Auctioning based Coordinated TV White Space Spectrum Sharing for Home Networks

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TV White Spaces

• “White Spaces” refer to areas where the spectrum is unused by the licensed user

• TV band: 470-790 MHz

• Protection of incumbent users is of utmost importance

• Favorable propagation characteristics motivates several use cases
  • Rural Broadband
  • Hot-spot Coverage
  • In-home Broadband
  • In-home Multimedia
  • Machine to Machine
White Space Database Assisted Access

• Database discovery

• Receives channel usage parameters based on its location from a WSDB it chooses.

• Leverage the WSDB for interference aware coordinated TVWS sharing among secondary users
Spectrum Sharing among Home Networks

- Secondary users are Home White Space Networks in our context
- TVWS access point obtains spectrum on behalf of in-home WSDs
- Spectrum Manager allocates TVWS channels to HWSNs considering availability, usage by other WSDs, spectrum demand, and interference among WSDs
Micro Auction based Spectrum Sharing

- We propose the use of short term auctions for coordinating spectrum among secondary users

- Key Considerations
  - Primary objective: Efficient Outcome
  - Truthful/Strategy-Proof
  - High Revenue
  - Low Computational Complexity
  - Efficient Spectrum Utilization
Why not traditional auction schemes?

- Channel Re-use
- Channel Sharing
- Heterogeneous Channel Availability
- Marginal Valuations
VERUM: An online multi-unit truthful iterative auction

- If the aggregate demand of a HWSN’s neighbors is less than the number of channels available at that HWSN, then the difference is “clinched” by the HWSN.
VERUM: An online multi-unit truthful iterative auction

A: 1, 2
V: 13, 8, 6

A: 1, 2, 3
V: 18, 16, 4

A: 2, 3
V: 8, 6, 2

A: 2, 3
V: 12, 10, 6

A: 1, 2, 3
V: 14, 12, 10
VERUM: An online multi-unit truthful iterative auction

Round Price: 2

- A: 1, 2
  - V: 13, 8, 6
- B: 3
- C: A: 1, 2, 3
  - V: 18, 16, 4
- D: A: 2, 3
  - V: 8, 6, 2
- E: A: 2, 3
  - V: 12, 10, 6
- A: 1, 2, 3
  - V: 14, 12, 10
VERUM: An online multi-unit truthful iterative auction

Round Price: 6

- Since demand of D is one where as two channels are available at E, a channel is "clinched" by E at price 6
**VERUM**: An online multi-unit truthful iterative auction

**Round Price: 8**

- A: 1, 2
  - V: 13, 8, 6

- A: 1, 2, 3
  - V: 18, 16, 4

- A: 2, 3
  - V: 8, 6, 2

- A: 2, 3
  - V: 12, 10, 6

- B

- C

- D

- E

- 2

- 2

- 3

- A: 1, 2, 3
  - V: 14, 12, 10

- E clinches another channel at price 8, as demand of D reduces to zero.
**VERUM**: An online multi-unit truthful iterative auction

### Round Price: 12

- **A**: 1, 2  
  - V: 13, 8, 6

- **A**: 1, 2, 3  
  - V: 18, 16, 4

- **A**: 2, 3  
  - V: 8, 6, 2

- **A**: 2, 3  
  - V: 12, 10, 6

- **B**: 1, 2, 3  
  - V: 14, 12, 10

- **C**: 0

- **D**: 0

- **E**: 0

- **C** clinches a channel as the aggregate demand of C's neighbors (A, B, and D) is two, where as three channels are available at C
• B and C clinch a channel each at price 13
**VERUM**: An online multi-unit truthful iterative auction

- Final allocations are, HWSN A wins one channel, B and C win two channels each.
- The channels are allocated using a greedy algorithm.
**VERUM**: How is it different from existing schemes?

- We compare **VERUM** against **VERITAS** and **SATYA**, two existing truthful, efficient auction schemes.
- To preserve truthfulness, they employ complex pricing schemes that realize Vickrey pricing.
- **VERITAS** does not support channel sharing, heterogeneous channel availability, and marginal valuations.
- **SATYA** supports channel sharing, heterogeneous channel availability and marginal valuation, but is only polynomial under certain restrictions.
**VERUM**: How is it different from existing schemes?

- We formulate the revenue maximizing spectrum allocation problem for both exclusive use and shared use as an integer linear program and solve it using Gurobi solver for comparison.

- SATYA has a lower revenue due to channel sharing opportunities lost due to bucketing and ironing.
VERUM: How is it different from existing schemes?

- The higher revenue in the urban scenario is due to lower density of HWSNs resulting in higher channel reuse.
Conclusions

• Interference-aware coordinated TVWS spectrum sharing framework for home networks that relies on short-term auctions and leverages the geolocation database to additionally keep track of secondary use of TVWS spectrum.

• We have developed an online multi-unit auction mechanism VERUM that is truthful and efficient.
Reference


Thank you!

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