Researchers develop 'envy-free' algorithm for settling disputes

February 3 2014

Whether it's season tickets to Green Bay Packers' games or silver place settings, divorce and inheritance have bred protracted disputes over the assignment of belongings. But, now, a trio of researchers has found a method for resolving such conflicts in an envy-free way.

The paper, authored by New York University's Steven Brams, Wilfrid Laurier University's D. Marc Kilgour, and the University of Graz's Christian Klamler and published this month in *Notices of the American Mathematical Society*, outlines a pair of algorithms that are based on the self-identified priorities of the parties.

"The problem of fairly dividing a divisible good, such as cake or land, between two people probably goes back to the dawn of civilization," write the authors.

They point out that dividing indivisible goods, like the marital property in a divorce, is harder, adding, "Unlike more demanding fair-division algorithms, which ask players to give more detailed information or make more difficult comparisons, our algorithms are easy to apply and, therefore, eminently practicable."

Their work is based on principles of fairness. In the first algorithm, the two players make simultaneous or independent choices in sequence, starting with their most-preferred items and progressively descending to less-preferred items that have not already been allocated. In the second, the players submit their complete preference rankings in advance to a

referee or arbitrator.

This algorithm is "envy free" because each party prefers each of its items to a corresponding item of the other party. A potential conflict arises, of course, when the two parties desire the same item at the same time. For example, assume players A and B rank four items, going from left to right, as follows:

A: 1 2 3 4
B: 2 3 4 1

Now, if we give A item 1 and B item 2 (their most preferred), the next unallocated item on both their lists is item 3. Who should get it? The algorithm gives it to A and gives item 4 to B, which is an envy-free allocation because each player prefers its items to the other player's:

A prefers item 1 to 2 and item 3 to 4
B prefers item 2 to 3 and item 4 to 1

Not only does each party prefer its pair of items to the other's, but there is no alternative allocation that both parties would prefer, which makes it efficient. Although such an efficient, envy-free allocation is not always possible, the algorithm finds one that comes as close to this ideal as can be achieved.

More information: Brams, a professor in NYU's Wilf Family Department of Politics, is the author of Game Theory and the Humanities: Bridging Two Worlds (2011) and Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures (2008), among other works.

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Provided by New York University

Citation: Researchers develop 'envy-free' algorithm for settling disputes (2014, February 3) retrieved 25 April 2024 from https://phys.org/news/2014-02-envy-free-algorithm-disputes.html

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