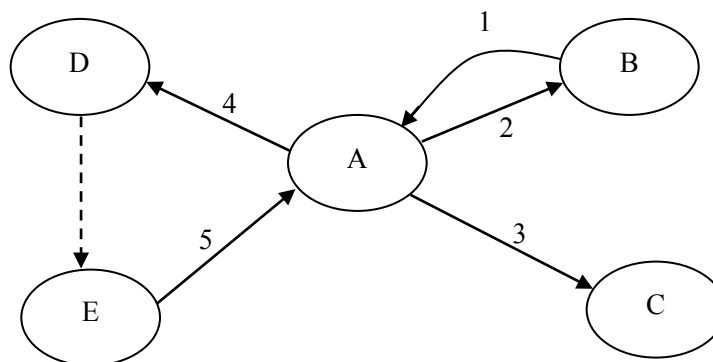# Combined Value Auction (CVA) Simulation

This in-class simulation goes with the article:

Ledyard, Olson, Porter, Swanson and Troma, The First Use of a Combined-Value Auction for Transportation Services, *Interfaces* 32:5, 2002, pp. 4-12.

## The Buyer's Requirements

The simulation is based on the simplified version of the problem based on the following network:



The buyer, a Big Box Retailer (BBR), is looking to purchase shipping services on the five lanes marked in the figure. BBR requires **one load** on each lane, and has a reservation price of **$800** on each lane.

There are seven shippers. Shippers 5,6 and 7 have contracts on lane D-E (not part of the BBR network). The net revenue from this contract is the shippers' private information.

## Shippers' Capacity

Shippers have the capacity of a certain number of lanes per week. This capacity includes any possible *backhauls*. A backhaul is driving an empty truck after dropping off a load. Shipper 1 is the national shipper and his weekly capacity is unlimited. Shippers 2 and 3 are local shippers, and they only have capacity for a single lane per week. Shipper 4 has the capacity of 4 lanes per week. Shippers 5,6, and 7 have the capacity of 3.

The following example illustrates the meaning of capacity. Since shippers 2 and 3 have the capacity of 1 lane, they can only handle packages that include a single lane. Shipper 4 can handle lanes 1,2, 3 and lane 3's backhaul, or a combination of any of the two other lanes and their backhaul. Shippers 5,6, and 7 can handle the combination of lanes 4,5, and the D-E link

*This note was prepared as the basis for class discussion.*

Prepared by Elena Katok, Professor
Jindal School of Management, University of Texas at Dallas

(this is the total of three lanes).  Alternatively, those shippers can handle any lane and its backhaul, as well as the combination of lanes 1 and 2.

## Bidding Packages

The table below lists all possible packages of the 5 lanes, and BBR's reservation price for each package, and bidders whose capacity is sufficient to bid on this package:

| | Lane 1 | Lane 2 | Lane 3 | Lane 4 | Lane 5 | Reservation Price | Bidders who can bid on this package |
|---|---|---|---|---|---|---|---|
| Package 1 | 1 | 1 | 1 | 1 | 1 | 4000 | 1 |
| Package 2 | 1 | 1 | 1 | 1 | 0 | 3200 | 1 |
| Package 3 | 1 | 1 | 1 | 0 | 1 | 3200 | 1 |
| Package 4 | 1 | 1 | 1 | 0 | 0 | 2400 | 1,4 |
| Package 5 | 1 | 1 | 0 | 1 | 1 | 3200 | 1 |
| Package 6 | 1 | 1 | 0 | 1 | 0 | 2400 | 1,4 |
| Package 7 | 1 | 1 | 0 | 0 | 1 | 2400 | 1,4 |
| Package 8 | 1 | 1 | 0 | 0 | 0 | 1600 | 1,4 |
| Package 9 | 1 | 0 | 1 | 1 | 1 | 3200 | 1 |
| Package 10 | 1 | 0 | 1 | 1 | 0 | 2400 | 1 |
| Package 11 | 1 | 0 | 1 | 0 | 1 | 2400 | 1 |
| Package 12 | 1 | 0 | 1 | 0 | 0 | 1600 | 1,4 |
| Package 13 | 1 | 0 | 0 | 1 | 1 | 2400 | 1 |
| Package 14 | 1 | 0 | 0 | 1 | 0 | 1600 | 1,4 |
| Package 15 | 1 | 0 | 0 | 0 | 1 | 1600 | 1,4 |
| Package 16 | 1 | 0 | 0 | 0 | 0 | 800 | 1,2,3,4,5,6,7 |
| Package 17 | 0 | 1 | 1 | 1 | 1 | 3200 | 1 |
| Package 18 | 0 | 1 | 1 | 1 | 0 | 2400 | 1 |
| Package 19 | 0 | 1 | 1 | 0 | 1 | 2400 | 1 |
| Package 20 | 0 | 1 | 1 | 0 | 0 | 1600 | 1,4 |
| Package 21 | 0 | 1 | 0 | 1 | 1 | 2400 | 1 |
| Package 22 | 0 | 1 | 0 | 1 | 0 | 1600 | 1,4 |
| Package 23 | 0 | 1 | 0 | 0 | 1 | 1600 | 1,4 |
| Package 24 | 0 | 1 | 0 | 0 | 0 | 800 | 1,2,3,4,5,6,7 |
| Package 25 | 0 | 0 | 1 | 1 | 1 | 2400 | 1 |
| Package 26 | 0 | 0 | 1 | 1 | 0 | 1600 | 1,4 |
| Package 27 | 0 | 0 | 1 | 0 | 1 | 1600 | 1,4 |
| Package 28 | 0 | 0 | 1 | 0 | 0 | 800 | 1,2,3,4,5,6,7 |
| Package 29 | 0 | 0 | 0 | 1 | 1 | 1600 | 1,4,5,6,7 |
| Package 30 | 0 | 0 | 0 | 1 | 0 | 800 | 1,2,3,4,5,6,7 |
| Package 31 | 0 | 0 | 0 | 0 | 1 | 800 | 1,2,3,4,5,6,7 |

When a package has a 1 corresponding to a lane, this means that the package includes this lane.  The reservation price is $800 × the number of lanes in a package.  So the reservation price for package 1 is $800 × 5 = $4000 because package 1 includes all five lanes.  Package 26 includes lanes 3 and 4, so the reservation price is $800 × 2 = $1600.

## Shippers' Private Information

The cost of a backhaul is $200 for all shippers with the exception of shippers 2 and 3, whose cost of backhaul is $50. The cost of servicing each lane is each shipper's private information. Additionally, the net revenue from the D-E link is private information for shippers 5,6, and 7; the other shippers do not have any revenue from the D-E link.

## Rules for the Combined-Value Auction

Bidding takes place in rounds. During each round each bidder can place a bid on any of the packages for which this bidder has the capacity. If bidder places a bid on a package without sufficient capacity, this bid will be ignored.

In each round, each bidder is allowed to place a bid on a single package only.

**Eligibility rule**: The "use-it-or-lose-it" rule applies. In the first round all bidders can bid on any of the packages they can handle. In subsequent rounds bidders can only bid on packages that have the same or fewer number of lanes than the package on which this bidder was active during the previous round.

**Bids are binding**. When a bid is winning on a package in a round, this bid is transferred to the next round. The bidder cannot withdraw a winning bid and bid on a different package. The bidder is allowed to decrease the bid on the winning package.

**All non-winning bids expire**. So to keep eligibility, a bidder has to be either winning a package or should have placed a bid on a package. The total number of lanes from these eligible packages determines the total number of lanes of the packages on which the bidder is subsequently eligible to bid.

**Example**: If in round 1 bidder 4 bids on package 26, in round 2 bidder 4 can place bids that include at most 2 lanes. These are not required to be package 26 (unless bidder 4 is winning package 26), but can, for example, be packages 22, 23 or 27. However, bidder 4 cannot bid on package 4 because package 4 contains 3 lanes, and bidder 4 is only eligible for 2 lanes.

The **minimum bid increment will start at $50**. Any changes to the minimum bid increment will be announced publicly. No bids above reservation prices will be accepted.

## How the Auction will be conducted

The auction will be conducted using the SoPHIE platform. You will start by completing the knowledge check, based primarily on this document. You will not know which bidder you are any of the private information until you log into SoPHIE in class. At that point you will know your bid number, and your private information, which will include your net cost for supplying all of the packages for which you have sufficient capacity (in other words, the packages you can bid on, as specified in the table on the previous page.

The auction ends when the decrease in cost between the previous round and the current round is less than or equal to 2%.