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Briefing Paper

Spectrum Policy in Singapore

November 2012

SPECTRUM POLICY IN SINGAPORE

In early 2013 Singapore's IDA plans to auction frequencies In the 1800MHz, 2.3GHz, and 2.5GHz bands for 4G mobile cellular services.

Current Spectrum Assignment

Existing Wireless Broadband Access (WBA) assignments were made in 2005 for 10 years and are based upon the IDA's Spectrum Rights Assignments plan spanning the 2.3GHz and 2.5GHz bands are shown in Table 1

Table 1	
Frequency	**Assignment**
2300 – 2330 MHz	QMax
2330 – 2350 MHz	QMax
2516 – 2528 MHz	M1
2540 – 2552 MHz	SingTel
2564 – 2576 MHz	P1
2576 – 2588 MHz	StarHub
2588 – 2600 MHz	P1
2636 – 2648 MHz	M1
2660 – 2672 MHz	SingTel
2672 – 2678 MHz	P1
Note: SingTel Mobile goes by the name STM	

In addition frequencies in the 1800MHz band were assigned in 2011 for 8 years to SingTel, StarHub and M1 for cellular services for 3G and now for 4G LTE. See Table 2:

Table 2		
Paired Frequency		**Assignment**
Lower band (MHz)	**Upper band (MHz)**	
1710 - 1715	1805 - 1810	SingTel
1715 - 1720	1810 –1815	StarHub
1720 - 1725	1815 - 1820	SingTel
1725 –1730	1820 – 1825	SingTel
1730 - 1735	1825 – 1830	SingTel
1735 - 1740	1830 – 1835	SingTel
1740 – 1745	1835 – 1840	StarHub
1745 - 1750	1840 – 1845	StarHub
1750 – 1755	1845 – 1850	StarHub
1755 - 1760	1850 - 1855	StarHub
1760 - 1785	1855 - 1880	M1

The 4G spectrum auction is designed to ensure continuity of services beyond 2015 and ahead of 2017. Although the bidding could be competitive there would seem in the eyes of industry analysts little commercial room for a fourth cellular operator in Singapore.[1]

Spectrum, Spectrum Designs and Outcomes

Auctions did not become widely used for the assignment of radio spectrum until the late 1990s. In the US the FCC first used an auction in 1994, and afterwards auctions became widely used in the assignment of spectrum for 3G mobile cellular services. There have been public

[1] "We do not anticipate aggressive bids as there is ample spectrum, unless: 1) all three telcos bid for more than 2x20MHz, which is the optimum required; or 2) new contenders emerge, which we think is unlikely given Singapore's small population with a very mature and competitive market. There were no new takers for the residual 3G spectrum in 2010. The 3G auction in 2001 and 2010 were awarded at reserve price as there was sufficient spectrum for the three incumbents." See http://sbr.com.sg/telecom-internet/news/singtel-starhub-and-m1-shun-spectrum-auction-in-2013

policy debates around the goal of auctions: between raising funds for the public purse[2] versus the achievement of industry policy goals, including encouraging new entry, safeguarding competition, promoting national network coverage, creating funds to support subsidized universal access services, and trying to ensure that scarce frequencies were efficiently awarded to maximize service value.[3]

Box 1 cites the aims of spectrum management policy in Canada. The interpretation put upon "economic and social benefits" clearly points towards reinvestment in the sector.

Box 1: Industry Canada[4]

In Canada the *Telecommunications Act* and *Spectrum Policy Framework for Canada* require the regulator to maximize the economic and social benefits from the use of radio spectrum according to:

1. Sustained competition in wireless telecommunications services market so that consumers and businesses benefit from competitive pricing and choice in service offerings
2. Robust investment and innovation by wireless telecommunications carriers so that Canadians benefit from world-class networks and the latest technologies
3. Availability of these benefits to Canadians across the country, including those in rural areas, in a timely fashion.

The FCC is similarly required by law to meet multiple goals and not focus simply on maximizing receipts. But in different jurisdictions different priorities won out.

In a period of financial crisis and economic austerity the appeal of raising funds for the treasury is hard for politicians to resist, not least in economies where network coverage and mobile penetration rates are already high. The operators view such strategies as a form of taxation on top of what they already pay in profit taxes, and argue that where the demand for cellular services is relatively inelastic these extra costs will get passed onto the consumer.

Against that argument, economists regard one-off high spectrum fees as sunk costs that are difficult to pass on if the environment is truly competitive.

However, this overlooks three issues: that the minimum *common* sunk cost could be passed on without loss of competitive advantage; that excessively high spectrum prices can damage the credit ratings of companies and thereby push up the cost of capital; the impact on operator liquidity can delay extensive network rollout. There is evidence of these consequences in the 3G auctions in the UK.[5]

An alternative approach adopted in Hong Kong for 3G was a royalty auction where bidders would bid on the size of the royalty they paid on their *gross* profits. [6] Choosing net profits would incentivise the

[2] In the UK, Ed Balls, the Labour Party's shadow Chancellor of the Exchequer, said he would use funds from the 4G auction to kick-start the UK economy by building 100,000 new homes: http://www.ibtimes.co.uk/articles/389640/20121001/labour-conference-ed-balls-4g-spectrum-shadow.htm

[3] The IDA in Singapore uses the money to reinvest in the industry; but then the Singapore government is not short of funds.

[4] http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10121.html

[5] See the debate in *Info* journal and a counter-view in John Ure (2001) 'Licensing third generation mobile' *Info* February 2001 http://trpc.biz/response-paper-to-licensing-framework-for-third-generation-mobile-services/ and for the 3G debate in Hong Kong, see John Ure (2003) 'Deconstructing 3G and reconstructing telecoms' (Telecommunications Policy) see http://trpc.biz/wp-content/uploads/2002_04_TRPC_Deconstructing3G_Workingpapers.pdf

[6] John Ure (2002) 'Auctions, Sunk Costs and Other Arcane 3G Issues' in Robin Mansell, Rohan Samarajiva and Amy Mahan (2002) Networking Knowledge for information Societies: Institutions & Intervention, Delft University Press: a festschrift for Professor William Melody: http://trpc.biz/wp-content/uploads/2002_06_AuctionsCosts_3GIssues_Commentary.pdf

gold-plating of costs, the Averch-Johnson problem.[7]

It can equally be argued that even where network coverage is already good, the benefits of ubiquitous 4G broadband wireless access (BWA) to the economy will be substantial in stimulating a host of ancillary developments in the areas of apps, content, marketing and business analytics, convergent media, a shift towards "smart cities", etc.

The competitive advantage of locations with BWA is held up as the by-product of technological progress and business innovation. But the question remains, what should be the priority goals of an auction? And what auction designs are ideally suited to achieving them?

SMRA and CCCA

Auctions have a long history with many variants, for example the 'English' ascending open-bid auction that is commonly used for art sales where each bidder knows the other bids and can outbid, and its opposite, the 'Dutch' auction which starts with a high asking price and descends until someone bids. It is fast, the first bid wins.

Auctions can have a reserve price, they can be preceded by a qualification round, in the case of spectrum they can impose caps to prevent one bidder sweeping the entire market; conditions can be imposed such as network rollout targets, and so on. Prior to 2007 the most common form of auction for radio spectrum was the simultaneous multiple round ascending auction (SMRA)[8] but then Ofcom in the UK published a consultation document on the combinatorial clock auction (CCA) proposed by Prof Peter Cramton.[9]

Where there are multiple frequencies available across different bands the CCA is becoming the auction of choice for many regulators. It has been used in Austria, Denmark, Ireland, the Netherlands, Switzerland and the UK and both Australia[10] and Canada[11] will use CCA for its digital dividend auction of frequencies in the 700MHz and 2.5GHz bands. The FCC has not yet applied CCA.[12]

IDA is proposing to use a 'Clock Plus auction' which Sweden and India have both used in their 4G spectrum auctions.[13]

[7] http://www.clt.astate.edu/crbrown/averch.ppt

[8] SMRA usually involves sealed bids for each round, the auctioneer upping the minimum bid for each round by 5% or 10% of the maximum from the previous round until there are no more bids for any of the lots.

[9] See Ofcom (2007) 'Discussion document on the award of available spectrum 1452 – 1492 MHz: Auction design' http://stakeholders.ofcom.org.uk/binaries/consultations/1452design/summary/1452design.pdf and Lawrence M Ausubel, Peter Cramton and Paul Milgrom (2006) 'The Clock-Proxy Auction: A Practical Combinatorial Auction Design' in Peter Cramton, Yoav Shoman and Richard Steinberg (eds.) *Combinatorial Auctions*, Chpt 5, pp. 115-138, MIT Press

[10] ACMA 'Spectrum auction: e-Bulletin' 2012 www.acma.gov.au/webwr/_assets/main/lib312060/ebulletin_september_11_final.doc

[11] Industry Canada (2012) 'Consultation on a Licensing Framework for Mobile Broadband Services (MBS) — 700 MHz Band' http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10363.html and http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10360.html

[12] Up to now FCC has used variants of SMRA, but was severely criticised by the Common Carriers Association for a poor outcome of the 2007 auction - see http://news.cnet.com/8301-13578_3-57522021-38/competitive-carriers-warn-fcc-to-learn-from-auction-mistakes/

[13] IDA (2012) 'Proposed Framework for the Reallocation of Spectrum for 4G Telecommunication Systems and Services' p.15 http://www.ida.gov.sg/doc/Policies%20and%20Regulation/Policies_and_Regulation_Level2/20060530180904/publicconsult_4Gspectrum.pdf

Combinatorial Clock Auction

The 'pure' CCA uses rules based upon the 'revealed preferences' of bidders to ensure that bidding is truthful and bidders do not game the system. Once the preferences of a bidder have been revealed subsequent rounds of bidding must conform.

Box 2: CCA Rounds

Round 1: application stage for bidders including initial deposit

Round 2: an administrative pre-qualification stage to approve the potential bidders legally, technically, operationally, commercially and financially

Round 3: principal clock bidding process commences. Bidders may make bids on any combination of spectrum lots (e.g. frequency bands) and categories of spectrum lots (e.g. FDD, TDD, low-power, high-power, etc.) subject to a frequency contiguity requirement. Each lot and category of lots buys the bidder 'eligibility' points.

The auctioneer determines whether the bids will be open (transparent) or sealed and summarized by the auctioneer as minimum bid levels for the next round of bidding. CCA uses rules based upon the 'revealed preferences' of bidders to ensure that bidding is genuine and not gaming-the-system.

Once the preferences of a bidder have been revealed in a round of bidding, subsequent rounds of bidding cannot violate those revealed preferences. In other words, no-one can bid for a combination of lots and categories of lots which exceed the eligibility points from the previous round.

However, as the bidding progresses there will be changes in relative prices between lots and categories of lots and a 'monotonic' eligibility rule becomes inflexible to these changes, so a revised proposal for the design of the auction may allow bidders to switch to new combinations that exceed in the number of lots the previous combinations, but they cannot exceed in terms of eligibility points.[14]

At the end of each round of the clock, the auctioneer will assess if excess demands remains for any of the lots and categories of lots. When no excess demand exists, when there are no further bids for combinations of spectrum bands, the stage 3 closes. Deposits may need to be topped up between bidding rounds.

Round 4: supplementary bidding is a sealed bid process. Bidders may make multiple but mutually exclusive bids for the combinations previously revealed as their preferences. This is to ensure that the final award of spectrum allows for assignment of contiguous frequencies given that it is unlikely bidders would ever prefer non-contiguous frequencies within bands. It also ensures that no bidder ends up with more spectrum than they bargained for, the aggregation problem.

Throughout the bidding process, spectrum caps may apply. Deposits may have to be topped up again. The auctioneer than uses an algorithm to determine a set of winning combinations, one only to each bidder, that satisfies the highest values bid within the constraints of policy, such as competition constraints.

Note this is a determination of the *number* of lots and lots in categories bid for and not necessarily of the specific frequencies of each lot. In the case of generic lots, such as paired spectrum and low-power requirements or bands with universal service obligations, the assignment of specific frequency bands takes place in Round 5 to ensure contiguous spectrum. The 'base' price is determined according to the 'second price' rule, that is the second highest price bid but the award goes to the highest bidder. The principle at stake here is to ensure that winners pay minimum prices, subject to the condition that *no losing bidder or combination of*

[14] This is the proposal of Lawrence M. Ausubel and Peter Cramton 'Activity Rules for the Combinational Clock Auction' http://www.ausubel.com/auction-papers/ausubel-cramton-activity-rules-for-cca.pdf

bidders including winners and losers) would be willing to pay more than they have already bid. This is seen as reducing any incentive for bidders to manipulate their bids.

Round 5: an assignment stage determines the actual distribution of frequencies among winning bidders. In some cases bidders can make a sealed bid for generic paired lots to ensure they are contiguous with specific frequencies, for example, with frequencies the bidder already operates or has won in the previous bidding. Prices from the assignment stage are added to the 'base' prices from the supplementary bidding stage.
Note: Based upon Ofcom (2011) 'Consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues' [15]

For the auctioneer, the major technicality is to determine the eligibility points per lot and category of lots. Ofcom based their assessment on recent auctions as shown in Table 3.[16]

Table 3

Country	**Approximate UK equivalent prices per lot using prices/MHz/pop (£m)**[1]			**Inferred eligibility points rounded)**[2]			
	800 MHz (2x5MHz lot)	2.6GHz paired (2x10 MHz lot)	2.6 GHz unpaired (50MHz lot)	*800MHz Germany*	*800 MHz Sweden*	*2.6GHz paired*	*2.6 GHz unpaired*
Austria		25	50	*14*	*8*	*1*	*2*
Germany	380	23	54	*18*		*1*	*2*
Denmark		133	267	*3*	*2*	*1*	*2*
Finland		3	11	*114*	*68*	*1*	*4*
Sweden (800MHz)	220						
Sweden (2.6GHz)		154	119	*3*	*2*	*2*	*1*
Norway		26	111	*14*	*8*	*1*	*4*

1. Values per lot for Austria and Denmark established from overall band value on a pro rata basis per MHz assuming 40MHz of fully useable spectrum in the 2.6GHz unpaired lot
2. Values in italics indicate values for 800MHz eligibility extrapolated from German and Swedish auction prices for indicative purposes

[15] Ofcom (2011) '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/combined-award/summary/combined-award.pdf
[16] For eligibility points in Canada's CCA see http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10369.html#p7.3

Choosing 5MHz lot sizes for sub-1GHz bands assumes that no commercial operator would want to enter the market with less. Bidding for contiguous lots builds up the spectrum real estate for the bidder.

Using the data from Table 3 Ofcom estimated in its Consultation Paper[17] the eligibility points for spectrum being auctioned in the 800MHz and 2.6GHz bands as shown in Box 3:

Box 3: Eligibility Points

- 800MHz - any lot of 2x5MHz = 30 points per lot
- 2.6GHz paired - any lot 2x10MHz in high-power category = 10 points per lot
- 2.6GHz paired - either 2x10MHz or 2x20MHz in a low-power category = 10 points or 20 points per lot
- 2.6GHz unpaired – single lot of 50MHz = 20 points for the lot
- Any other < 1GHz paired lots in case of relinquishment – 2x5MHz lots = 30 points per lot
- Any other > 1GHz paired lots in case of relinquishment – 2x10MHz lots = 10 points per lot

The CP measures eligibility points in units of 5MHz lots for frequencies below 1GHz, but with so many lots this would significantly increase the complexity of the combinational bidding process. The CP therefore recommends the use of 10MHz lots in the auction. In regard to the 50MHz unpaired spectrum in the 2.6GHz band, Ofcom recommended one lot, noting that 5MHz guard bands were required at the lower and upper limits. Breaking 50MHz into smaller lots could give rise to multiple guard bands and significantly reduced useable spectrum.

Whenever spectrum auctions are designed, minutiae considerations such as these inevitably add complexity to complexity.

CCA is a more complex method of auctioning than SMRA, but variants of it are becoming the auction of choice because it appears to reduce inefficiencies. The principal danger is the aggregation problem of 'stranded' frequencies where a winning combination may include non-contiguous frequencies. CCA rules prohibit such combinations from being bid. The SMRA can be similarly constrained when it allows for bidding for 'packages' of frequencies.

It can also include 'augmented switching rules' which allow bidders to switch bids in response to changes in the relative prices of frequencies, but only if the withdrawn bid was the highest for that lot and the new bid is for a lot where another bidder is highest.

As there is no penalty for withdrawing a bid this increases the flexibility of the process. If there is 'package' bidding then aggregation of contiguous frequencies is facilitated by packaging adjacent lots.

An alternative way to tackle the aggregation problem is to permit post-auction spectrum trading, but an auction process that avoids the problem from the beginning it to be preferred. The Ofcom CP discusses how far different auction designs can mitigate various types of risk. Table 4 summarises these points.

[17] http://stakeholders.ofcom.org.uk/binaries/consultations/1452design/summary/1452design.pdf p.103

Table 4		
Key inefficiency issues	**SMRA variants**	**CCA**
Substitution and aggregation risks	Risks are significant even with limited combinational ('package') bidding allowed. With package bidding added to augmented switching and the computational complexity of setting minimum prices at the end of end round grows	As all packages are mutually exclusive there is little danger of aggregation risk, of bidders ending up with stranded frequencies
Bid shading or under-bidding	High risk under augmented switching as bidders wary of stranded frequencies	The risk is minimalized due to the final price condition that no losing bidder or combination of bidders including winners and losers) would be willing to pay more than they have already bid.
Threshold problem of bidders demanding few lots cannot displace bidders demanding many lots	The problem arises when packages of lots are up for bidding	The problem exists because packages are bid for, but the clock rounds can help small bidders coordinate better
Complexity and strategic bidding	Many bidders and many lots can give rise to complex bidding strategies; a package approach simplifies bidding but price information may not be very transparent	Package bidding is more straightforward and clock rounds reveal price information in preparation for the supplementary bidding round
Unsold lots	With augmented switching the risk of stranded frequencies can result in unsold lots, but bidding rules can adjust for this.	Mutually exclusive bidding for packages reduces this risk, but lack of competition between bidders can still result in unsold lots
Strategic demand reduction to buy less but at lower overall prices	Prices across lots and packages need not be equal so scope of gain for demand reduction may not exist	Prices across lots and packages need not be equal so scope of gain for demand reduction may not exist

Singapore's Clock Plus Proposal

The IDA has proposed a simplified version of the CCA known as Clock Plus. IDA will package all frequencies into one of 3 generic lots as shown in Table 5. A total of 14 + 8 + 6 = 28 lots are available for combinational bidding.

Table 5			
Category	**Lots available**	**Spectrum range (MHz)**	
1800 MHz	14 x 2x5MHz (total 2 x 70MHz)	**Lower band**	**Upper band**
		1715 - 1785	1810 - 1880
2.5 GHz FDD	8 x 2x5MHz (total 2 x 40MHz)	**Lower band**	**Upper band**
		2500 - 2560	2620 - 2680
TDD	6 x 10MHz (total 60Mhz)	2300 – 2330 and 2570 - 2600	
Note: Paired FDD spectrum in 1800MHz and 2.5GHz; unpaired TDD spectrum in 2.3GHz and 2.5GHz			

Given that all bids are for generic categories, there is no need for a supplementary (Round 4) of bidding, and the assignment (Round 5) stage ensures that frequencies are contiguous. Winning bidders within categories will be invited to express their preferences for particular contiguous frequency lots.

Where there is competition a final sealed bid will be held and "IDA will allocate specific spectrum lots based upon the highest value of the combination of bids." (p.16).

This implies that it will not necessarily be highest bid for a particular set of frequencies that wins but the combination of all bids that maximizes the value of the

auction. No reference is made by IDA to a 'second pricing' rule.

Table 6 is an illustration of choosing the highest bids versus choosing the bids that maximize total value. Bidder 1 is the highest bidder (10) for lot A. Bidder 1 is also the highest bidder (9) for lot B but under the rule that each bidder can only win one lot (a spectrum cap) the next highest bidder is bidder 2. Bidder 3 is highest bidder (9) for lot C. The sum total of winning bids is therefore 26; but the combination of bids that maximizes value assigns lot A to bidder 2, lot B to bidder 1 and lot C to bidder 3 producing a total value of 27.

Table 6					
Bidder	**Lot A**	**Lot B**	**Lot C**	**Highest Bid**	**Highest Value**
1	10	9	8	10	9
2	9	7	8	7	9
3	7	6	9	9	9
Value				**26**	**27**

PPDR and the Competition for Spectrum

As discussed at the IIC Asia Forum on the digital dividend (see http://trpc.biz/the-digital-dividend/ to download the Briefing Paper) new technologies such as cognitive radio, smart antennae, spectrum aggregation techniques which combine frequencies from different bands are opening up possibilities for frequency sharing in spectrum management.

The coming digital dividend of large swathes of spectrum in the UHF band especially raises the question: which services should be allocated these frequencies and how should the assignment process take place?

The decisions have to include what should be allocated as licensed and unlicensed spectrum, and of licensed spectrum which services should be primary users and which secondary users. Among primary users of licensed spectrum the odds globally and regionally are very much in favour of 4G cellular standards such as LTE-Advanced.[18]

Fighting for a slice of unlicensed spectrum is the White Space TV devices lobby following the lead in the USA and trials in the UK and in Singapore.[19]

But there is another contender of major public interest, and that is PPDR (public protection and disaster relief) services. When everything else is moving into broadband and taking advantage of new media technologies, PPDR services remain stuck in narrowband on the following frequencies: 146-174MHz, 350-470MHz, 806-824/851-869MHz.

In an age of ubiquitous broadband wireless for consumers, it is possible for passers-by to take video and audio recordings of accidents or threats to public safety and post them immediately on YouTube or other social media. It seems wrong that public emergency services are not equipped to do the same.

The immediate concern of emergency teams would be to convey information to command centres, but it is also in the public interest to be able to disseminate similar information if necessary via social media to give early warnings.

[18] But China has announced the use of TDD 2.6GHz for its TD-LTE standard: http://www.prnewswire.com/news-releases/china-launches-26ghz-tdd-spectrum-planning-at-td-lte-technology-and-spectrum-workshop-in-dubai-allocating-26ghz-frequency-band-ranging-from-2500-2690hz-and-the-entire-band-of-190mhz-for-td-lte-174311531.html

[19] See media release http://www.a-star.edu.sg/Media/News/PressReleases/tabid/828/articleType/ArticleView/articleId/1705/Default.aspx

The Phoenix Center for Advanced Legal and Economic public Policy Studies[20] conducted a study in 2010-2011 in the US on the impact of allocating 2x10MHz of contiguous spectrum in the UHF band, the so-called D Block. They conducted a cost-benefit analysis, looking at the revenues forgone by not auctioning the 20MHz D Block of contiguous spectrum to commercial users versus the benefits accruing from assigning the D Block to PPDR.

Their estimate of the revenues from an auction to commercial users ranged from USD1 – 3 billion, whereas the opportunity cost of not assigning to PPDR ranged from USD2 – 6 billion, depending upon assumptions. Offering non-contiguous 10MHz blocks to PPDR would incur USD4 billion in deployment charges and offer inferior performance.

The study also found that experiments in spectrum sharing between PPDR and other users were a failure. Besides the complexities involved of ensuring PPDR priority when required, placing an emergency services encumbrance on spectrum in an earlier D Block auction had raised only USD472 million or just 14% of the estimated USD3.3 billion value of the same spectrum unencumbered.

Issuing spectrum to PPDR and other public services calls for an alternative pricing model if the frequencies are not open to the rigours of competitive demand. Shadow pricing, otherwise known as administered incentive pricing (AIP) has been a popular alternative to auctions among governments looking for market-type approaches.

AIP searches for next most profitable usage of the frequencies in question, otherwise known as the opportunity cost or the spectrum fees forgone by the regulator for not auctioning the spectrum competitively.

But there are estimation problems with that approach. The same spectrum auctioned at different times can fetch different prices, and the spectrum sold on a the secondary market where buyers are looking for profit margins may value the frequencies at less than they were initially bought and possibly hoarded.[21]

While regulators want to ensure that public services such as PPDR have an incentive to use spectrum efficiently, it is difficult to imagine confiscating frequencies if the integrity of the service is at risk. An administrative approach that reviews operational use of spectrum may be more appropriate. Sharing the frequencies that remain unused outside of emergencies or at certain times of day or when no special public events are taking place that may require emergency services on standby, is another option, but the evidence from the USA seems to suggest that does not work well, if only because there may be few takers if the spectrum is encumbered.

[20] http://www.phoenix-center.org/PolicyBulletin/PCPB26OnePagerFinal.pdf

[21] See also ITU (2012) 'Exploring the Value and Economic Valuation of Spectrum' Broadband Series http://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_SpectrumValue.pdf

Other Regulatory Innovations

Over recent years several market-focused innovations have been introduced into spectrum management regulation,[22] most notably spectrum trading and class licensing.[23] Class licensing can cover many things, but in this case it can mean being able to offer public services using unlicensed spectrum. White space services could fall into this category, although more cautious regulators may still insist on licensed spectrum.

The radio interference issues are being addressed in the US by the creation of spectrum usage data bases; so far it seems with good results. Both the UK and Singapore are adopting a similar approach.

Spectrum trading in theory should not be necessary if auctions result in the most efficient assignment of frequencies between service providers, but in the normal course of events business plans change as do markets and consumer preferences.

Regulations governing takeovers and mergers are one safeguard for the public, but a more flexible approach is spectrum trading which can involve changes in ownership or leasing or sub-leasing arrangements. See figures 1 and 2.[24]

Ofcom in the UK has recently proposed spectrum trading for mobile network licences in the 900MHz, 1800MHz and 2100MHz bands.[25]

Spectrum trading falls short of spectrum liberalization where the latter may involve changes of service provision: that is an allocation rather than an assignment issue.

Where regional or global harmonization is desirable, this can be a problem although future technology developments may one day address the issue.

Where harmonization is not a problem then spectrum liberalization is more feasible. Norway, for example, has liberalized all spectrum over 2GHz.

Several jurisdictions permit spectrum trading to in some measure, such as Australia and New Zealand, the UK and the US and several South American countries. The evidence to date shows overwhelmingly that where trading is permitted the most traded part of the spectrum and the highest value of trades is in public wireless cellular frequencies. [26]

[22] For a useful review, see Dr Bob Horton (2012) 'Spectrum Policy in a Hyperconnected Digital Mobile World' GSR 2012 Discussion Paper http://www.ictregulationtoolkit.org/en/Publication.4030.html

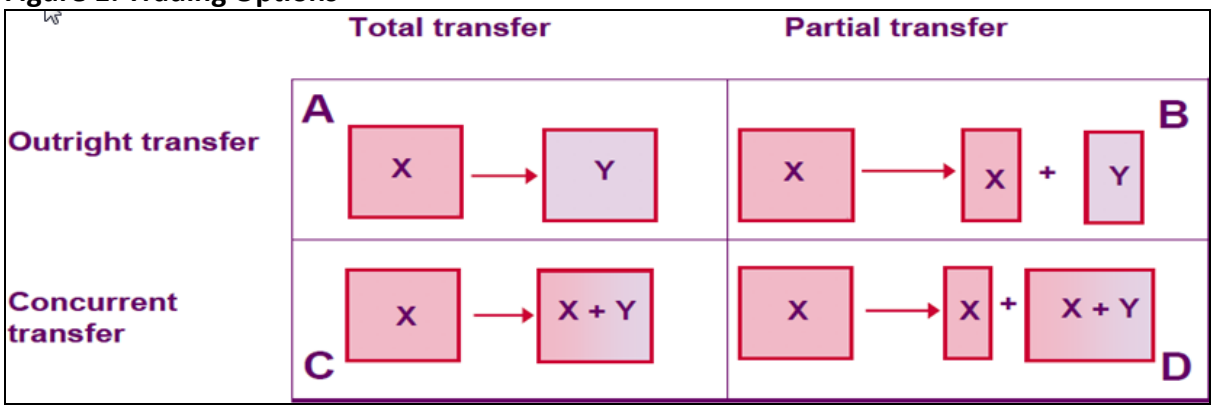
[23] See Ofcom (2011) 'Notice of proposals to make 900 MHz, 1800 MHz & 2100 MHz public wireless network licences tradable' http://stakeholders.ofcom.org.uk/binaries/consultations/trading-900-1800-2100/summary/900-1800-2100.pdf

[24] See http://trpc.biz/spectrum-liberalization/

[25] Ofcom (2011) http://stakeholders.ofcom.org.uk/binaries/consultations/trading-900-1800-2100/summary/900-1800-2100.pdf

[26] For details, see J.Ure (2010) 'Spectrum Liberalization' at http://trpc.biz/spectrum-liberalization/

Figure 1: Trading Options



Source: Ofcom

Figure 2: Trading Options