

Evolution of Spectrum Auction from 3G to 5G in Hong Kong

香港從 3G 到 5G 頻譜拍賣的演變

Office of The Communications Authority

通訊事務管理局辦公室

Introduction

Radio spectrum is scarce public resource. To promote the efficient allocation and use of it, it is a prevailing government policy to adopt a market-based approach in the management of radio spectrum wherever there are likely to be competing demands from providers of non-Government services, unless there are overriding public policy reasons to do otherwise. Assignment by auction is regarded as the most appropriate market-based approach for the assignment of spectrum resources as it provides a fair, transparent, objective and economically efficient means to determine to whom and at what price the spectrum should be assigned. On the other hand, for spectrum where there are no competing demands such as those in the high frequency bands (such as the 26/28 GHz bands) with ample supply of spectrum, administrative assignment will be used.

Since 2001, the Communications Authority (“CA”) has conducted 13 spectrum auctions, raising a total of \$21.5 billion for the Government Revenue.

引言

無線電頻譜是珍貴的公眾資源。為了促進有效分配和使用無線電頻譜，政府的一貫政策是，當非政府服務提供者可能對相關頻譜有競爭性需求時，除非有凌駕性的公共政策考慮因素，當局會採用市場主導的方式來管理頻譜。藉拍賣方式作指配被視為指配頻譜資源的最合適市場主導方式，因為它提供一個公平、透明、客觀和具有經濟效益的方法，以決定頻譜應指配予誰及以什麼價格指配。另一方面，對於沒有競爭性需求的頻譜，如那些位於高頻帶（如 26/28 吉赫頻帶）並有充足供應的頻譜，則會採用行政方式指配。

自 2001 年以來，通訊事務管理局（通訊局）已進行了 13 次頻譜拍賣，為政府帶來 215 億元收入。

	Date 日期	Frequency Band (Service) 頻帶（服務）	Amount of Spectrum Auctioned (MHz) 拍賣頻譜數量（吉赫）	Spectrum Utilisation Fee (\$ million) 頻譜使用費（百萬元）
1	October 2001 2001 年 10 月	1.9 - 2.2 GHz (3G) 1.9 - 2.2 吉赫 (3G)	138.4	5,231
2	October 2007 2007 年 10 月	850 MHz (CDMA 2000) 850 兆赫 (CDMA 2000)	15	76
3	January 2009 2009 年 1 月	2.5/2.6 GHz (4G) 2.5/2.6 吉赫 (4G)	90	1,536
4	June 2009 2009 年 6 月	1800 MHz (4G) 1800 兆赫 (4G)	9.6	188
5	June 2010 2010 年 6 月	700 MHz (Mobile TV) 700 兆赫 (Mobile TV)	8	175
6	March 2011 2011 年 3 月	850/900 MHz (3G) 850/900 兆赫 (3G)	20	1,952
7	February 2012 2012 年 2 月	2.3 GHz (4G) 2.3 吉赫 (4G)	90	470
8	March 2013 2013 年 3 月	2.5/2.6 GHz (4G) 2.5/2.6 吉赫 (4G)	50	1,540
9	December 2014 2014 年 12 月	1.9 - 2.2 GHz (3G + 4G) 1.9 - 2.2 吉赫 (3G + 4G)	49.2	2,421
10	December 2018 2018 年 12 月	900/1800 MHz (2G + 3G + 4G) 900/1800 兆赫 (2G + 3G + 4G)	120	6,000

	Date 日期	Frequency Band (Service) 頻帶 (服務)	Amount of Spectrum Auctioned (MHz) 拍賣頻譜數量 (吉赫)	Spectrum Utilisation Fee (\$ million) 頻譜使用費 (百萬元)
11	October 2019 2019 年 10 月	3.5 GHz (5G) 3.5 吉赫 (5G)	200	1,006
12	October 2019 2019 年 10 月	4.9 GHz (5G) 4.9 吉赫 (5G)	80	240
13	November 2019 2019 年 11 月	3.3 GHz (5G) 3.3 吉赫 (5G)	100	665
	Total: 合共:		970.2	21,500

When talking about “auction”, people might think of a vigorous bidding scene with bidders raising hands and shouting “I offer \$1 million”, “\$2 millions for me”, “\$3 millions ...” in an auction room. In reality, this is not the way how spectrum auctions are conducted in Hong Kong and many other jurisdictions. To avoid potential collusion where bidders may signal to each other in the course of bidding, bidders of spectrum auctions are physically separated without meeting one another. Then, how are spectrum auctions actually conducted in Hong Kong?

From “dark-room” auction to Internet-based auction platform

The first spectrum auction in Hong Kong was conducted in 2001 for the four 3G licences. The bidding process was designed to require each bidder to have its representatives confined in a dedicated room for making bids, and such arrangement is referred to as “dark-room” auction. The auctioneer delivered messages to bidders through the one-way audio broadcast system. Bidders submitted bids by faxing the bidding forms to the auctioneer. However, the “dark-room” auction was not conducted eventually as the number of bidders was equal to the number of 3G licences at the outset. Nevertheless, in order to determine the order of selecting the specific frequency blocks among the four bidders, a sealed bid was conducted.

Later in 2009, the spectrum auction mechanism was further enhanced and an Internet-based auction platform was introduced. Instead of being confined in the “dark room”, bidders could stay in their own offices to place their bids. The following figure shows a schematic set-up for the Internet-based auction platform.

當談到「拍賣」時，我們可能會想到一個激烈的競投場面，眾競投人在拍賣室舉手高喊「我出價 100 萬元」，「我 200 萬元」，「300 萬元 ...」。事實上，這並非在香港和許多其他司法管轄區進行頻譜拍賣的形式。為了避免競投人可能在競投過程中互傳訊息以進行合謀行為，頻譜拍賣的競投人會被分隔開，令他們不可見面。那麼，香港的頻譜拍賣實際上是如何進行呢？

從「黑房」拍賣到互聯網拍賣平台

香港首次頻譜拍賣於 2001 年進行，拍賣四個 3G 牌照。競投過程的設計，是規限每名競投人的代表須位處在其專用的房間內進行競投，這種安排被稱為「黑房」拍賣。拍賣官通過單向語音廣播系統向眾競投人傳遞資訊。每名競投人則填寫競投表格並傳真給拍賣官來提交投標。然而，由於一開始競投人的數目已等於 3G 牌照的數目，「黑房」拍賣最終沒有進行。不過，是次拍賣進行了一次暗標方式競投，以決定四名競投人選擇特定頻組的次序。

之後在 2009 年，頻譜拍賣機制進一步作出改善，並引進了互聯網拍賣平台。競投人可以位處在自己的辦公室內進行競投，而無須被規限於「黑房」裡。下圖顯示互聯網拍賣平台的設置。

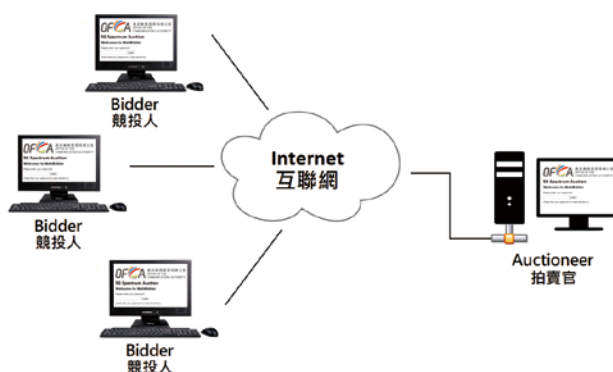


Figure 1: Schematic diagram of the Internet-based auction platform
圖 1: 互聯網拍賣平台的示意圖

As illustrated in the table below, the use of Internet-based auction platform is more effective and efficient for both the auctioneer and the bidders when compared to the “dark-room” auction.

如下表所示，對拍賣官和競投人來說，使用互聯網拍賣平台較「黑房」拍賣更方便和更有效率。

	Dark-room Auction 「黑房」拍賣	Internet-based Auction Platform 互聯網拍賣平台
Means 方法	Mainly using fax machine 主要使用傳真機	Mainly using computers and Internet-based auction software 主要使用電腦和互聯網拍賣軟件
Bidder's venue 競投人所處地點	Designated bidding rooms assigned by the auctioneer 拍賣官指定的競投室	Bidders' own offices 競投人自己的辦公室
Communication between the auctioneer and bidders 拍賣官與競投人之間的通訊	Audio broadcast system 語音廣播系統	Internet-based auction software 互聯網拍賣軟件
Bidding price 競投價格	Bidders offer their bidding prices 競投人自由出價	Auctioneer to determine the bidding price 拍賣官設定每一回合的競投價格
Record of the bidding activity 競投活動記錄	Using videotape-recording 保存於錄影帶上	Records kept in the Internet-based auction platform 保存於互聯網拍賣平台
Efficiency 效率	<ul style="list-style-type: none"> - Intensive resources are required - Inconvenient to both auctioneer and bidders - Longer duration for the whole auction - 需要大量資源 - 對拍賣官和競投人都不方便 - 整個拍賣所需的時間較長 	<ul style="list-style-type: none"> - Less resources are required - More convenient to both auctioneer and bidders - Shorter duration for the whole auction - 所需資源較少 - 對拍賣官和競投人都較方便 - 整個拍賣所需的時間較短

Use of a variety of auction formats for 5G spectrum

Apart from the advantages mentioned above, the Internet-based auction platform can also support different auction formats, enabling the CA to adopt the most suitable format for each auction exercise.

The most commonly used auction format is simultaneous multi-round ascending (“SMRA”) format, which allows bidders to bid for multiple blocks at the same time, with the price of each frequency block being adjusted independently and each bidder allowed to switch its choice of specific frequency blocks during the bidding. The auction ends when there is no further bid for any block, with each bidder acquiring their preferred frequency blocks based on their own business consideration. The SMRA format was well received by the local industry and had been adopted for auctions of spectrum in various bands from 2009 to 2018 used for provision of 3G and 4G services.

採用不同拍賣方式拍賣 5G 頻譜

除了上述好處外，互聯網拍賣平台還可以支援不同的拍賣方式，讓通訊局在每次拍賣可採用最適合的拍賣方式。

最常用的拍賣方式是「同時多輪增價」，它容許競投人同時競投多個頻段，而每個頻段的價格都會獨立調整，競投人可在競投期間更改其選擇的特定頻段。當所有頻段再沒有新的出價時，拍賣便隨之結束，而結果是每名競投人根據其業務考慮投得其心儀的頻段。「同時多輪增價」拍賣方式獲業界廣泛接受，並在 2009 至 2018 年期間採用來拍賣位於不同頻帶的頻譜，以提供 3G 和 4G 服務。

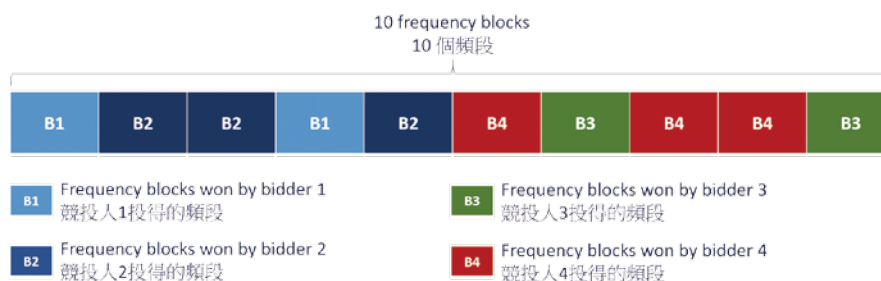


Figure 2: Auction result using SMRA format
圖 2: 「同時多輪增價」拍賣方式的拍賣結果

However, SMRA cannot guarantee that successful bidders would be assigned with contiguous frequency blocks. Non-contiguous frequency block assignment may reduce spectral efficiency for use of spectrum. When there are a large number of frequency blocks to be auctioned and where contiguous assignment is important, clock auction format is preferred to SMRA. During the clock auction, bidders only bid for the number of frequency blocks they want to acquire at the first stage known as the quantity phase. Right after this, the specific assignment of which contiguous frequency blocks to each bidder will be determined by means of a sealed-bid in the second stage, known as assignment phase. The figures below illustrate how the two phases work.

然而，「同時多輪增價」拍賣方式並不能保證成功競投人可獲指配毗連的頻段。非毗連頻段的指配可能會降低頻譜使用效率。當需要拍賣大量頻段，而毗連指配是重要時，「時鐘」拍賣方式會比「同時多輪增價」拍賣方式優勝。在「時鐘」拍賣方式的第一階段，競投人只競投他們想要獲得的頻段數量（稱為「數量階段」）。其後在第二階段，當局則以暗標方式去決定每名競投人所獲指配的特定毗連頻段（稱為「指配階段」）。下圖說明這兩個競投階段是如何操作。



Figure 3: Quantity phase where bidders bid for the number of frequency blocks
圖 3: 競投人在「數量階段」競投頻段數量



Figure 4: Assignment phase where bidders bid for the assignment of specific contiguous frequency blocks
圖 4: 競投人在「指配階段」競投特定毗連頻段的指配

In 2019, both SMRA and clock auction formats were adopted for the auctions of 5G spectrum in various bands. Taking into account the large number of frequency blocks in the 3.3 GHz and 3.5 GHz bands (ten blocks in the former and twenty blocks in the latter), the clock auction format was adopted to enable contiguous assignment of frequency blocks to every successful bidder. For the 4.9 GHz band auction, as only two frequency blocks were put for auction, SMRA auction format was adopted.

在 2019 年，通訊局採用了「同時多輪增價」及「時鐘」拍賣方式來拍賣位於不同頻帶的 5G 頻譜。考慮到 3.3 吉赫和 3.5 吉赫頻帶內有大量的頻段（前者為 10 個頻段，後者為 20 個頻段），通訊局採用了「時鐘」拍賣方式，將毗連頻段指配給每名成功競投人。至於 4.9 吉赫頻帶的拍賣，由於只有兩個頻段需要拍賣，通訊局採用了「同時多輪增價」拍賣方式。

Conclusion

Spectrum auctions evolve over time in response to the specific requirements of each spectrum assignment exercise. The CA strives to ensure that the best suited bidding arrangements and formats are adopted with a view to improving the effectiveness of auctions and ensuring that spectrum as a scarce public resource will go into the hands of those who can make the best use of it. There will be another round of spectrum auctions in 2021 for assignment of spectrum in various frequency bands to support the development of 5G services. We look forward to the active participation by interested industry players. ●

總結

頻譜拍賣會隨著時間而演變，以滿足每次頻譜指配的具體要求。通訊局致力確保採用最合適的拍賣安排和方式，以提高拍賣的效益，並確保頻譜作為珍貴的公眾資源，能交予最有效使用者之手中。在 2021 年，通訊局將舉行另一輪頻譜拍賣，指配位於不同頻帶的頻譜以支援 5G 服務的發展。我們期待有興趣的業界人士積極參與。 ●