	288645	243000	0	10939	1612	3600	0	41	2181	2505	16	0	1	19543	21300	0	11
10	300	3	17155	51345	495000	0	0	561	561	288645	243000	0	9547	875	3600	0	36	1852	2178	18	0	0	19538	19800	0	7
10	500	1	29029	85545	825000	0	0	642	642	481045	405000	0	15971	2753	3600	0	39	1986	2511	17	0	0	32543	35500	0	15
10	500	2	28929	85545	825000	0	0	762	762	481045	405000	0	16071	3600	3600	0	30	2099	2623	16	0	2	32544	36000	0	19
10	500	3	26654	85545	825000	0	18346	265	3600	481045	405000	0	18346	3600	3600	0	35	2169	2692	15	0	1	32545	36500	0	14
Avg									737						3164							0				9
Solved									26						7											27

Table EC.10 Computational results on `Authentic` instances with six ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1247	5515	21000	0	0	1	1	19415	15000	0	0	4	4	0	4	200	308	4	0	0	1715	2100	0	0
6	100	2	1523	5515	21000	0	0	1	1	19415	15000	0	0	18	18	0	9	215	323	4	0	0	1715	2100	0	0
6	100	3	1778	5515	21000	0	0	1	1	19415	15000	0	0	4	4	0	5	195	306	7	0	0	1714	2000	0	0
6	300	1	3871	16515	63000	0	0	3	3	58215	45000	0	0	21	21	0	6	190	497	3	0	0	5115	6300	0	0
6	300	2	3495	16515	63000	0	0	2	2	58215	45000	0	0	21	21	0	4	219	527	4	0	0	5115	6300	0	0
6	300	3	3530	16515	63000	0	0	2	2	58215	45000	0	0	13	13	0	6	218	525	3	0	0	5115	6300	0	0
6	500	1	7892	27515	105000	0	0	25	25	97015	75000	0	0	64	64	0	7	198	707	5	0	0	8515	10500	0	1
6	500	2	8703	27515	105000	0	0	23	23	97015	75000	0	0	139	139	0	7	202	712	6	0	0	8515	10500	0	0
6	500	3	7071	27515	105000	0	0	14	14	97015	75000	0	0	581	581	0	7	193	701	4	0	0	8515	10500	0	1
8	100	1	1935	7515	28000	0	0	2	2	26015	20000	0	0	12	12	0	9	393	503	6	0	0	1715	2100	0	0
8	100	2	1854	7515	28000	0	0	6	6	26015	20000	0	0	61	61	0	8	408	517	5	0	0	1715	2100	0	0
8	100	3	1515	7515	28000	0	0	2	2	26015	20000	0	0	11	11	0	8	420	528	4	0	0	1715	2100	0	0
8	300	1	6871	22515	84000	0	0	10	10	78015	60000	0	0	334	334	0	7	415	722	3	0	0	5115	6300	0	1
8	300	2	6108	22515	84000	0	0	12	12	78015	60000	0	0	410	410	0	3	404	711	3	0	0	5115	6300	0	1
8	300	3	5704	22515	84000	0	0	12	12	78015	60000	0	0	56	56	0	7	415	722	3	0	0	5115	6300	0	0
8	500	1	8530	37515	140000	0	0	22	22	130015	100000	0	0	2289	2289	0	12	404	911	3	0	0	8515	10500	0	1
8	500	2	8410	37515	140000	0	0	22	22	130015	100000	0	0	1964	1964	0	13	399	907	4	0	0	8515	10500	0	1
8	500	3	8310	37515	140000	0	0	20	20	130015	100000	0	0	252	252	0	9	406	916	6	0	0	8515	10500	0	0
10	100	1	1717	9515	35000	0	0	3	3	32615	25000	0	0	20	20	0	9	660	773	9	0	0	1715	2100	0	0
10	100	2	2337	9515	35000	0	0	6	6	32615	25000	0	0	93	93	0	5	664	772	4	0	0	1715	2100	0	0
10	100	3	1735	9515	35000	0	0	3	3	32615	25000	0	0	13	13	0	11	644	754	6	0	0	1715	2100	0	0
10	300	1	7892	28515	105000	0	0	30	30	97815	75000	0	0	905	905	0	5	664	973	5	0	0	5115	6300	0	0
10	300	2	8703	28515	105000	0	0	59	59	97815	75000	0	0	2210	2210	0	9	656	967	7	0	0	5115	6300	0	0
10	300	3	7071	28515	105000	0	0	29	29	97815	75000	0	0	682	682	0	12	659	966	3	0	0	5115	6300	0	0
10	500	1	11267	47515	175000	0	0	54	54	163015	125000	0	0	2519	2519	0	11	676	1185	5	0	0	8515	10500	0	1
10	500	2	9589	47515	175000	0	0	70	70	163015	125000	0	15411	849	3600	0	6	681	1191	6	0	0	8515	10500	0	1
10	500	3	12434	47515	175000	0	0	80	80	163015	125000	0	12566	214	3600	0	9	663	1170	3	0	0	8515	10500	0	1
Avg									19						737							0				0
Solved									27						25											27

Table EC.11 Computational results on `Authentic` instances with eight ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1651	7728	50400	0	0	20	20	36028	29400	0	0	365	365	0	11	378	497	13	0	0	3725	4000	0	0
6	100	2	1644	7728	50400	0	0	12	12	36028	29400	0	0	223	223	0	11	414	533	13	0	0	3727	4200	0	0
6	100	3	1628	7728	50400	0	0	7	7	36028	29400	0	0	206	206	0	12	375	490	9	0	0	3727	4200	0	0
6	300	1	5598	23128	151200	0	0	52	52	108028	88200	0	0	2095	2095	0	10	423	732	3	0	0	11128	12900	0	2
6	300	2	4795	23128	151200	0	0	49	49	108028	88200	0	0	2673	2673	0	8	387	701	8	0	0	11127	12600	0	2
6	300	3	5124	23128	151200	0	0	49	49	108028	88200	0	0	2141	2141	0	10	377	688	5	0	0	11128	12900	0	2
6	500	1	5704	38528	252000	0	0	69	69	180028	147000	0	134	1287	3600	0	10	399	912	7	0	0	18528	21500	0	4
6	500	2	8865	38528	252000	0	0	93	93	180028	147000	0	147	1596	3600	0	4	357	869	6	0	0	18527	21000	0	10
6	500	3	5208	38528	252000	0	0	47	47	180028	147000	0	0	861	861	0	11	396	911	9	0	0	18528	21500	0	3
8	100	1	2265	10528	67200	0	0	77	77	48228	39200	0	0	537	537	0	16	773	893	14	0	0	3728	4300	0	0
8	100	2	1734	10528	67200	0	0	253	253	48228	39200	0	0	504	504	0	17	827	951	18	0	0	3721	3600	0	0
8	100	3	2676	10528	67200	0	0	20	20	48228	39200	0	0	683	683	0	17	756	875	13	0	0	3727	4200	0	0
8	300	1	5928	31528	201600	0	0	78	78	144628	117600	0	77	2517	3600	0	15	802	1117	9	0	0	11128	12900	0	2
8	300	2	6393	31528	201600	0	0	167	167	144628	117600	0	0	3513	3513	0	18	783	1097	8	0	0	11128	12900	0	3
8	300	3	6184	31528	201600	0	0	200	200	144628	117600	0	3	3345	3600	0	15	754	1070	10	0	0	11128	12900	0	4
8	500	1	9545	52528	336000	0	0	152	152	241028	196000	0	18455	1151	3600	0	18	800	1312	6	0	0	18528	21500	0	6
8	500	2	10455	52528	336000	0	0	349	349	241028	196000	0	17545	1175	3600	0	7	800	1313	7	0	0	18528	21500	0	5
8	500	3	11667	52528	336000	0	0	387	387	241028	196000	0	15835	1303	3600	0	15	787	1301	8	0	0	18526	20500	0	6
10	100	1	2679	13328	84000	0	0	55	55	60428	49000	0	0	1976	1976	0	23	1285	1409	18	0	0	3727	4200	0	0
10	100	2	2540	13328	84000	0	0	77	77	60428	49000	0	0	1455	1455	0	20	1299	1425	20	0	0	3728	4300	0	1
10	100	3	2913	13328	84000	0	0	90	90	60428	49000	0	0	726	726	0	18	1263	1383	14	0	0	3726	4100	0	0
10	300	1	5704	39928	252000	0	0	202	202	181228	147000	0	331	3121	3600	0	28	1317	1631	8	0	0	11128	12900	0	6
10	300	2	8865	39928	252000	0	0	264	264	181228	147000	0	414	3146	3600	0	17	1258	1569	5	0	0	11127	12600	0	1
10	300	3	5208	39928	252000	0	0	67	67	181228	147000	0	153	3010	3600	0	13	1326	1646	14	0	0	11128	12900	0	3
10	500	1	10266	66528	420000	0	0	447	447	302028	245000	0	24236	1932	3600	0	16	1265	1776	5	0	0	18527	21000	0	5
10	500	2	12955	66528	420000	0	0	433	433	302028	245000	0	22045	2612	3600	0	23	1245	1754	3	0	0	18528	21500	0	5
10	500	3	13868	66528	420000	0	0	591	591	302028	245000	0	21132	2468	3600	0	26	1285	1798	7	0	0	18528	21500	0	7
Avg									159						2398							0				3
Solved									27						14											27

Table EC.12 Computational results on `Authentic` instances with ten ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1874	9945	99000	0	0	72	72	57445	48600	0	0	1913	1913	0	15	645	775	22	0	0	6538	6600	0	1
6	100	2	1724	9945	99000	0	0	104	104	57445	48600	0	0	1284	1284	0	12	672	811	31	0	0	6538	6600	0	1
6	100	3	1764	9945	99000	0	0	51	51	57445	48600	0	0	1932	1932	0	14	661	791	22	0	0	6540	6800	0	2
6	300	1	4588	29745	297000	0	2	367	3600	172245	145800	0	25	1617	3600	0	15	631	967	28	0	0	19541	20700	0	11
6	300	2	4960	29745	297000	0	0	660	660	172245	145800	0	236	3427	3600	0	17	725	1047	14	0	0	19543	21300	0	40
6	300	3	5444	29745	297000	0	0	319	319	172245	145800	0	10458	1105	3600	0	18	611	931	12	0	0	19544	21600	0	152
6	500	1	8203	49545	495000	0	0	1540	1540	287045	243000	0	18797	3508	3600	0	26	625	1139	6	0	0	32545	36500	0	30
6	500	2	10320	49545	495000	0	0	1668	1668	287045	243000	0	16680	2661	3600	0	21	622	1138	8	0	0	32544	36000	0	19
6	500	3	8263	49545	495000	0	0	1261	1261	287045	243000	0	18737	2018	3600	0	17	611	1127	8	0	0	32545	36500	0	51
8	100	1	2162	13545	132000	0	0	101	101	76845	64800	0	0	3477	3477	0	30	1264	1407	35	0	1	6543	7100	0	2
8	100	2	1960	13545	132000	0	0	98	98	76845	64800	0	0	3579	3579	0	31	1308	1446	30	0	1	6545	7300	0	2
8	100	3	2428	13545	132000	0	0	153	153	76845	64800	0	0	2900	2900	0	25	1297	1425	20	0	0	6540	6800	0	3
8	300	1	5675	40545	396000	0	0	1698	1698	230445	194400	0	15925	1484	3600	0	29	1273	1598	17	0	0	19545	21900	0	20
8	300	2	6403	40545	396000	0	0	1284	1284	230445	194400	0	14899	1330	3600	0	24	1297	1628	23	0	1	19542	21000	0	45
8	300	3	7159	40545	396000	0	0	2360	2360	230445	194400	0	14441	1718	3600	0	28	1267	1584	9	0	1	19545	21900	0	9
8	500	1	12323	67545	660000	0	0	2098	2098	384045	324000	0	23179	3600	3600	0	18	1280	1801	13	0	0	32539	33500	0	14
8	500	2	10825	67545	660000	0	0	2475	2475	384045	324000	0	25175	3600	3600	0	34	1282	1804	14	0	0	32545	36500	0	30
8	500	3	10644	67545	660000	0	0	1937	1937	384045	324000	0	24858	3600	3600	0	22	1257	1774	9	0	0	32544	36000	0	40
10	100	1	2572	17145	165000	0	0	118	118	96245	81000	0	25	3085	3600	0	45	2227	2369	34	0	1	6545	7300	0	10
10	100	2	2640	17145	165000	0	0	308	308	96245	81000	0	0	2939	2939	0	41	2141	2286	37	0	1	6545	7300	0	9
10	100	3	2706	17145	165000	0	0	106	106	96245	81000	0	0	3510	3510	0	28	2104	2236	24	0	1	6543	7100	0	3
10	300	1	8203	51345	495000	0	0	1190	1190	288645	243000	0	18797	2161	3600	0	32	2101	2417	8	0	1	19545	21900	0	143
10	300	2	10320	51345	495000	0	0	748	748	288645	243000	0	16680	1699	3600	0	27	2059	2374	7	0	1	19544	21600	0	64
10	300	3	8263	51345	495000	0	0	1179	1179	288645	243000	0	18737	2137	3600	0	46	2060	2383	15	0	1	19545	21900	0	15
10	500	1	14473	85545	825000	0	30527	263	3600	481045	405000	0	30527	3600	3600	0	22	2134	2650	8	0	2	32545	36500	0	29
10	500	2	16311	85545	825000	0	0	2396	2396	481045	405000	0	28689	3600	3600	0	38	2137	2656	11	0	3	32545	36500	0	35
10	500	3	13458	85545	825000	0	0	2027	2027	481045	405000	0	31044	3600	3600	0	23	2148	2677	21	0	3	32541	34500	0	24
Avg									1228						3331							1				30
Solved									25						8											27

Table EC.13 Computational results on `Required` instances with six ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1934	5515	21000	2	2	53	53	19415	15000	2	2	9	9	2	4	151	260	3	2	0	1975	1622	2	0
6	100	2	1468	5515	21000	1	1	1	1	19415	15000	1	1	161	161	1	3	150	263	5	1	0	1852	1815	1	0
6	100	3	1704	5515	21000	2	2	61	61	19415	15000	0	2	4	3600	2	6	214	329	6	2	0	1982	1920	2	0
6	300	1	4382	16515	63000	0	2	7	3600	58215	45000	0	2	16	3600	2	4	169	480	4	2	0	5381	5319	2	195
6	300	2	5400	16515	63000	6	6	255	255	58215	45000	6	6	54	54	3	6	104	414	5	6	0	5884	4257	6	1
6	300	3	4383	16515	63000	4	4	893	893	58215	45000	0	4	30	3600	2	4	172	489	7	4	0	5632	4635	4	0
6	500	1	8568	27515	105000	2	2	2452	2452	97015	75000	0	2	128	3600	2	3	170	679	3	2	0	8781	8719	2	4
6	500	2	7477	27515	105000	3	3	1144	1144	97015	75000	2	3	993	3600	3	3	156	661	1	3	0	8905	7330	3	19
6	500	3	7766	27515	105000	1	1	1708	1708	97015	75000	0	1	52	3600	1	5	175	688	5	1	0	8654	8617	1	9
8	100	1	2357	7515	28000	3	3	171	171	26015	20000	0	3	3	3600	3	6	328	443	6	3	0	2259	2142	3	6
8	100	2	1818	7515	28000	3	3	248	248	26015	20000	1	3	11	3600	3	5	380	501	9	3	0	2260	2143	3	1
8	100	3	1715	7515	28000	1	1	102	102	26015	20000	0	1	56	3600	1	2	372	485	5	1	0	1904	1857	1	1
8	300	1	7241	22515	84000	0	3	12	3600	78015	60000	0	3	43	3600	3	6	326	633	2	3	0	5659	5542	3	12
8	300	2	7200	22515	84000	6	6	495	495	78015	60000	6	6	453	453	3	6	208	520	5	6	0	6184	4497	6	1
8	300	3	5163	22515	84000	1	1	486	486	78015	60000	0	1	57	3600	1	5	375	690	6	1	0	5304	5257	1	3
8	500	1	8515	37515	140000	0	2	25	3600	130015	100000	0	2	259	3600	2	7	360	873	5	2	0	8882	8800	2	6
8	500	2	11856	37515	140000	3	3	2663	2663	130015	100000	0	3	105	3600	3	7	370	883	5	3	0	9060	8943	3	4
8	500	3	11772	37515	140000	0	1	22	3600	130015	100000	0	1	1261	3600	1	5	347	858	4	1	0	8703	8656	1	648
10	100	1	2165	9515	35000	2	2	454	454	32615	25000	0	2	17	3600	2	11	691	810	8	2	0	2182	2080	2	7
10	100	2	2743	9515	35000	5	5	110	110	32615	25000	5	5	38	38	5	10	559	691	15	5	0	2861	2342	5	9
10	100	3	2207	9515	35000	1	1	23	23	32615	25000	1	1	48	48	1	1	469	574	1	1	0	1948	1597	1	0
10	300	1	8568	28515	105000	4	4	1317	1317	97815	75000	0	4	2438	3600	4	5	575	882	2	4	0	6037	5845	4	3
10	300	2	6942	28515	105000	0	2	12	3600	97815	75000	0	2	80	3600	2	9	604	915	4	2	0	5582	5480	2	1
10	300	3	7766	28515	105000	1	1	733	733	97815	75000	0	1	50	3600	1	9	611	926	6	1	0	5354	5297	1	3
10	500	1	11097	47515	175000	1	1	23	23	163015	125000	0	1	137	137	1	5	452	959	2	1	0	8748	7197	1	1
10	500	2	13105	47515	175000	0	2	28	3600	163015	125000	0	2	193	3600	2	7	606	1119	5	2	0	8982	8880	2	377
10	500	3	11618	47515	175000	0	4	28	3600	163015	125000	0	6	1849	3600	4	10	620	1139	8	4	0	9438	9246	4	7
Avg									1429						2700							0				49
Solved									20						7											27

Table EC.14 Computational results on `Required` instances with eight ports

				AP93						DC15						This Paper									
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1970	7728	50400	0	2	3	3600	36028	29400	0	2	219	3600	2	15	345	474	13	2	0	4161	3971	2	12
6	100	2	1551	7728	50400	1	1	91	91	36028	29400	0	1	815	3600	1	9	373	510	16	1	0	3958	3900	1	4
6	100	3	1758	7728	50400	0	3	103	3600	36028	29400	0	3	898	3600	3	13	368	501	14	3	0	4373	4245	3	380
6	300	1	4708	23128	151200	1	1	1423	1423	108028	88200	0	2	1624	3600	1	11	416	735	7	1	0	11358	11300	1	26
6	300	2	5455	23128	151200	0	3	21	3600	108028	88200	0	3	1260	3600	3	12	378	695	6	3	0	11772	11644	3	58
6	300	3	5616	23128	151200	0	3	19	3600	108028	88200	0	3	477	3600	3	10	354	671	6	3	0	11770	11346	3	58
6	500	1	9241	38528	252000	3	3	3528	3528	180028	147000	0	4	445	3600	3	7	340	975	44	3	0	19160	14568	3	2407
6	500	2	9411	38528	252000	0	2	7	3600	180028	147000	0	2	185	3600	1	2	209	726	6	2	0	18948	14382	2	6
6	500	3	7214	38528	252000	0	5	44	3600	180028	147000	0	124	1571	3600	3	13	339	854	5	3	0	19173	19045	3	106
8	100	1	1921	10528	67200	1	1	25	25	48228	39200	0	1	558	3600	1	8	626	769	19	1	0	4032	3470	1	1
8	100	2	2469	10528	67200	2	3	18	3600	48228	39200	0	3	32	3600	2	13	733	896	27	3	1	4619	3969	3	158
8	100	3	2506	10528	67200	0	3	306	3600	48228	39200	0	3	870	3600	3	17	700	823	9	3	0	4622	4356	3	45
8	300	1	6072	31528	201600	0	4	2841	3600	144628	117600	0	11	320	3600	4	13	685	1018	14	4	0	12310	10616	4	3496
8	300	2	6763	31528	201600	0	5	2095	3600	144628	117600	0	21	1670	3600	3	11	728	1047	7	3	0	12024	11854	3	84
8	300	3	6508	31528	201600	0	5	60	3600	144628	117600	0	17	3112	3600	4	12	645	1017	28	4	0	12310	10616	8	3600
8	500	1	10054	52528	336000	0	2	318	3600	241028	196000	0	17448	946	3600	2	15	757	1273	6	2	0	19134	19013	3	3600
8	500	2	10612	52528	336000	0	3	471	3600	241028	196000	0	176	3242	3600	3	12	784	1297	4	3	0	19426	19256	3	477
8	500	3	11483	52528	336000	0	4	181	3600	241028	196000	0	141	3169	3600	3	16	652	1216	25	3	0	19418	16768	4	3600
10	100	1	2827	13328	84000	4	4	1727	1727	60428	49000	0	4	3268	3600	4	29	1213	1346	14	4	0	5253	4883	4	207
10	100	2	2900	13328	84000	0	6	482	3600	60428	49000	0	6	2916	3600	5	13	1074	1234	25	5	0	5622	4814	6	3600
10	100	3	3153	13328	84000	0	8	7	3600	60428	49000	0	8	2235	3600	4	13	835	965	13	8	1	6740	5394	8	3
10	300	1	9241	39928	252000	0	11	46	3600	181228	147000	0	9	234	3600	5	13	1062	1487	41	8	2	14144	10998	13	3600
10	300	2	9411	39928	252000	0	6	1130	3600	181228	147000	0	7	78	3600	3	10	758	1080	9	6	1	13388	10350	6	30
10	300	3	7214	39928	252000	0	1	198	3600	181228	147000	0	474	1409	3600	1	10	1166	1483	6	1	0	11525	11439	1	181
10	500	1	13045	66528	420000	0	8	1410	3600	302028	245000	0	21457	641	3600	2	7	1122	1652	13	5	1	20422	17614	5	3283
10	500	2	15876	66528	420000	0	4	271	3600	302028	245000	0	490	2025	3600	2	18	984	1512	12	4	1	20044	17294	4	13
10	500	3	13015	66528	420000	0	21985	109	3600	302028	245000	0	7	3264	3600	3	16	1187	1776	34	4	0	20045	16800	6	3600
Avg									3185						3600							1				1209
Solved									5						0											21

Table EC.15 Computational results on `Required` instances with ten ports

				AP93						DC15						This Paper										
$\bar{r}$	$\bar{c}$	no	nCont	Rows	Cols	LB	UB	T_{ub}	T_{tot}	Rows	Cols	LB	UB	T_{ub}	T_{tot}	LB_0	UB_0	nDOI	Vars	Iter	LB	T_{lb}	Rows	Cols	UB	T_{tot}
6	100	1	1648	9945	99000	1	1	362	362	57445	48600	0	1	685	3600	1	13	638	811	34	1	1	6882	6407	1	64
6	100	2	1825	9945	99000	0	1	806	3600	57445	48600	0	6	2958	3600	1	16	614	781	30	1	0	6883	6604	1	20
6	100	3	2257	9945	99000	1	1	82	82	57445	48600	1	1	398	398	1	13	544	671	10	1	0	6872	6103	1	1
6	300	1	6117	29745	297000	0	2	276	3600	172245	145800	0	260	2929	3600	2	19	593	926	13	2	0	20186	20058	2	454
6	300	2	6104	29745	297000	0	8	349	3600	172245	145800	0	16	449	3600	2	10	480	827	20	4	1	20774	16721	4	96
6	300	3	5228	29745	297000	2	6	312	3600	172245	145800	0	7	872	3600	3	12	475	997	78	5	1	21075	15520	6	3600
6	500	1	11368	49545	495000	0	15632	82	3600	287045	243000	0	15134	806	3600	3	18	515	1038	8	3	0	33487	32818	3	176
6	500	2	10427	49545	495000	0	16573	61	3600	287045	243000	0	10	2998	3600	2	13	459	1213	93	5	1	34075	24920	7	3600
6	500	3	8712	49545	495000	0	1	613	3600	287045	243000	0	17790	1786	3600	1	16	648	1179	12	1	0	32886	32803	5	3600
8	100	1	2052	13545	132000	0	11	2496	3600	76845	64800	0	81	2094	3600	4	18	1260	1529	63	4	3	8292	7242	5	3600
8	100	2	2761	13545	132000	0	3	1253	3600	76845	64800	0	3	3081	3600	3	20	1050	1193	18	3	0	7860	7057	3	71
8	100	3	2652	13545	132000	0	6	1536	3600	76845	64800	0	18	3007	3600	4	24	1148	1349	37	4	1	8291	7336	6	3600
8	300	1	6609	40545	396000	0	3	706	3600	230445	194400	0	14693	1306	3600	2	29	1214	1552	16	2	1	20441	19980	2	554
8	300	2	7108	40545	396000	0	2	623	3600	230445	194400	0	14194	1224	3600	2	23	1271	1599	11	2	2	20440	19682	2	1289
8	300	3	5893	40545	396000	2	15707	86	3600	230445	194400	0	47	2329	3600	2	15	1202	1598	37	3	5	20863	18564	4	3600
8	500	1	14322	67545	660000	0	23	266	3600	384045	324000	0	21180	1868	3600	2	11	968	1492	9	4	1	34278	27553	4	314
8	500	2	10349	67545	660000	0	25651	99	3600	384045	324000	0	25153	2737	3600	1	21	1105	1651	20	2	3	33431	29788	100008	3600
8	500	3	10674	67545	660000	0	2	782	3600	384045	324000	0	24828	3600	3600	2	30	1331	1856	9	2	1	33442	33278	2	2460
10	100	1	3557	17145	165000	0	6	8	3600	96245	81000	0	6	1719	3600	2	9	1255	1414	27	6	2	9882	7684	6	290
10	100	2	3734	17145	165000	0	5	3111	3600	96245	81000	0	28	3176	3600	2	28	1782	2020	52	5	4	9348	8153	6	3600
10	100	3	4089	17145	165000	0	5	1850	3600	96245	81000	0	40	2349	3600	5	30	1894	2037	18	5	3	9359	8916	5	628
10	300	1	11368	51345	495000	1	1	597	597	288645	243000	0	15334	970	3600	1	17	1738	2069	12	1	1	20131	19714	1	103
10	300	2	10427	51345	495000	0	11	86	3600	288645	243000	0	16275	752	3600	4	22	1564	2118	86	8	5	24003	18079	10	3600
10	300	3	8712	51345	495000	0	18288	77	3600	288645	243000	0	17990	2017	3600	3	29	2090	2429	16	3	10	21250	20969	3	1539
10	500	1	16873	85545	825000	0	5	1866	3600	481045	405000	0	27629	3600	3600	2	28	1625	2266	45	5	4	35340	28475	8	3600
10	500	2	17014	85545	825000	0	1	657	3600	481045	405000	0	27488	3600	3600	1	17	1776	2325	20	1	2	33125	29520	1	49
10	500	3	13761	85545	825000	0	4	1759	3600	481045	405000	0	30741	3600	3600	4	19	2094	2633	16	4	9	34806	34444	800004	3600
Avg									3239						3481							2				1767
Solved									3						1											16