LEARN Tutorial

Forward Auction Assignment Phase

February 27, 2015

Two Phases for Forward Auction

- Ascending Clock Phase
  - Determines winners of generic blocks in two categories
  - Category 1: proposed at most 15% weighted-pops impaired by interference from broadcast stations
  - Category 2: proposed over 15% to at most 50% weighted-pops impaired
  - Will not offer blocks if more than 50% pops impaired
- Assignment Phase
  - Determines assignment of frequency-specific licenses to winners of generic blocks

Assignment Phase Goals

- Make bidding relatively easy

  Proposals include:

  – Bidding in the assignment phase is not required

  – Reduce the number of assignment phase rounds by grouping markets with similar winners and winnings

  – Second-price pricing rule encourages simple bidding strategy

- Promote efficient and intensive spectrum use

  – Proposed to give highest priority to assigning contiguous frequencies to bidders where possible

  – Proposed sequenced rounds to facilitate acquiring common frequencies across geographic areas

Assignment Phase Overview

Proposals for assignment phase:

- Series of single-round sealed bid rounds
- In each round, bidders submit sealed bids for combinations of frequency-specific licenses in a PEA (or a group of PEAs)
  - Allowed to bid for combinations of licenses that correspond to the quantity in each category won in the clock phase
- At the conclusion of the round an optimization is solved to assign licenses to bidders
- No distinction between reserved and unreserved blocks during the assignment rounds

Topics

- Sequencing and grouping
- Bidding
- Contiguity objectives
- Assignment determination
- Payment determination

Proposed Sequencing of Rounds

- Run rounds for high-demand PEAs first; then for regions
- For high-demand PEAs
  - Order each PEA by descending weighted-pops
  - Conduct bidding *sequentially*: one PEA at a time
- For the six REAGs (Regional Economic Area Grouping)
  - Each PEA is associated with one of the six continental REAGs
  - For each REAG, order PEAs by descending weighted-pops
  - Conduct bidding *simultaneously* for the REAGs, but sequentially within each REAG
- Sequencing allows bidders to incorporate frequency assignments from previously-assigned areas into their bid preferences for other areas

Sequencing Example

Round	PEA [State]					
1	001 [NY]					
2	002 [CA]					
…	…					
40	040 [AL]					
	REAG 1	REAG 2	REAG 3	REAG 4	REAG 5	REAG 6
41	041 [NY]	043 [NC]	052 [WV]	046 [AR]	047 [TX]	042 [HI]
42	044 [NY]	045 [NC]	056 [MI]	051 [KY]	053 [AZ]	070 [OR]
43	048 [PA]	050 [SC]	058 [IN]	055 [AL]	063 [OK]	076 [NV]
…	…	…	…	…	…	…

Grouping

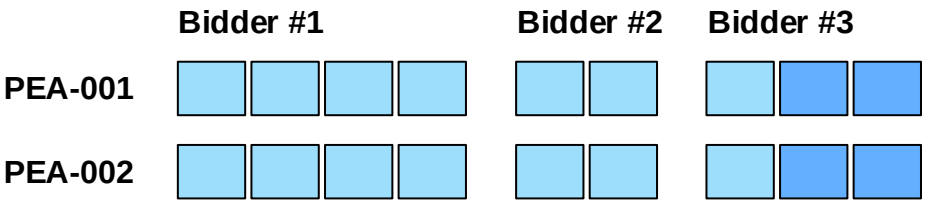
- To reduce the number of rounds, proposed single round for groups of PEAs when possible
- Conditions for grouping PEAs:
  - The PEAs are either all “high demand” or all in the same REAG
  - Same number of blocks were offered in the clock phase in each of the PEAs
  - Category 2 licenses are in the same frequency blocks
  - The winning bidders from the clock phase and the number of blocks of each Category 1 and Category 2 blocks they have won are sufficiently similar

Example 1

- PEA-001 and PEA-002 are “high-demand” PEAs
- 114 MHz Band Plan – paired 5 MHz blocks
  (For illustration purposes, examples show only the downlink blocks)

- Category 1 ▭ and Category 2 ▭ blocks are as follows:

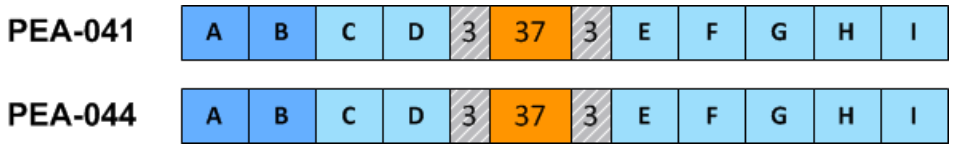
- Clock phase winnings



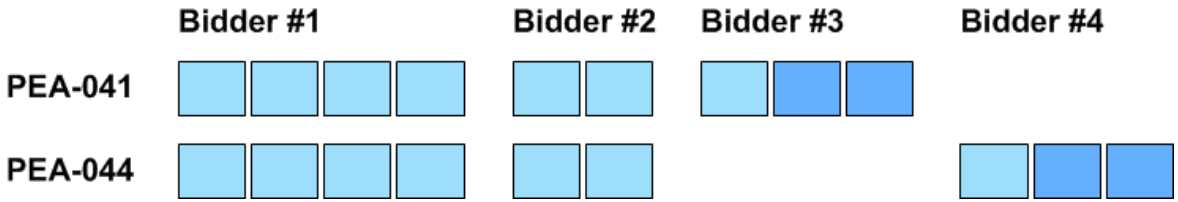
- A single assignment round is conducted for PEA-001 and PEA-002

Example 2

- PEA-041 and PEA-044 are both in REAG1
- 114 MHz; Category 1 and Category 2 blocks are as follows:



- Clock phase winnings



- A single assignment round is conducted for PEA-041 and PEA-044

Proposed Sequencing of Rounds with Grouping

- Group PEAs where possible
  - Weighted-pops for the group is the sum of the weighted-pops of all the PEAs in the group
- Run rounds for high-demand PEAs first; then for regions
- For high-demand PEAs
  - Order each PEA/group of PEAs by descending weighted-pops
  - Conduct bidding *sequentially*: one PEA/group of PEAs at a time
- For six REAGs
  - For each REAG, order PEAs/groups of PEAs by descending weighted-pops
  - Conduct bidding *simultaneously* for the REAGs, but sequentially within each REAG

Sequencing with Grouped PEAs

Round	PEA(s)					
1	001, 002, 015					
2	003, 025					
…	…					
30	040					
	REAG 1	REAG 2	REAG 3	REAG 4	REAG 5	REAG 6
31	041, 044	043	052	046	047	042
32	048	044	056	051, 055	053	070
33	060, 069, 077	050	058	055	063	076
…	…	…	…	…	…	…

Bidding

- A bidder submits bids on combinations of licenses consistent with its clock phase winnings
  - A bidder can bid any dollar amount
  - Bid is the maximum payment that the bidder is willing to pay above the discounted base clock price
    - The base clock price is established in the clock phase
    - Discounts for license-specific impairments will be applied when determining final payment amounts
  - The system will treat any combination for which no bid is received as having a $0 bid

Bidding Examples

- Example: 108 MHz

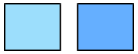
  - Bidder won four Category 1 blocks in clock phase 
  - Bidder submits the following bids:
    - $50: 

    - $80: 

    - $150: 

  - The systems considers a $0 for all other combinations

- Example: 84 MHz

  - Five Category 1 & two Category 2
  - Bidder won one Category 1 & one Category 2 block in clock phase 
  - Bidder submits the following bids:
    - $30: 

    - $20: 

  - The systems considers a $0 for all other combinations

Contiguity

- Design goal: assign contiguous frequencies to bidders within a PEA or group of PEAs
- Contiguity may not always be possible
  - Channel 37
  - Two categories of licenses
- Example: 108 MHz with 8 Category 1 blocks, each of 2 bidders won 4 blocks in clock phase

- It is not possible for both bidders to get 4 contiguous blocks

Contiguity Objectives

Proposed to maximize contiguity according to the following prioritized objectives:

1. Maximize the number of bidders who are assigned at least two contiguous blocks

2. Minimize the number of “stranded” blocks, i.e. blocks that are not contiguous to any other blocks of the same bidder

3. Maximize the number of bidders who are assigned only contiguous blocks

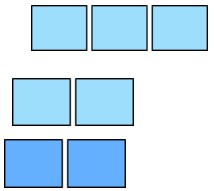
Contiguity Objectives

- Objectives are applied in order of priority
  - First, determine the maximum number of bidders that can be assigned at least two contiguous blocks
  - Second, of the assignments that ensure that the maximum number of bidders are assigned at least two contiguous blocks, determine the minimum number of stranded blocks
  - Third, of the assignments that optimize both of the above, determine the maximum number of bidders whose blocks are all contiguous
- Results are added as “rules” to the winner determination optimization

Objective 1 Example

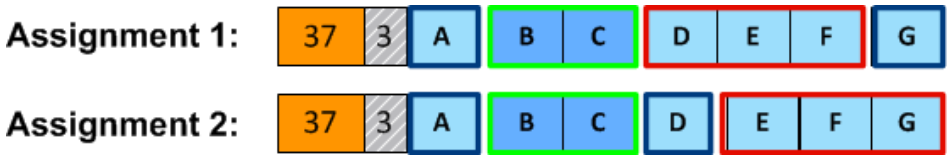
- 84 MHz

- Three winners from the clock phase
  - Bidder 1 won three Category 1 blocks
  - Bidder 2 won two Category 1 blocks
  - Bidder 3 won two Category 2 blocks



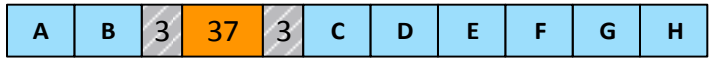
- Possible assignments that meet the objective:

- Without the 1st contiguity objective Bidder 2 could be assigned only non-contiguous blocks

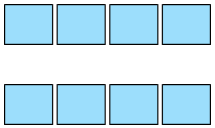


Objective 2 Example

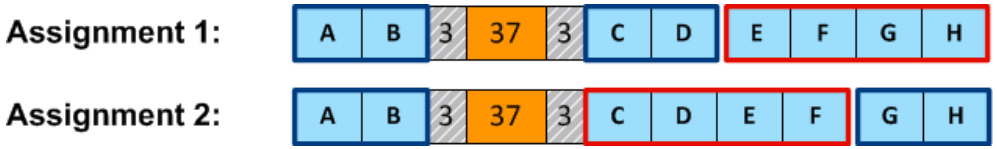
- 108 MHz



- Two winners from clock phase
  - Bidder 1 won 4 Category 1 blocks
  - Bidder 2 won 4 Category 1 blocks



- Possible assignments that meet both objectives:



- Without the 2nd contiguity objective one bidder could have stranded blocks

Assignment Determination

- The winning assignment maximizes the sum of bids while satisfying all three objectives
  - Ties will be broken using pseudo-random numbers

Assignment Determination Example

- 108 MHz 

- Two winners from clock phase; 4 blocks each
- Bidder 1 bids:
  - $50: 

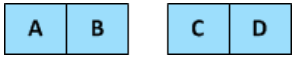
; $80: 

; $150: 

- Bidder 2 bids:
  - $60 

; $100 

- Winning assignment
  - Bidder 1: 

Bidder 2: 

  - Maximum revenue $150

Assignment Phase Payment

- To allow for simple bidding strategies, proposed second-price assignment phase payment
  - For every assignment phase winner, the system calculates the price that would have been just sufficient to result in the same winning assignment
  - A bidder can comfortably bid the value it places on an assignment, knowing that it will need to pay only the minimum amount that is sufficient to win, and never more than its bid
- Steps to determining the assignment phase payment amount
  - Solve the winner determination with $0 bids for that bidder
  - Calculate the difference in revenue
  - Subtract the difference from the bidder's bid amount

Second-price Determination

- 108 MHz

- Two winners from clock phase; 4 blocks each
- Determine max revenue if Bidder 1 had bid $0
- Bidder 1 bids:
  - $0: C D E F $0: D E F G; $0: E F G H
- Bidder 2 bids:
  - $60 C D E F ; $100 E F G H
- Winning assignment would be
  - Bidder 1: A B C D Bidder 2: E F G H
  - Maximum revenue $100

Second-price Determination

- Calculate the difference in maximum revenue with Bidder 1's bids and the maximum revenue with $0 bids for Bidder 1

  Revenue Difference: $150 - $100 = $50

- Calculate Bidder 1's assignment round payment as its bid amount minus the difference in revenues

  Payment for Bidder 1: $150 – $50 = $100

Final Payment

- For a specific license, proposed the final payment be determined as:
  - Clock phase price for the category/PEA
  - Adjusted for percentage of any impairment to the frequency block
  - Plus any assignment round payment
  - Reduced by any small business bidding credit

Final Payment Example

- Bidder wins 4 Category 1 block at $1000 each in Clock Phase
- In the Assignment Phase, the bidder bids $150 for blocks (E,F,G,H), and is assigned those blocks with assignment phase payment = $100
- Block E is 2% impaired; Blocks F, G and H are 0% impaired
- The final price is {($1000)*(.98) + 3*1000}+{$100} = $4,080
- If the bidder were eligible for a bidding credit, the price would be reduced further by the applicable bidding credit percentage