New Zealand

Accelerating the introduction of spectrum sharing using market-based mechanisms.

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The paper

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- Two jobs of Spectrum Management
  - Spectrum Allocation
  - Spectrum Assignment
- Spectrum Sharing
  - Technological enablers
  - UK's Spectrum Sharing Framework (2016)
  - New Zealand's Managed Spectrum Parks (2009)
- Effectiveness and Efficiency
- Market-based mechanisms: examples
  - Ofcom spectrum sharing options for 2013 2.6 GHz auction
  - FCC's Licensed vs Unlicensed auction

Two jobs of Spectrum Management

(Cave, Doyle and Webb, 2007)

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- Spectrum Allocation
- Spectrum Assignment

Spectrum Sharing

(PCAST, 2012)

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- Technological enablers

(Han et al, 2016), (Beltrán et al, 2016)

- UK's Spectrum Sharing Framework (2016)

(Ofcom, 2016)

- New Zealand's Managed Spectrum Parks (2009)

(MBIE, 2010), (Beltrán, 2015)

Effectiveness and Efficiency

(Larbi-Apau and Moseley, 2010)

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What is the best use that can be given to a given frequency band and who should be entitled – or licensed to use it?

If a Spectrum Authority puts spectrum to its best use, it will maximize the effectiveness of the allocation, and

If a Spectrum Authority puts the spectrum in the hands of those who value it the most, it will maximize the efficiency of the assignment.

Market-based mechanisms: examples

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- FCC's Licensed vs Unlicensed auction

(Bykowsky, Sharkey and Olson, 2008)

Ofcom spectrum sharing options for 2013 2.6 GHz auction

(Ofcom, 2012)

FCC's Licensed vs Unlicensed auction

(Bykowsky, Sharkey and Olson, 2008)

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- FCC's Licensed vs Unlicensed auction

Licensed vs Unlicensed bids

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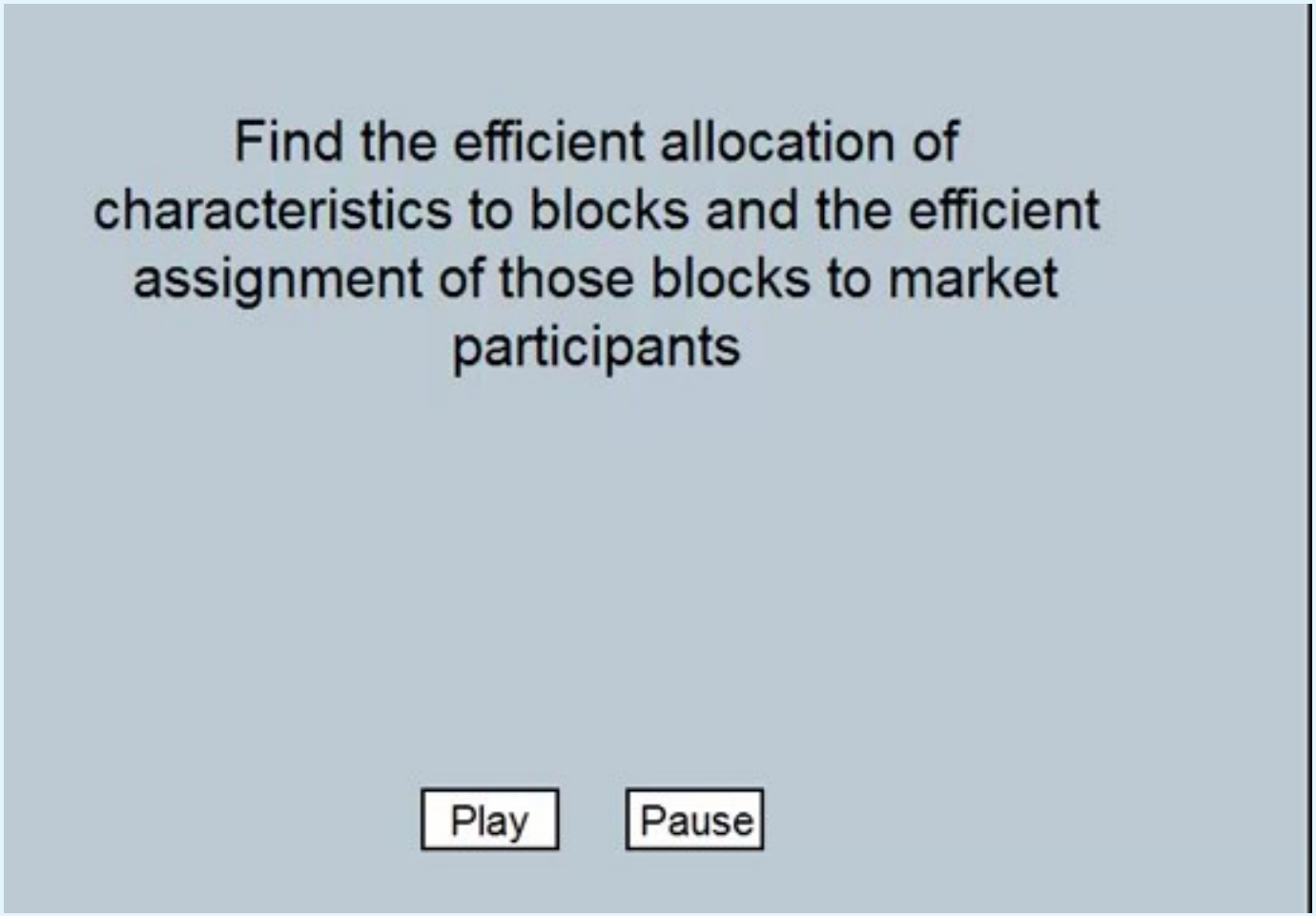

2013 Ofcom's 2.6 GHz auction

(Ofcom, 2012)

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- Ofcom's 2013 800 MHz & 2.6 GHz auction

Combinatorial Clock Auction, CCA

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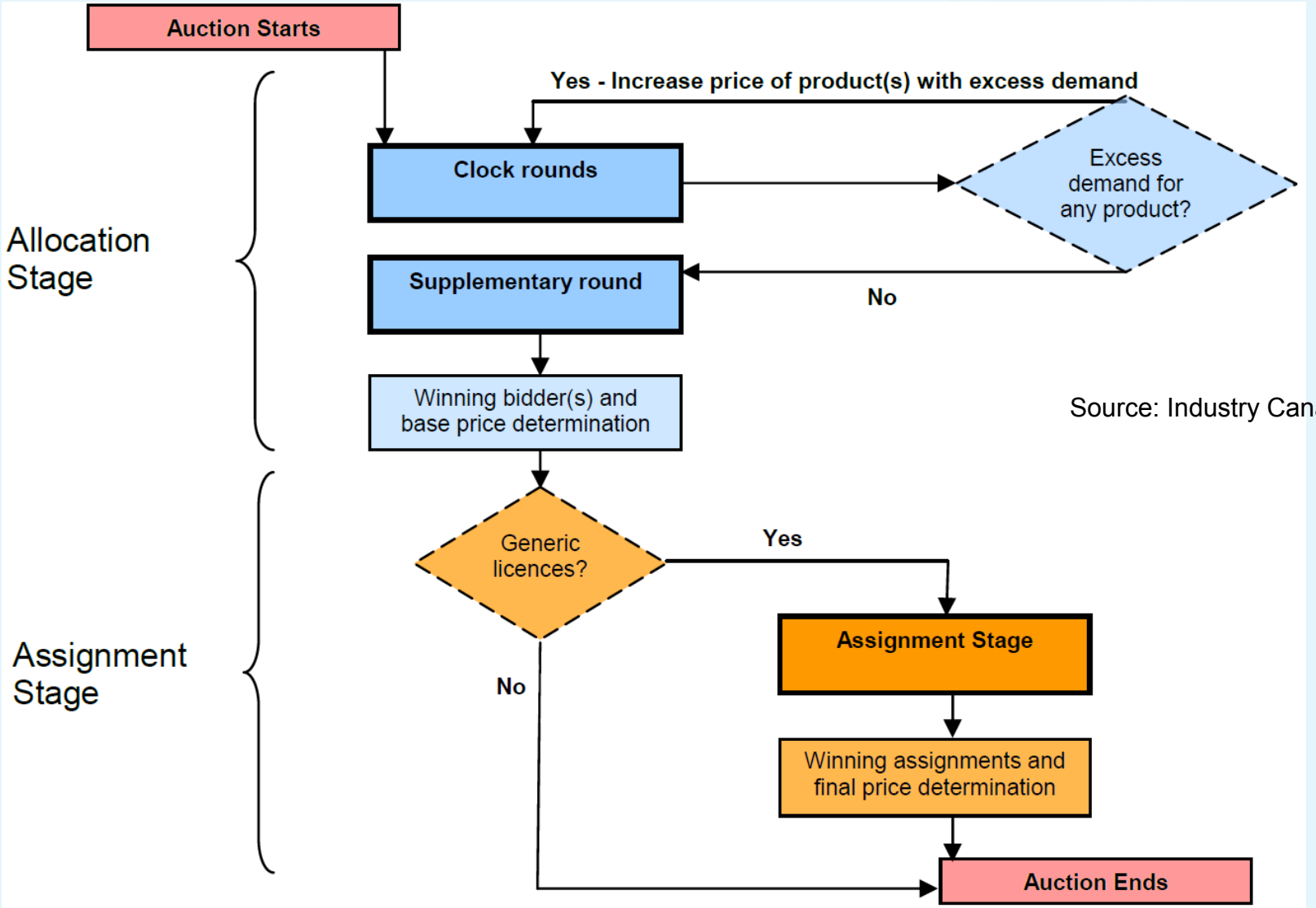

Source: Industry Canada

Clock Rounds Stage (aka Principal Stage)

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Round	SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5
	Prices					Supply -->	2	2	2	2	2		Σ	Σ	Σ	Σ	Σ
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	

Clock Rounds stage

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2013 | New Zealand | The University of Auckland

Round	SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5
	Prices					Supply -->	2	2	2	2	2		Σ	Σ	Σ	Σ	Σ
1	100	100	60	60	60		2	2					8	10	12	12	15
2																	
3																	
4																	
5																	
6																	
7																	
8																	

Clock Rounds stage

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2013 | New Zealand | The University of Auckland

Round	SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5
	Prices					Supply -->	2	2	2	2	2		Σ	Σ	Σ	Σ	Σ
1	100	100	60	60	60		2	2					8	10	12	12	15
2	105	105	60	60	60		2	2					7	9	12	12	15

Clock Rounds stage

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2013 | New Zealand | The University of Auckland

Round	SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5
	Prices					Supply -->	2	2	2	2	2
1	100	100	60	60	60		2	2			
2	105	105	65	65	65		2	2			
3	110	110	70	70	70				2		2

Clock Rounds stage

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2013 New Zealand The University of Auckland

Round	SA1	SA2	SA3	SA4	SA5		SA1	SA2	SA3	SA4	SA5
	Prices					Supply -->	2	2	2	2	2
1	100	100	60	60	60		2	2			
2	105	105	65	65	65		2	2			
3	110	110	70	70	70				2	2	2
4	110	110	80	90	80				2	1	2
5	110	110	90	95	90				2	1	1
6	115	115	95	100	100		1	1	1		
7	125	125	95	110	110		1	1			
8	125	130	110	115	115		1	1			

Back to …
Ofcom's 800 MHz & 2.6 GHz auction

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Spectrum Sharing involves two operators with adjacent frequencies combining their respective smaller channels in a spectrum band in order to be able to use a wider cannel from this combination (Ofcom 2012)

Auction design sought to facilitate:

- Joint bidding
- Spectrum Sharing (SS)

Auction preference expression

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Design challenge: to allow bidders to express preferences for winning spectrum next to another bidder.

Two sources of potential benefits from SS:

- From pooling of capacity resources
- From gains available from larger channels

The latter requires channels to be contiguous.

Hence preference expression.

Issues in SS in the Assignment Stage: An Example

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Goal: to allow bidders to reflect preferences for being both

- at particular frequencies, and,
- next to another specific bidder.

Example:

- 60 MHz (paired) of spectrum to be auctioned
- Blocks are 5 MHz each
- Coverage obligation imposed on a certain bidder
- Only the top four blocks of the upper band are suitable for meeting the coverage obligation

Example

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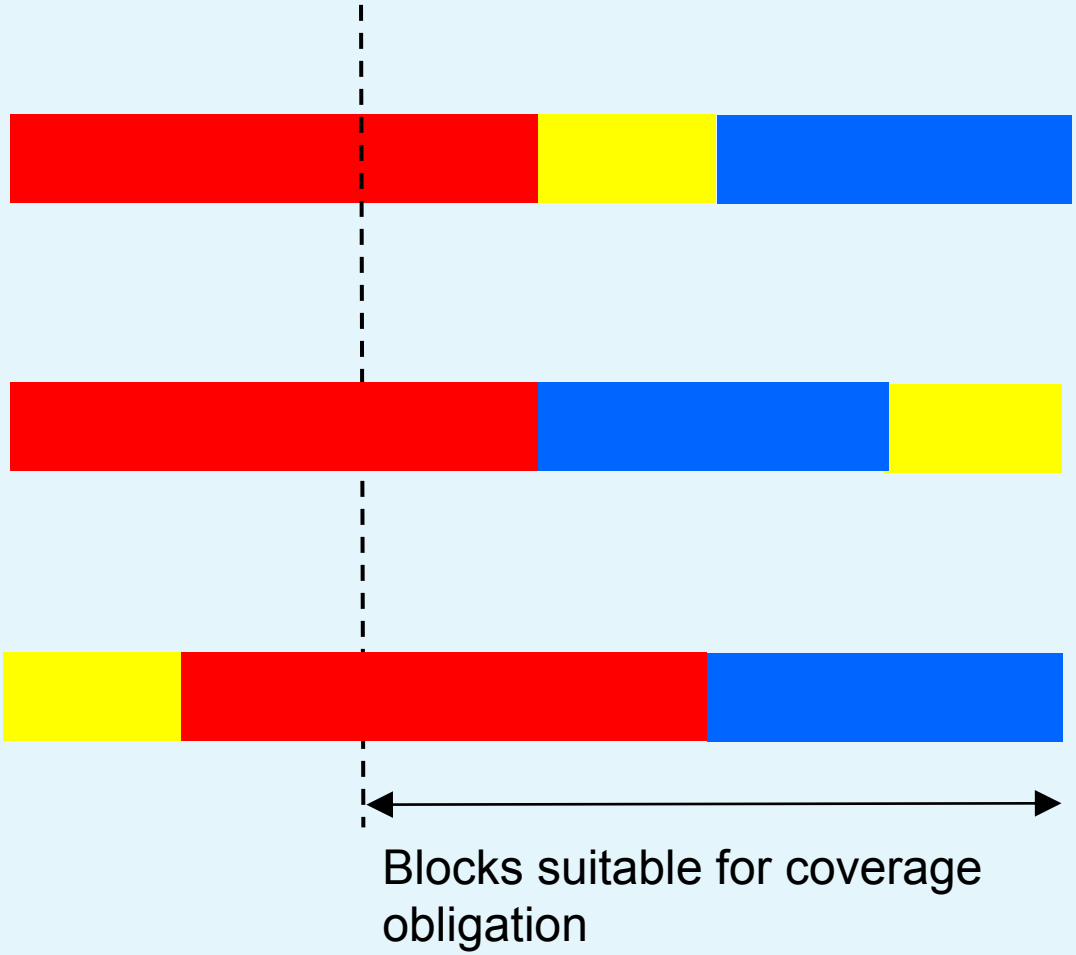
Principal Stage resulted in

- A won 2 x 15
- B won 2 x 5
- C won 2 x 10
- C is the bidder with coverage obligation

Question: is there a range of feasible assignments that allows any bidder to be contiguous to any other bidder at least in one arrangement?

Example



Challenge:
To manage the tension between the objectives on coverage obligation and the options for SS

Option for SS in the Assignment Stage

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Assuming contiguity is important (highly valued):

- Principal Stage winners negotiate amongs themselves
- Allowing the creation of joint bidding vehicles in the Assignment Stage
- Allowing bids that are contingent on whether a bidder prefer to be next to another bidder

In conclusion …

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- Spectrum sharing can enhance the spectrum authority's capabilities with a management scheme aimed to
  - increase the effectiveness of allocations and
  - the efficiency of assignments.
- Market-based mechanisms that include auctions for the assignment of rights to share the spectrum are not only conceivable but possibly efficient ways to decide about the best use and user of the spectrum

thank you
tēnā koutou
gracias

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References

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New Zealand

The University of Auckland

F. Beltrán, S.K. Ray, and J. and Gutiérrez, "Understanding the current operation and future roles of wireless networks: Co-existence, competition and co-operation in the unlicensed spectrum bands", accepted for publication in *Journal of Selected Areas of Communications*, (2016).

F. Beltrán, "Assessing alternative spectrum assignment methods to achieve social goals for broadband access" ITS Regional, Los Angeles, (2015).

M.M. Bykowsky, W.W. Sharkey, and M., Olson, "A Market-Based Approach to Establishing Licensing Rules: Licensed versus Unlicensed Use of Spectrum", *US Federal Communications Commission, OSP Paper 43*, (2008). https://www.fcc.gov/reports-research/working-papers/market-based-approach-establishing-licensing-rules-licensed-versus

M. Cave, C. Doyle, and W. Webb, "Essentials of Modern Spectrum Management", Cambridge University Press (2007).

Y. Han, E. Ekicia, H. Kremo, and O. Altintas, "Spectrum sharing methods for the coexistence of multiple RF systems: A survey", *Ad-Hoc Networks*, In-print.

J. A. Larbi-Apau, and J. L. Moseley, "Performance-based measurement: Action for organizations and HPT accountability", *Perf. Improv.*, (2010), 49: 7–17.

MBIE Ministry of Business, Innovation and Employment Managed Spectrum Parks Allocation Rules. New Zealand Government, (2010) www.rsm.govt.nz

Ofcom, "A framework for spectrum sharing", available at http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing-framework/statement/statement.pdf (2016). Last access April 24, 2016.

Ofcom, "Second Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues", http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/summary/combined-award-2.pdf (2012). Last access May 30, 2016.

PCAST, Report to the President: Realizing the Full Potential of Government-held spectrum to spur economic growth, (2012).