Reply Analysis of
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Introduction

We have been asked by counsel for AT&T to respond to comments filed on the FCC's proposed incentive auctions. In Che, Haile and Kearns (2013) (henceforth "CHK") we provided extensive comments on the FCC's Notice of Proposed Rulemaking and accompanying proposal of Milgrom, Ausubel, Levin and Segal (2012) (henceforth "MALS"). Many of our responses to comments by others will refer to our discussion and proposals in CHK.

In general, most commenters agreed with our assessment that the MALS proposals regarding the forward and reverse auctions offered a strong baseline from which to build a final auction design.

For the forward auction, commenters generally agreed with us that the MALS design offers substantial improvements over the Simultaneous Multi-Round ("SMR") auction used in prior FCC spectrum auctions. There was general support for the use of clocks and generic licenses in particular. Many commenters also agreed with our concern about the exposure problem, which remains unaddressed by the MALS auction design and is likely to limit auction revenue, distort bidding behavior, and lead to inefficient allocations. On the other hand, some commenters expressed concern about the potential for introducing package bidding to the forward auction. In particular, some view package bidding as inherently too complex. Others object to package bidding based on a view that package bidding discriminates against small bidders.

A specific package bidding proposal was offered in CHK. As we explain below, our Clock Package Auction (CPA) proposal avoids the pitfalls underlying the commenters' concerns. The CPA alters the MALS design in only three ways:

1. It expands the set of objects offered to include a small number of packages, using a geographically driven hierarchical package design closely tied to the actual structure of bidder complementarities between spectrum licenses.
2. It specifies how excess demand can then be properly calculated.
3. It provides a rule governing price clocks that ensures that package prices are additive in the prices of the package components when possible.

The CPA proposal does not add significant complexity to the MALS auction design. Indeed it simplifies bidding for most bidders by providing a means of addressing the exposure problem, thereby avoiding the need for schemes by package bidders to reduce their exposure risk and

schemes by component bidders seeking to take advantage of others' exposure risk. Such strategies have been prevalent in past FCC spectrum auctions and create high demands on the sophistication of bidders seeking to bid optimally.

While this yields an important reduction in complexity relative to the MALS proposal, the MALS proposal's use of price clocks and generic licenses already simplifies bidding substantially relative to the SMR auction design. Thus, the CPA proposal design in fact offers substantial reductions in complexity relative to past FCC auctions.

We also explain below that the CPA does not discriminate against small bidders. Indeed the opposite is true. Contrary to common assertions that package bidding creates a threshold problem, we show that the threshold problem already arises in the MALS auction. Further we see no new potential for a threshold problem in the CPA that does not already exist in the MALS auction. In fact, there is at least one sense in which the CPA reduces the severity of the threshold problem relative to the MALS design and, *a fortiori*, the SMR auction design.

On the other hand, the CPA offers two specific corrections of biases against small bidders that exist in the MALS auction design. One is the exposure problem. Although exposure risk would affect almost all bidders in the MALS auction, it is important to recognize that small bidders seeking to enter the market are among those that need protection against this risk. The CPA offers such protection. The second bias against small bidders in the MALS auction design is the "overflow problem." As discussed in CHK, this flaw in the MALS design will tend to force small bidders out of the market by raising the prices they must pay even when their demands are not a source of scarcity. The CPA eliminates the overflow problem.

We also discuss general concerns that the CPA would be susceptible to incentives for manipulative bidding. We consider several specific types of manipulative strategies that might be attractive in other types of auctions and demonstrate that the specific rules of the CPA make these strategies unattractive to bidders. We see no new incentives for bid manipulation in the CPA relative to the MALS auction. Indeed, because elimination of the exposure problem eliminates the need for bidding schemes aimed at minimizing exposure risk (or exploiting that of other bidders), there may be fewer incentives for manipulative bidding in the CPA than in the MALS auction.

Finally, we address concerns about the reverse auction design raised by some commenters. We argue below that from a bidder's perspective there is no significant difference between a sequential and interleaved auction design. We also point out that, unlike other "sealed bid"

auction designs, the option to conduct the reverse auction by proxy bidding would not complicate bidding but would simplify it.

Complexity of Package Bidding

Several commenters suggest that package bidding is inherently complex.[1] This is true if one assumes that package bidding implies allowing bidding on all possible combinations of licenses. Even with generic licenses, with 172 EAs in the 50 states, this gives roughly 6 sexdecillion (6×10^{51}) different packages on which bids might be made!

However, package bidding is not synonymous with unrestricted packages. Further, the Clock Package Auction (CPA) proposed in CHK specifies a limited set of packages. Although in principle complementarities between objects in a multi-object auction could be arbitrary, in the case of spectrum licenses complementarities depend primarily on geographic contiguity and population distribution. This makes it possible to restrict the set of packages severely in terms of the number of packages considered while still allowing bidders to effectively express the relevant complementarities in their valuations.

Under the specific CHK proposal to offer EA licenses, MEA licenses, REAG licenses, and nationwide licenses, the number of objects for sale would increase from 172 to 229. Aside from the introduction of these objects, the CPA is essentially identical in complexity (indeed, in almost all dimensions) to the MALS ascending clock auction. The generic treatment of licenses keeps decision making as simple as possible and avoids the possibility that identical licenses sell at different prices. And bidders need not choose what to bid but only which objects they wish to demand at the current clock prices. Even with the proposed addition of package objects, the ascending clock auction design is in fact much simpler than the SMR auction that has been used in previous FCC spectrum auctions.

Further, the addition of packages will actually *reduce* complexity for most bidders, who will seek multiple complementary licenses. Unlike auctions that exclude packages, bidders in the CPA need not develop strategies for managing the severe exposure risk that would otherwise be involved in bidding for combinations of licenses needed by an entrant to build a viable network or by an existing provider seeking to make effective use of the newly offered spectrum band. Even bidders seeking single licenses face a simpler bidding problem in the CPA, as they

[1] *See, e.g.*, Comments of United States Cellular Corporation, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, at 51 (Jan. 25, 2013) ("USSC Comments"); Comments of Cellular South, Inc., *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, at 5 n.11 (Jan. 25, 2013) ("Cell South Comments").

have no incentives to manipulate their bids in attempts to exploit the exposure risk of package bidders.

Package Bidding and Treatment of Small Bidders

The Threshold Problem

Several commenters express concern about the effect that package bidding would have on small bidders, due to the "threshold problem" (Bykowsky, Cull and Ledyard (2000)).[2] The threshold problem can arise when a package bidder is competing against multiple bidders, each seeking a component of the package. In such situations, the "small bidders'' may have incentives to free ride by holding back their demand in the hope that others will contribute more toward pushing the sum of the component prices past the willingness to pay of the package bidder. Such free riding can result in allocation of licenses to the package bidder even when the small bidders together place greater value on them than the package bidder does.

The threshold problem is a potential concern in most types of auctions in which some bidders view licenses as complements. This includes the MALS auction, the SMR auction used in previous FCC auctions, and the CPA variation of MALS. However, we see no potential for a threshold problem in the CPA that does not also exist in the MALS auction (or in an SMR auction). And, as we show below, there is at least one sense in which the threshold problem can be more severe in the MALS auction than in the CPA**.**

The threshold problem has been discussed extensively since the first FCC spectrum auctions. Unfortunately, this discussion has often been imprecise. It is commonly asserted that the threshold problem is introduced by combinatorial auction designs. This is incorrect. The threshold problem exists in many auctions without combinatorial bidding, including the SMR auction used in previous FCC auctions and the MALS clock design proposed for the forward auction in the upcoming incentive auctions.

[2] *See, e.g.*, USSC Comments at 53; Comments of the MetroPCS, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, at 14 (Jan. 25, 2013) ("RTG Comments"); Comments of the Rural Telecommunications Group, Inc., *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, at 9 (Jan. 25, 2013) ("RTG Comments").

We will illustrate this with a simple example. Let there be two licenses, A and B. Suppose there are three bidders with valuations for the objects as follows:

	Object:	A	B	A+B
Bidder:				
1		3	0	3
2		0	3	3
3		0	0	4

The efficient allocation awards license A to bidder 1 and license B to bidder 2.

Consider the MALS auction and suppose that the current clock prices are $p_A = p_B = 1$. If all bidders follow straightforward bidding, bidder 1 will demand A as long as $p_A < 3$, bidder 2 will demand B as long as $p_B < 3$, and bidder 3 will demand a unit of each as long as $p_A + p_B < 4$.[3] The auction will end at prices $p_A = p_B = 2$ and the efficient allocation will be obtained.

However, consider a deviation by bidder 1. Instead of continuing to demand A at prices $p_A = p_B = 1$, he instead drops his demand for A, maintaining his eligibility by bidding on some other license whose price is rising in every round. If bidders 2 and 3 continue to follow straightforward bidding,[4] p_B will rise while p_A will not. Once p_B reaches $3-\varepsilon$, bidder 1 returns to demand A. The auction then ends at prices $p_A = 1+\varepsilon, p_B = 3$ where bidder 3 drops out. By withholding his true interest for A, bidder 1 is able to free ride on the straightforward bidding behavior of bidder 2 and obtain license A at a lower price. Of course, there is no reason for only bidder 1 to think this way. But if bidders 1 and 2 both attempt to free ride, bidder 3 may win. This is the threshold problem. Bidders 1 and 2 must both contribute to the effort to displace the package bidder, but each would prefer the other to contribute more.

This illustrates an important point. The threshold problem is not the result of package bidding (there is none in the MALS auction). Rather, it is the result of "package valuations,'' i.e., of complementarities that bidders act on to at least some degree. The same problem would arise in the SMR auction.

It is easy to see both that the threshold problem arises in the CPA as well and that there is no new threshold problem relative to the MALS auction. At prices

[3] Note that we are assuming here that bidder 3 is ignoring the exposure problem, but as we explain below, the conclusion does not hinge on this assumption.

[4] Under "straightforward bidding'' each bidder demands the set of objects that would maximize his profit if the current prices turned out to be final prices.

$$p_A = p_B = 1$$
$$p_{AB} = 2$$

bidder 1 is again tempted to withhold his demand for A, waiting until prices reach

$$p_A = 1$$
$$p_B = 3 - \varepsilon$$
$$p_{AB} = 4$$

to again demand A. When prices rise to

$$p_A = 1 + \varepsilon$$
$$p_B = 3$$
$$p_{AB} = 4 + \varepsilon$$

bidder 3 exits. However, once again, if bidders 1 and 2 both try to free ride this way, bidder 3 may win.

Although these examples suggest an identical threshold problem in the MALS auction and CPA, one might be concerned that we have been too pessimistic about the MALS auction. In particular, we have assumed above that bidder 3 ignores the exposure problem entirely when bidding. This may indeed be unrealistic. As discussed in CHK, the threshold problem is likely to suppress the bids of package bidders, likely leading to reduced revenue and inefficient allocations. However, less aggressive behavior by the package bidder does not necessarily soften the threshold problem. Above we assumed that bidder 3 continued to demand license j as long as

$$p_j \leq 4 - p_{-j}.$$

Suppose instead that he exposes himself to only half the risk, demanding j only as long as

$$p_j \leq \frac{4 - p_{-j}}{2}.$$

For example, if the price of A remains zero but that of B rises, this means that bidder 3 is willing to demand B only until its price reaches 2, thus putting on the line half of his package value.

Now the free riding incentive exists at the beginning of the auction. Suppose that the auction begins at reserve prices of ε. Hoping that bidder 2 bids straightforwardly, bidder 1 might, for example, plan to wait until p_B reaches $2 - \varepsilon$ to demand A for the first time with the auction then proceeding as follows

p_A	p_B	Demands
ε	ε	0,B,A+B
$\vdots$	$\vdots$	"
ε	$2-\varepsilon$	A,B,A+B
2ε	2	A,B,0

Thus, it is not generally true that the threshold problem softens when package bidders respond more conservatively to the threshold problem.[5] Here, the incentive to free ride begins immediately: each component bidder has an incentive to withhold its demand throughout the auction because, depending on how the other component bidder behaves, it may be possible to obtain the license at the reserve price. This contrasts with the CPA where the lowest price at which a component bidder could win is 1 (for example, bidder 3 is willing to pay 4 for AB while bidder 2 will pay no more than 3 for B; thus bidder 1 cannot win A at a price below 1).[6] Thus, there is at least one sense in which the threshold problem may be viewed as more severe in the MALS auction than in the CPA.

Note, however, that the use of price clocks in both the MALS auction and the CPA may reduce the need for bidders to “coordinate” in overcoming the threshold problem relative to an SMR auction. In the SMR auction, the same incentives arise. But the SMR auction provides no "suggested'' prices that might be used to coordinate. Ausubel, Cramton and Milgrom (2006, p. 134) have previously argued (in the context of the clock phase of the CCA) that "the price adjustment process is effectively resolving the threshold problem by specifying who should contribute what as the clock ticks higher." This may overstate the effectiveness of price clocks, but they may indeed reduce the need for bidders to "coordinate" to unseat a package bidder. One way to see this is to observe that a component bidder does not need to form a winning coalition with other component bidders to win his desired component license. All he needs is to demand the desired component in each round.

Another feature of the CPA is its use of additive package pricing (except in the case of excess demand for the package itself). Without this feature, large gaps could arise between the standing price for a package and the sum of the standing prices for the components of the package. This could be a serious concern when packages are added to the SMR auction, for example. When such gaps arise, bidders for the components must coordinate to overcome this gap in order to displace the package bidder. With additive package pricing, clock prices reveal to the component bidders a set of prices which, if accepted, would unseat the package bidder

[5] Of course, if the package bidder acts as if he has *no* complementarity, the threshold problem will not arise. However, given the substantial complementarities between spectrum licenses, the FCC should not hope for this outcome.

[6] Bidder 1 could still begin withholding demand at the beginning of the auction in the CPA. But unlike the MALS auction, he has no strict incentive to do so.

unless that bidder also agrees to a higher price. This may substantially mitigate the severity of the threshold problem.

This observation has been made previously by Goeree and Holt (2010, p. 148) in the context of their Hierarchical Package Bidding (HBP) extension of the SMR auction design, which uses additive package pricing to determine minimum acceptable bids: "bidders on individual licenses in that region would know how high they have to bid to unseat the provisional regional winner. In this sense, prices help these bidders solve a coordination or 'threshold problem'."[7]
Note that "package prices" are effectively additive in the MALS auction design as well: a bidder seeking the package AB must offer a total of $p_A + p_B$. Thus, we do not claim that the use of additive clock pricing in the CPA offers superior mitigation of the threshold problem relative to the MALS design. Rather, we point out that the CPA retains the substantial advantages of the MALS design without introducing any new threshold problem. Nonetheless, the previous example suggests that the CPA, by mitigating the exposure problem that exists in the MALS design, may in fact soften the severity of the free-riding incentives (threshold problem) that exist in the MALS auction design.

In practice, the threshold problem and its impact are less likely to be significant in clock auctions (e.g., MALS or CPA) than in the SMR auction. For strategic withholding of demand to be profitable, a component bidder must know that he is facing a package bidder and another component bidder to free-ride on. The presence of such opponents may be identifiable in an SMR auction, which reveals provisional winners in each round. But clock auctions do not reveal which opponents are demanding which objects. All a bidder can see are the prices quoted on different items; the sources of price movements are not revealed. A price increase on an individual license could just as likely be triggered by a component demand as by a package demand. This anonymity feature also makes ineffective any attempts by a bidder to strategically exploit a potential threshold problem, e.g., a component bidder pretending to be a package bidder or an individual bidder pretending to be a package bidder. The uncertainty about the free-riding potential does not of course mean that bidders will not attempt to free-ride. They may if they perceive a sufficient likelihood of an opportunity and expect a sufficient gain from it. But free-riding is not without risk. When a bidder holds back his demand at a price significantly below his value, he is risking a sizable profit since the auction could end in the next round. Uncertainty about even the existence of the free-riding incentive lowers the potential gain that could tempt a bidder to take on such risk.

[7] Goeree and Holt (2010) also provide evidence from the laboratory that, even in an SMR auction with package bidding, restricting packages to a hierarchical structure (as we proposed for the CPA) helps bidders overcome the threshold problem by eliminating ambiguity about which component prices must rise to displace the package bidder.

The Overflow Problem

In CHK we pointed out that the MALS auction design introduces a new type of bias against bidders seeking single licenses or small groups of licenses. Bidders seeking packages of licenses will be constrained by the fact that unequal quantities of spectrum will be cleared in different markets. Consequently there will be EAs in which the number of licenses available exceeds the maximum number of the encompassing regional packages that can be allocated. The auction design needs to account for this. Otherwise bidders for single EA licenses can face rising prices even when their demands are not a source of scarcity. This will push such bidders out of the market unnecessarily and lead to misallocation and/or undersell.

We discussed the overflow problem in greater detail in CHK, where we showed that the CPA eliminates the overflow problem. This is possible because the CPA provides a bidding language that allows the price clocks to ensure that EA license prices do not rise when the excess demand is for the package rather than for the EA license itself. This is possible only when bidders can express package bids and when the clock adjustment process properly accounts for feasibility constraints, making sure that demand for packages flows down to the EA licenses only when the demands for single EA licenses are themselves a source of scarcity at the current prices.

Entrants

Exposure risk has been neglected in most prior FCC auction designs.[8] In some cases this has likely led to withdrawal of potential entrants from the auction. In other cases, this has forced package bidders to bid strategically, deviating from straightforward bidding in hopes of resolving uncertainty about closing prices of some licenses before committing to other licenses in the package. Bidders competing against package bidders unprotected against exposure risk have incentives for strategic bidding designed to maximize their competitors' exposure risk, potentially softening competition. Such incentives for bid manipulation are undesirable in themselves, as they can lead to poor price discovery and inefficient allocations. Further, the

[8] An exception is the 700MHz Upper C Block auction of (regulatorily) impaired spectrum, where a SMR auction with limited hierarchical package bidding was used following the design of Goeree and Holt (2010). See also Rothkopf, Pekec and Harstad (1998) for an early proposal to use hierarchical packages in an ascending auction. Another exception is Auction 66 of spectrum for Advanced Wireless Services, where licenses for Regional Economic Areas were offered in addition to licenses for Economic Areas and Cellular Market Areas.

need to understand such bidding strategies places a heavy burden on entrants seeking to bid effectively in the auction.

Although the MALS forward auction design introduces a number of important improvements on the SMR auction, it does nothing to address the problems discussed above. The MALS design neglects the exposure problem entirely.

The CPA design substantially mitigates exposure risk by using a geography-based hierarchical package structure we understand to be closely tied to the actual structure of complementarities between licenses in the mobile wireless industry. By minimizing exposure risk, the CPA eliminates bias in the MALS design (and SMR) against bidders seeking packages by eliminating (or substantially reducing) the risk of exposure. This is likely to improve both the efficiency of the spectrum allocation and auction revenues. One can see evidence of the latter in the FCC's Auction 66, where bids for REAG licenses were on average 37 percent higher per MHz than those for EAs covering the same population.[9] The exposure problem is likely to affect all bidders, due to the economies of scale from horizontal spectrum contiguity (see CHK for additional discussion) and the fixed costs associated with introduction of a new frequency band to an existing wireless deployment. Smaller firms seeking to enter the wireless market certainly are not immune to this exposure risk. And they face, in addition, the need to establish a sufficient geographic footprint to enable service to consumers who now expect coverage to extend outside small areas like EAs. As argued by Cramton et al. (2007, p. 23), "Package bidding levels the playing field and removing it would seriously damage the prospects for new entry."

Manipulative Bidding

It has been suggested that the CPA design may introduce incentives for strategic bid manipulation. No specific manipulations have been articulated, and we speculate that the concerns may arise from a misunderstanding of the CPA.

The CPA changes no rules of the MALS auction design. The CPA design modifies the MALS design only by (1) adding new objects (packages), (2) explaining how excess demand can then be properly calculated, and (3) defining rules for how price clocks are to adjust to maintain additive package pricing when possible. All else is the same. This includes, for example, the rule regarding reductions in expressed demand: as in the MALS proposal, in the CPA a bidder may reduce his quantity demanded of an object only when its price increases.

[9] If one compares price per MHz-Pop, the premium paid for REA licenses was more than 100%.

We have already pointed out that, by eliminating (or substantially reducing) the exposure problem, incentives for strategic manipulation of bids that are present in the SMR and MALS design will be eliminated (or substantially reduced) by the CPA design. Thus, there is at least one way in which the CPA *reduces* incentives for manipulative bidding. Furthermore, we do not see any new opportunities for profitable bid manipulation that result from the modification of the MALS auction embodied in the CPA design proposal.

An example may help to illustrate the protection against profitable manipulation offered by the specific design of the CPA. Suppose there is one license available in each of two EAs, A and B. One bidder seeking the AB package competes against two component bidders demanding A and B, respectively. Call the first bidder the package bidder and the latter two bidders the A-bidder and B-bidder. There are several ways one might imagine a bidder manipulating his bids in hopes of improving his profit:

(i) *The package bidder may pretend to be a component bidder in order to divide and conquer the component bidders:* One possibility is for the package bidder to run up the price clock for A by repeatedly demanding it until the A-bidder drops out, then switch to demanding the AB package he actually desires. This strategy would not help the package bidder to lower the price for the package, since any increase in the price of A triggers a commensurate price increase in the package price. The package bidder can do no better than by demanding the desired package straightforwardly (i.e., until its price reaches his valuation for the package). Nor would either component bidder be preempted by such a manipulation by the package bidder. A component bidder can never lose by demanding its desired component straightforwardly (i.e., until price rises to his valuation for the component). This is in contrast to the SMR in which a package bidder could indeed lower the price of the package, or weaken the competition, by driving out a component bidder.[10] Thus, **due to the additive package pricing rule of the CPA, there is no gain from this type of manipulation**.

(ii) *A component bidder, say the A-bidder, may seek to shift the competitive burden to the B-bidder:* He may try to do this by either (i) withholding his demand on A (parking eligibility on some other licenses with rising prices), (ii) demanding B to push up its price, or (iii) demanding the package AB. We extensively discussed the first possibility earlier in considering the threshold problem, and the second possibility involves a risk of winning a license that the A-bidder does not desire. Importantly, these two options are also available in MALS with the same consequences. The only new option made available by package bidding in CPA is the last option. And this option is totally ineffective as a means of lowering the price for A, leading only to a risk of ending up with an unwanted item. Demanding the package AB creates excess demand for this

[10] This was the main motivation of the FCC 700 MHz auctions which limited the withdrawal of component bids even when they were no longer provisionally winning. Limiting bid withdrawal has a serious side effect, however, for it ties up the budget of the bidder and thus constrains his ability to move across different licenses as prices change.

package and leads to the same increase in the price of A that would have resulted if the A-bidder had just bid for A.[11] Thus, **the CPA's introduction of packages to the MALS auction introduces no new opportunity for manipulation of this type**.

(iii) *There are in fact no package bidders, but a component bidder may pretend to be a package bidder by demanding a package of licenses:* One can imagine a bidder engaging in such behavior in an attempt to cause his opponents to free-ride on each other (withhold their demands) and allow him to win. As mentioned earlier, such an attempt to "signal" package preferences might be effective in the SMR setting but will not work in a clock auction in which bidders see only prices rather than demands. The anonymity of demands in the CPA means that the opponents will not know the source of an observed price increase, so the bidder cannot communicate the message he wishes to send. At the same time, such an attempt will entail a risk of the A-bidder ending up with a package of licenses he does not want. Thus, **this strategy has cost but no benefit**.

We acknowledge (see also CHK) the possibility that some licenses may go unsold in the CPA. This can happen, for example, when a component bidder drops out but remaining component bidders manage to displace the package bidder. This kind of undersell potential should be familiar from the clock phase of the Combinatorial Clock Auction ("CCA"). However, the magnitude of undersell in the CPA will tend to be far less than that under the clock phase of the CCA. This is because in the clock phase of the CCA, a bidder may drop his demand for an object whose price has not risen, as long as the price has risen for some other object he also demanded. This is not permitted in the CPA.[12] Bidders may reduce demand only on objects whose prices have increased. This rule is natural in an auction and offers a compromise between the extremely lax bid withdrawal rule of the CCA clock phase and the severe MALS rule, which discriminates against package bidders by prohibiting such a bidder from reducing his demand for a package unless the price of *every* component has increased.

If some items are unsold at the end of the auction, we proposed in CHK that the FCC should retain the option of reoffering them via another clock auction. As discussed in CHK, the prospect of unsold items being available in such a supplementary resale auction, possibly at lower prices, could create incentives for "small" bidders to withhold demand in the primary auction. However, such a strategy would be highly risky, since such a bidder could not be

[11] The only case in which the A-bidder's added demand for AB would not "flow down" to object A under the CPA rules is when (due to unequal spectrum clearing in markets A and B) this additional unit of demand for AB does not conflict with any existing demand for one of the components. If that is component A, then the A-bidder does not need the price of B to rise for him to win A. If that is component B, then the A-bidder's manipulative demand for AB does not flow down to B. Thus, manipulative bidding for AB cannot help the A-bidder.

[12] In the CPA, only a bidder for a nationwide license has the same flexibility for demand reductions that exists in the CCA clock phase. If that is a significant concern, the national license could be excluded from the specific package structure proposed in CHK. The resulting structure would remain a multitree, as the CPA requires for unambiguous determination of excess demand. We understand (see for example the Comments of T-Mobile) that a substantial share of the geographic license complementarities that will exist in these auctions could be captured by having only MEA and REAG packages.

certain that his desired license would go unsold, or that the FCC would indeed choose to reoffer the license. Thus we do not expect such a strategy to be an attractive option for bidders.

Single Pass Reverse Auction

Several commenters expressed concern about separation between the forward and reverse auctions.[13] In CHK we proposed the option of conducting the reverse auction in a single pass. This option offers a number of advantages, including simplifying bidder participation in the reverse auction. Reverse auction bidders would not need to be reconvened to establish prices for each new closing target. And accepted bids in the reverse auction would be made on the same day with the same information. This contrasts with an interleaved design in which clock prices for the reverse auction resume from the closing prices obtained for the previous (unsuccessful) clearing target. In that case, bidders demanding high prices might effectively commit themselves to being repacked days or weeks ahead of the final offers that are made by other stations.

Further, the single-pass option would not introduce significant complexity for reverse auction bidders. From a bidder's perspective, the single-pass auction would be virtually identical to one of sequencing the reverse and forward auctions under an interleaved design. Just as with the interleaved design proposal, a bidder merely responds to a sequence of price offers by selecting its preferred option at each set of prices. The single pass option would traverse a wider range of prices than any single reverse auction stage under the interleaved design, but the bidder's options during the auction would be identical under both designs, as would the rules determining allocations and prices paid to bidders for each relinquishment option.

Proxy Bidding in the Reverse Auction

Several commenters expressed concerns about the demands on reverse auction bidders if a sealed bid mechanism or proxy bidding system is used. We share the concern that many types of sealed bid mechanisms would introduce unnecessary complexity in the reverse auction. For example, we discussed practical limitations of the Vickrey-Clarke-Groves (VCG) auction in CHK. We also discouraged the use of a discriminatory ("pay-as-bid") design in the reverse auction. A discriminatory auction requires substantial sophistication from bidders. To bid optimally, they must develop a clear understanding not only of their own valuations, but of the competition

[13] *See, e.g.*, MetroPCS Comments at 8.

they are likely to face. Such an auction design may be well suited to environments in which bidders have substantial bidding expertise, but not a one-off auction in which firms with little or no bidding experience are asked to bid to sell large assets.

Nevertheless, these limitations are not inherent to all sealed bid auctions, nor to clock auctions with proxy bidding. A clock auction with proxy bidding was one option we discussed in CHK, where we pointed out that proxy bidding may offer a substantial benefit to the well functioning of the reverse auction by allowing repacking problems to be solved offline rather than in real time. The single-pass reverse auction proposed in CHK adds no significant complexity to the reverse auction relative to the MALS clock auction proposal. Indeed, proxy bidding *simplifies* participation (this is why it is used by eBay, for example). Rather than standing by waiting to see whether prices reach a level where a bidder's preferred relinquishment option would switch, a bidder can simply report the "switch points" to the proxy system with assurance that his plan will be executed automatically.

References

Ausubel, L. M., P. Cramton, and P. Milgrom (2006). "The Clock-Proxy Auction: A Practical Combinatorial Auction Design," in *Combinatorial Auctions*, ed. by P. Cramton, Y. Shoham, and R. Steinberg, 115-138. MIT Press.

Bykowsky, M.M., R.J. Cull, R.J., and J.O. Ledyard (2000). "Mutually Destructive Bidding: The FCC Auction Design Problem," *Journal of Regulatory Economics*, 17 (3), 205–228.

Che, Y.K., P. Haile, and M. Kearns (2013). "Design of the FCC Incentive Auctions,'' comments on behalf of AT&T.

Cramton, P. , G. Rosston, A. Skrzypacz, and R. Wilson (2007). "Comments on the FCC Wireless Bureau's Proposed Competitive Bidding Procedures for Auction 73," (DA 07-3415, August 17, 2007; AU Docket No. 07-157).

Goeree, J.K. and C.A. Holt (2010). Hierarchical Package Bidding: A Paper & Pencil Combinatorial Auction," *Games and Economic Behavior*, 70, 146--69.

Milgrom, P., L. Ausubel, J. Levin, and I. Segal (2012). "Incentive Auction Rules Options and Discussion," Auctionomics and Power Auctions.

Rothkopf, M., A. Pekec, and R. Harstad (1998). "Computationally Manageable Combinational Auctions," *Management Science*, 44, 1131–1147.