Discussion on "A Kernel-Oriented Algorithm for Transmission Expansion Planning"

J. Zolezzi, H. Rudnick, and F. Evans

In the above paper,[1] the authors present an interesting solution to the problem of assigning the expansion costs of a transmission system operating in multilateral access. It is a multi-agent system based on cooperative game theory procedures, specifically in the theory of the excess and the Kernel-like solution. The theoretical formulation is easy to follow, but its practical application leaves many open questions. We will appreciate the comments and further explanations of the authors to the following questions.

How do the algorithms of assignment of transmission costs operate, in particular the BSV and the KCA, for multilateral access or bilateral transactions?

At the start of the game it is indicated that the coalitions choose the strongest agent (in the Kernel sense). However, it is not clear the procedure, since the determination of the strongest agent would require assuming *a priori* a configuration of payments. It is necessary to evaluate the excesses, which could be obtained by means of the Shapley Value or another alternative.

Which mechanisms are outlined by the suggested algorithm (KCA), to prevent that the agents have a positive attitude toward the game and tell the truth in every stage of the game? This is particularly important in the case of the Kernel algorithm that assigns costs for stages or rounds, in that each couple of coalitions is stable in the Kernel sense.

We also have some comments in relation to the numerical examples:

Given the values and capacities indicated in Tables I and II, why is it not possible the existence of the coalition of four agents $\{1,\,3,\,5,\,6\}$ with a value of −61?

The values of some coalitions should be (as indicated in table 2):

$\{1,\,4,\,6\}$; −30 and not −60,
$\{2,\,4,\,6\}$; −120 and not −150,
$\{1,\,4,\,5,\,6\}$; −182 and not −243,
$\{2,\,3,\,4,\,6\}$; −90 and not −120.

In the process of formation of coalitions for the 6 bus Garver Test Systems, according to the authors the Kernel corresponds to $[1,\,\{2-6\},\,3,\,4,\,5] - [\{1,\,2,\,6\},\,3,\,4,\,5] - [\{1,\,2,\,4,\,6\},\,3,\,5] - [\{1,\,2,\,3,\,4,\,6\},\,5] - \mathrm{GC}$.

However the sequence should be developed in the following way: $[1,\,\{2-6\},\,3,\,4,\,5] - [\{1,\,2,\,6\},\,3,\,4,\,5] - [\{1,\,2,\,3,\,6\},\,4,\,5] - [\{1,\,2,\,3,\,4,\,6\},\,5] - \mathrm{GC}$.

The justification of the above statement is long, but clear signs that that is the correct sequence are obtained from the vector of payments of the game in question. It corresponds to $(16.25,\,-76.25,\,16.25,\,-60,\,-40,\,13.75)$, where we notice clearly that agents 4 and 5 remain indifferent to be part of a coalition, while agent 3 achieves benefits by being part of it.

It is our impression that the assignment of the costs to all the lines of the transmission system in point C.6 is not correct, when considering a total cost of expansion of 130 monetary units. This cost only corresponds to the new lines and it does not represent the total costs of the system.

We have benefited considerably with previous interactions with the authors on their valuable research and we thank them for their disposition to collaborate with us. We look forward to learning from their response to our questions.

Manuscript received November 1, 2000.

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Publisher Item Identifier S 0885-8950(01)09814-5.

[1] J. Contreras and F. F. Wu, *IEEE Trans. Power Systems*, vol. 15, no. 4, pp. 1434–1440, November 2000.

Closure to Discussion of "A Kernel-Oriented Algorithm for Transmission Expansion Planning"

Javier Contreras and Felix F. Wu

We would like to thank the authors for their interest in our paper.[1] The questions will be addressed in the order they appear in the discussion.

Regarding the appropriateness of our mechanism for multilateral trades: this paper and a previous one [1] have tried to address the problem of assignment of transmission costs (BSV and KCA). The first part of both papers has dealt with coalition formation, that can be considered as a sequence of successive bilateral contracts. We believe that this method can be seen as a purely bilateral transaction mechanism only if the process stops at the first step, where the first bilateral coalitions are formed. If the process is allowed to continue, negotiations are still bilateral, but the number of agents that belong to a meta-agent is usually more than one. If negotiations were multilateral, there would be a combinatorial explosion in the number of possible combinations, making the problem very hard to solve. For a multi-agent example of multilateral trades see a subsequent paper [2]. The only difference between this paper and ours is the use of an objective function that minimizes costs and the fulfillment of Kirchhoff's law as a constraint for power injections. In [2], the agents are also looking for their own benefit, and the negotiation and allocation mechanisms are identical to our algorithms.

As to the question of selecting the strongest agent in the KCA algorithm: choosing a coalition leader in the KCA may be done via choosing the strongest agent in terms of whatever is presumed to be the criterion for strength. This criterion is up to the user; either by playing a separate game or by assuming a common criterion agreed at the beginning.

In answer to the truth-telling question: BSVA and KCA assume a benevolent, truth-telling behavior, but there are several techniques available not to prevent but to lower the risks of lying agents. These techniques should be appropriately inserted in the overall KCA, which might be nontrivial. However, note that a lying agent may be not as marketable as another one that tells the truth, and that could lead him to tell the truth in many cases.

In response to the numerical examples questions: the authors are right. Coalition {1, 3, 5, 6} has a value of −61, that corresponds to

Manuscript received February 20, 2001.

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Publisher Item Identifier S 0885-8950(01)09815-7.

[1] J. Contreras and F. F. Wu, *IEEE Trans. Power Systems*, vol 15, no. 4, pp. 1434–1440, November 2000.

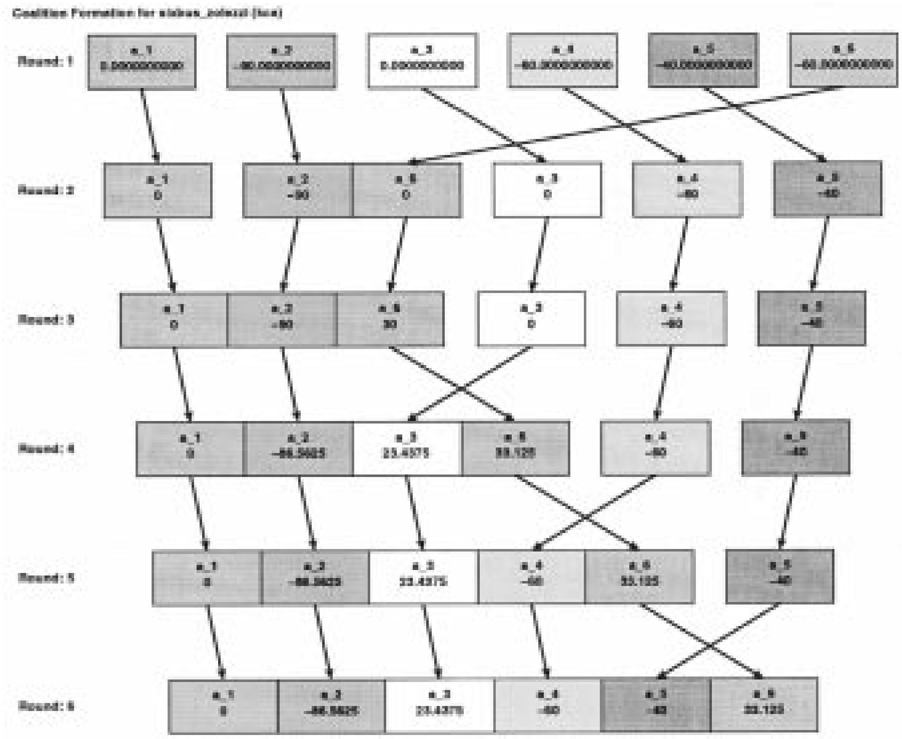

Fig. 1. KCA results with corrections, as suggested by the authors.

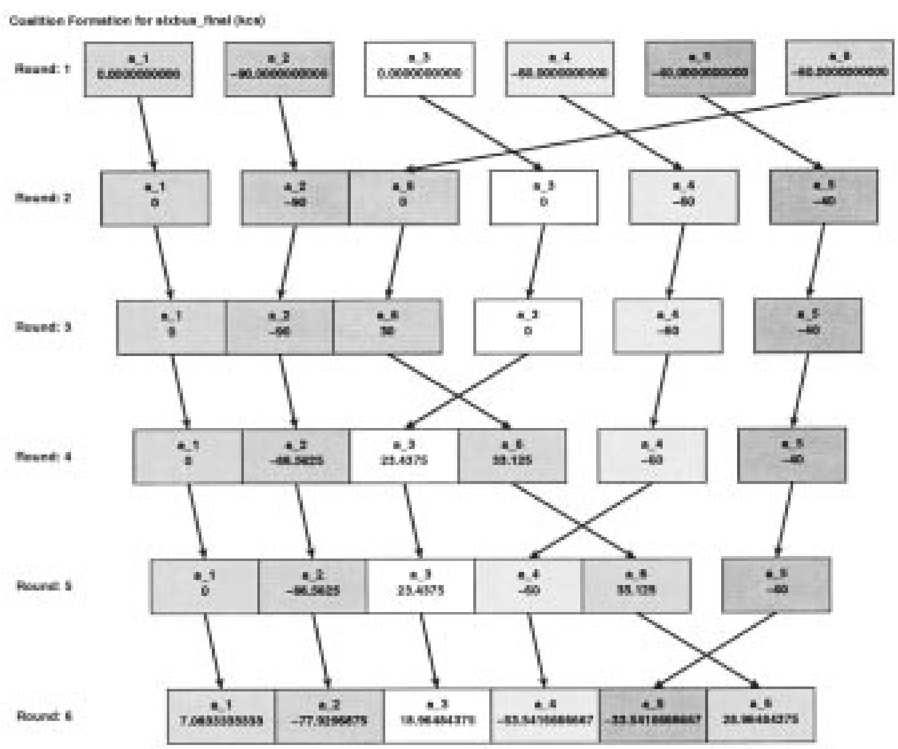

Fig. 2. KCA results with corrections, as suggested by the authors, plus a GC value of -110.

one new line between bus 5 and 6. This error is due to the use of a network expansion program that did not consider that coalition as possible. Also, coalition values of {1, 4, 6}, {2, 4, 6}, {1, 4, 5, 6} and {2, 3, 4, 6} are equal to -30, -120, -182 and -90, respectively. These errors were due to two different causes: first, there was an unfortunate typo in [1], and the load in bus 4 was -160, instead of -180. Second, the program did not always calculate the right answers either. Finally, note that the correct value of the final coalition should be -110, and not -130; see [3].

In answer to the KCA sequence of coalitions question: the authors point out that it should be: [1,{2, 6}, 3, 4, 5] → [{1, 2, 6}, 3, 4, 5] → [{1, 2, 3, 6}, 4, 5] → [{1, 2, 3, 4, 6}, 5] → Grand Coalition (GC). As far as we know, our original coalition sequence: [1,{2, 6}, 3, 4, 5] → [{1, 2, 6}, 3, 4, 5] → [{1, 2, 4, 6}, 3, 5] → [{1, 2, 3, 4, 6}, 5] →

Grand Coalition (GC) is correct; however, note that when introducing the correct values in Table II:

value of {1, 3, 5, 6} = -61
value of {1, 4, 6} = -30
value of {2, 4, 6} = -120
value of {1, 4, 5, 6} = -182
value of {2, 3, 4, 6} = -90

then, the new KCA coalition formation process coincides with the one proposed by the authors, as shown in Fig. 1. Also, note that when including the correct GC value equal to -110, the coalition formation process is as shown in Fig. 2.

Finally, it is asked whether point C.6 is correct when using a total cost of expansion equal to 130. In our paper, Table IV showed all sunk costs where, unfortunately, there was no KCA solution when the GC cost was -330, where old and newly expanded lines' costs were included. That was not sufficiently explained in the paper. But, replacing the GC total cost by -130, and keeping the remaining values of Table IV, the solution was equal to (0, -90, 0, -60, -40, 0) after only one step. Later, the process ended. This issue should be subject of further research.

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Discussion of "Unit Commitment by Lagrangian Relaxation and Genetic Algorithms"

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I would like to congratulate the authors of the above paper[1] for their contribution in using Lagrangian Relaxation and Genetic Algorithm to solve the Unit Commitment (UC) problem.

The authors introduce a method to solve the unit commitment (UC) problem based on the combination of Lagrangian Relaxation (LR) and Genetic Algorithms (GA). They solve the problem using the LR procedure and update the multipliers using a GA method.

1) Two have been the general approaches to solve the UC problem through LR techniques. The earliest, proposed by Merlin and Sandrin [12], solves the dual problem and, in those iterations in which the dual solution meets the spinning reserve constraints, an economic dispatch algorithm is run to achieve a primal solution. The method converges when the relative difference between the primal cost and the dual cost is small enough. Some other references of this method are [1], [2]. The second approach, proposed by Galiana and Zhuang [13], solves the problem in three stages. In the first one the dual problem is solved. Starting from the solution of the dual problem (Stage 1) and through the second and third stages, a solution to the primal problem is achieved. This method is the most commonly used in the recent years [29], [3]–[9]. It only looks for a primal solution when a near optimal dual solution is found and therefore the economic dispatch algorithm is just needed once. This paper present a method based on the approach presented in [12]. Have the authors tried the other approach [13]? Could they compare both approaches in terms of quality of the solution and CPU time?
2) In step 6 of the LRGA algorithm presented, after setting the commitments variables to the solution of the problem solved in step 4, an economic dispatch procedure is solved to compute the power production of each unit and the primal problem cost. This means that the solution of the dual problem meets the spinning reserve constraints which it is not the general case. Could the authors comment on this subject?
3) The subgradient technique has been widely used to solve the dual problem of the UC problem. Nevertheless, new techniques have been proposed recently to update the multipliers [6]–[9]. These techniques achieve a much faster convergence than the subgradient technique. What kind of multiplier updating procedure have the authors implemented to compare the performance of their LRGA method to an LR method? Have the authors tried any of the new multiplier updating techniques?

Manuscript received August 1, 2000.
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Publisher Item Identifier S 0885-8950(01)09816-9.

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