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November 23, 1993

Dear Paul, Bob, Barry, Jeremy, Preston, Mark, Bob, and Evan:

The extension of the filing deadline for replies gives us all a touch of breathing room. I've had a couple of enlightening chats with Barry, and just received a copy of Preston's "reply", so it seems that (with the permission of my client) it's my turn to share my thoughts.

I think we're all in agreement that there's no *perfect* way to handle the PCS license auction. But perhaps by adding an informal round to the comments/reply process, we can come a bit closer to consensus. (It's fortunate that we all have — or at least seem to have — clients whose primary concern is that a decent procedure be adopted, rather than that the chosen procedure be biased in their favor.)

My own "comments" proposal has some of the flavor of all of the others: large-to-small MTA sequencing (like Barry and Jeremy and the initial FCC proposal), simultaneous ascending-bid sales of pairs of MTA licenses and small sets of BTA licenses (like Paul and Bob and Preston, although on a smaller scale), and combinatorial sales across spectrum (like Mark and Bob, although again on a smaller scale). It might not be perfect, but it's my best shot at this point.

With the exception of Barry and Jeremy, we've all come down strongly against nationwide-only combinatorial bidding. But that's an add-on issue on which the FCC will have to make the final call.

If there *is* to be a sequential sale of MTA licenses, I think we are all in agreement that the block-A and block-B licenses should be sold simultaneously. I also think we agree that large-to-small is the right basic ordering. However, one idea that came up while talking with Barry would be to sell the island-MTA licenses first (Puerto Rico and Hawaii). This would partially appease NYNEX, and would give all the applicants a look at the process before New York hits the block. (And, of course, geographic hubbing is not much of an issue at the island-MTA level.)

Preston and I both have portions of our proposals which involve withdrawable bids, and I suspect that Mark and Bob will have to add bid-withdrawal to any revision of their proposal. Bid withdrawal is an unattractive feature in general; that's why I limited it to spectrum-aggregation auctions at the BTA level (and, I think, why Paul and Bob left it out of their proposal, accepting instead the possibility of bidders getting stuck with extremely bizarre aggregations of MTA licenses). I'd love to hear thoughts on whether *any* type of withdrawable bids should be part of the adopted procedure (i.e., whether there's any way to make bid withdrawal practical and simple). Certainly, if there's no way to handle withdrawal acceptly, I would sacrifice spectrum-aggregating combinations, and go for simultaneous ascending-bid auctions of block-C-through-G licenses (either all together, or CD followed by EFG) on small groups of contiguous BTAs.

Why do I say "on *small* groups of contiguous BTAs"? I suspect that the time-to-conclusion of simultaneous ascending-bid auctions increases faster than linearly in the number of items being sold (at least under Paul and Bob's procedure). Any thoughts here?

And is there some way to really make large-scale simultaneous auctions better? While I have problems with Paul and Bob's proposal on an efficiency and timing basis, I have even bigger problems with Preston's due to the strategic problems that it lays on bidders.

Included below is a distribution list for this material, including fax numbers. If some of you can also get client permission to share your thoughts, I will welcome your replies (and I'm sure that everyone else on the list will, too).

Best regards,

Bob Weber

Distribution List:

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Reply to Comments on FCC 93-455: Notice of Proposed Rule Making

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November 24, 1993

Reply to Comments on FCC 93-455: Notice of Proposed Rule Making

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1. Introduction

Numerous comments have been filed in response to FCC 93-455: Notice of Proposed Rule Making. Clearly, many institutions have invested substantial resources, and many individuals have spent substantial time, in trying to help the FCC find the most appropriate way to allocate by auction the PCS licenses it intends to issue.

Unfortunately, there is no "perfect" way to conduct the auction. Any proposal must reflect some compromise between issues of economic theory and issues of practicability. In the various comments, the compromise has been made in many different ways, resulting in a number of strikingly-different proposals.

In this "reply to comments", I will attempt to summarize some of the most important issues that have been raised, to highlight the issues on which consensus seems to have emerged, and to point out some of the places where I believe the compromises have gone too far in one direction or the other.

This reply will refer, at times, to the paper attached to TDS's original comments. In the interest of brevity, detailed discussion presented therein will not be repeated here.

2. A compelling case has been presented against nationwide-only combinatorial bidding

The arguments presented in many of the filed comments together provide very strong reasons for *not* allowing nationwide-only combinatorial bidding. The arguments are of two types: Some concern nationwide-only combinatorial bidding specifically, and others more generally concern facilitation of the acquisition of nationwide licenses.

The three primary arguments against nationwide-only combinatorial bidding are summarized below:

(a) Bidders for individual MTA licenses will face a strategic "free-rider" problem. Each must bid not only for a license, but also against prospective nationwide bids. The need to bid against nationwide bids is a burden shared by all bidders for individual licenses, and each faces the temptation to let others bear the lion's share of the burden. The result is a potential suppression of the total of the winning individual bids, and consequently the increased likelihood of a nationwide combinatorial bid winning even when individual bids might have, in the absence of combinatorial bidding, yielded a more efficient allocation of licenses. In addition, the lessened probability of winning an individual license can lead some smaller applicants to forgo expenditures for required research prior to auction participation, and to abstain from the block-A and block-B auctions, despite the fact that they value some individual licenses more highly than the applicants which do choose to compete.

(b) Applicants seeking a substantial, but less-than-national, presence in the market will be forced to enter nationwide bids to protect their interests. Such an applicant, if it wins a nationwide license, will consequently acquire licenses which it does not desire, or which would be valued more highly (and developed more effectively) by other licensees. (Indeed, it is extraordinarily unlikely that any one applicant will value every MTA license in the nation more highly than any other applicant.) Therefore, the selling of a nationwide license will be likely to yield either inefficient development, or significant profits to the purchaser in the after-auction market.

(c) There is varying legal opinion concerning the propriety of accepting nationwide combinatorial bids. It is therefore likely that challenges will be filed against any procedure which includes nationwide combinatorial bidding. Whether the challenges are successful or not, the issuance of licenses and the beginning of service provision will inevitably be delayed.

In addition, a number of points have been raised against nationwide combinatorial bidding which actually constitute arguments against *allowing* any applicant to acquire nationwide coverage, whether through combinatorial bidding or some other process. These include the increased potential for noncompetitive or anticompetitive behavior, retardation of technological innovation, lessened incentives for the development of interoperability standards, lack of licensee focus on the needs of individual markets, lack of general diversity, and slower overall buildout.

In light of these additional points, it is recommended that the FCC give serious consideration to the adoption of overall population-coverage limits for any single licensee or consortium.

Surprisingly, those comments which include nationwide-only combinatorial bidding in their proposed procedures really fail to make any particularly-strong case supporting it. Therefore, it seems quite inappropriate for the FCC to cling to this idea.

3. There are severe problems inherent in all proposed auction rules (both no-combinations and all-combinations procedures) which call for the simultaneous ascending-bid sale of all MTA licenses

Once nationwide-only combinatorial bidding is eliminated from consideration, the proposals for PCS auctions fall neatly into three categories: sequential ascending-bid auctions, simultaneous ascending-bid auctions with no combinatorial bidding, and simultaneous ascending-bid auctions allowing all possible combinations of licenses to be bid upon.

A. Simultaneous combination-free auctions are discussed in great detail in the Pacific Bell/Nevada Bell and PacTel comments. Several aspects of those comments warrant reply.

First and foremost, the proposed (by Pacific Bell/Nevada Bell) simultaneous ascending-bid auction will expose bidders to substantial amounts of strategic risk, and holds the potential for extremely-inefficient outcomes requiring substantial post-auction trading. Many of the likely auction participants will hold an interest in assembling regional packages of licenses covering several geographically-contiguous MTAs, typically centered around a "hub" MTA. (Of course, some might choose to seek packages covering a major transportation corridor, or to focus their efforts only on the acquisition of licenses covering non-contiguous major metropolitan areas.) Consider an applicant attempting to acquire a license covering a particular large MTA together with licenses on several smaller adjacent MTAs. At no point in the auction will this applicant ever hold the guarantee that it will obtain the large-MTA license. There will always be the possibility that, after days (or weeks, or months) of inactivity in bidding for this license, some other applicant, shifting its attention from some other region, will reopen the bidding for this particular license by raising the bid. Therefore, the current high bidder must remain reluctant to bid aggressively for the licenses on adjacent MTAs. This will have three effects: It will lessen the prices drawn by those other licenses. It will slow the progress of the auction. And it will lead, at times, to a final allocation very different from what an applicant desired, with the applicant winning a ring of licenses but losing the desired hub. (Such an allocation would likely be very unsuited to the services and

technology that the applicant planned to offer.) Yet, since bids are non-withdrawable under this proposal, the applicant will not be able to free resources committed to the current high bids in order to seek a full regional package elsewhere.

Next, the estimate of auction time requirements (a few weeks?) is wildly optimistic. Imagine how the process might unfold. A number of larger applicants, each hoping to acquire one or more regional holdings with a large metropolitan hub, compete for the major metropolitan areas. Waiting to see how the competition develops across the larger MTAs, many of these bidders "lay back", bidding on only one or two licenses each day. In the meantime, since daily participation is required of all bidders, smaller applicants, not yet knowing how the market will develop, put in a single bid each day on a relatively-inexpensive license (not really hoping to win that license, but simply acting to remain eligible to bid seriously at some later point). Eventually (with only one round of bidding per day, perhaps after many weeks), the bids on the largest MTAs slow down, and activity picks up on MTAs contiguous to those which have already drawn substantial activity. Yet even here, since the bidding on the largest MTAs is not yet "closed", bidders seeking to expand around a hub face the risk of a later bid topping theirs, and therefore suppress their bids somewhat (protecting against the risk of being "aced out"). Only after the MTA bidding has settled down do other bidders begin to compete seriously, choosing day-by-day which of the 2500-odd BTA licenses to bid for. In consequence, the auction (with the proposed single round of bidding each day) could easily stretch out far beyond a year.

Finally, in an attempt to deal with the potential for the proposed auction to drag on interminably, it is also proposed that bid increments have a substantial lower bound (e.g., 5% of the currently-high bid). Yet the higher one sets the minimum bid increment in an ascending-bid auction, the closer one comes to actually holding a sealed-bid auction, with all of its concomitant problems: reduced information revelation, greater exposure of bidders to the "Winner's Curse" (and consequently, reduced revenues to the seller), a greater need for bidders to estimate their competitors' bidding limits before they enter their own bids (i.e., more "game-playing"), and the like. (Of course, a sealed-bid auction is for all purposes equivalent to an ascending-bid auction with a sufficiently-large minimum bid increment: All bidders submit initial bids, the auctioneer recognizes the highest, and it wins since no-one can afford to make an increase.)

The PacTel proposal attempts to deal with some of the problems discussed above by selling each license as soon as the bidding stops *for that license*. This is a bit better in some ways, yet worse in others. Better, since delayed reopening can't occur, so the potential for grossly-inefficient license allocation is somewhat reduced. Worse, since more guessing is required in the early rounds.

Imagine an applicant seeking either of two licenses covering different areas, but lacking the resources to acquire both. Such an applicant must constantly worry that bidding on one will close, while that applicant is currently bidding on the other (which is currently available at a more attractive price). If the price in the still-active auction climbs too high, the applicant will not be allowed to reopen the bidding for the other license, even if the applicant would have been willing to pay substantially more than the price at which the bidding closed.

To avoid this situation, the PacTel proposal permits bid retraction at a modest penalty. But then the feedback loop becomes extraordinarily complicated, with cascading retractions (if the second-highest bidder also is overcommitted elsewhere). Furthermore, smaller applicants will be disadvantaged by their exposure to bid-withdrawal penalties (relative to larger applicants, which might not face the same underlying resource constraints, and therefore would never have to retract bids). An additional problem

is that an applicant holding several winning bids, and wishing to retract one or more, holds the ability to choose which of the second-high bidders to "favor" with its retraction: The temptations for "deal-making" can be substantial (and can even ripple back into the final rounds of the original auctions, as some bidders consider the value of "holding up" others by over-bidding, and then "negotiating" a retraction).

The PacTel proposal briefly discusses on-the-fly adjustment of minimum bid increments, with the goal of bringing all auctions to conclusion at roughly the same time. But if this is done, the efficiency gains this procedure might offer over the Pacific Bell/Nevada Bell proposal are lost.

In summary, both of the proposals discussed here are seriously flawed. Simultaneous ascending-bid auctions of individual items are indeed appropriate in some settings: One such setting is discussed later in this reply (for the sale of pairs of 30 MHz licenses covering the same MTA). But when some bidders face capital constraints, and others seek to acquire sets of items considered more valuable than the individual components, the problems associated with simultaneous ascending-bid auctions appear insurmountable.

B. A simultaneous ascending-bid auction, permitting bidding for all combinations of items, is proposed by NTIA. In an ideal world, this would be precisely the right procedure to use. Unfortunately, ...

The world we live in is one of bounded computing ability, which falls far short of what is required to make this proposed procedure work. Huge numbers of possible combination bids would have to be assessed (and reassessed as the bidding goes on) by bidders: Rough calculations show that, at a penny per possible combination, the U.S. national debt could be paid many times over. At the least, the resources needed for a bidder to monitor all interesting strategic opportunities would be substantial enough to disadvantage smaller potential competitors.

In addition, the free-rider problem which is present in nationwide-only combinatorial bidding is also present in all-combinations bidding, and to a much more substantial extent. To deal with this, NTIA proposes that bidders not only be allowed to bid on subsets, but also be allowed to "negotiate" with other bidders on joint bid increases needed to top a bid entered by some other bidder for a larger subset of licenses including those sought separately by the negotiating parties. This, of course, creates both another level of complexity to the auction process, and opportunities for abuses (such as playing off one negotiating partner against another, or proposing collusion ("I'll pick up the larger share of the bid increase here, if you'll agree not to bid on this other license ..."), or discriminating against some potential negotiating partners).

An issue *not* discussed in the NTIA proposal is bid withdrawal. If one applicant is the high bidder for some license, and another bidder is high for another, and a third bidder tops the sum of the two bids with a bid for both licenses, will the individual bids be canceled? If so, then the burden of negotiations (to pull together a set of separate bids to top the joint bid) is increased. If not, then each of the individual bidders must worry that the other will later increase its bid enough to reactivate *both* individual bids; either individual bidders with overall resource constraints will therefore find themselves unable to shift their bidding activity elsewhere, or they must be given an opportunity to withdraw their bids (after which the next-highest individuals must also be given such an opportunity, and so on).

The idea behind this proposal is an attractive one. It is only the scale of the PCS auction which makes it intractable. In a later section of this reply, the use of a combinatorial bidding scheme on a smaller scale (for spectrum aggregation in the sale of BTA licenses) is advocated.

Section summary: None of the proposals discussed here are unreasonable, *in the proper setting*. Elements of each are present in the proposal filed by TDS in the "comments" round; that proposal will be summarized later in this reply. However, the simultaneous sale of licenses covering 51 MTAs is not a proper setting for the use of any of these proposed procedures. Therefore, **the sale of MTA licenses must be conducted in sequence**.

4. There is a general consensus that the sequential sale of MTA licenses should progress from the MTAs with the largest population to those with the smallest

The primary advantages of this order of sequencing are that it facilitates regional "hubbing", and that it brings substantial valuable information (concerning both pricing and licensee identity) into the public domain quickly. The information will help applicants bidding for licenses covering smaller MTAs, and for 20 or 10 MHz licenses at the BTA level, to refine their acquisition strategies, and hence will enhance the efficiency of the final allocation of licenses.

5. The simultaneous sale of both 30 MHz licenses covering an MTA is preferable to the sale of all licenses in one block before all licenses in the other

Selling both 30 MHz licenses covering a single MTA before moving on to another MTA will quickly clarify the regional hubbing situation. To only sell a single license before selling licenses on adjacent blocks will grant a substantial informational advantage to the winner of the single license (over other applicants who intend to compete for the second license covering the MTA, but don't yet know whether they will be successful).

Once it is decided to sell both licenses before moving on to another MTA, it remains to decide upon a method of sale. Selling the two licenses in sequence forces bidders to make strategic "guesses" which can reduce the efficiency of the final allocation, and reduce revenues from the sale. Each bidder must decide in the first round whether to continue to compete, or to wait for the second round and hope to win at a more attractive price. If two bidders which value both licenses quite highly guess incorrectly and choose to wait, the second license could sell for a much higher price than the first, and the first could end up in the hands of an applicant which would extract less value from it than the losing second-round applicant; this inefficiency could only be resolved in the after-auction market, with profits to the license seller that went uncaptured by the government in the auction. (Or, if both choose to bid aggressively in the first round, an efficient allocation will result, but the first-round winner could end up paying a substantially higher price than the second-round winner, even if both valued the licenses equally.)

To simplify strategic (game-theoretic) issues, and increase the likelihood of an efficient allocation at prices which more-closely reflect the values of the licenses to the winners, the two licenses should be sold simultaneously. Either simultaneous ascending-bid auctions, or a hybrid single-ascending-bid auction, could be used. Details concerning these alternatives are discussed in the Appendix to this reply.

6. Many of the problems in proposals for the simultaneous sale of all MTA licenses are much less severe when the sale of all BTA licenses within an MTA is considered

When attention is restricted to BTA-level licenses within a single MTA, many of the problems discussed in section 3 disappear. With the A and B blocks already allocated, most applicants will know which regions hold greatest interest for them. While some aggregations of BTA licenses within an MTA will still be more attractive than others, a much smaller variety of logically "hubbed" packages will exist than at the national (MTA) level. Smaller numbers of bidders can be anticipated at each sale, and the numbers of licenses to be sold at once (if the C and D blocks are offered separately from the E, F, and G blocks) will be smaller than in a sale of all MTA licenses.

In the previously-filed TDS comments, a particular procedure was proposed: The simultaneous ascending-bid sale of all BTA licenses within a single MTA, with combinatorial bidding allowed for spectrum aggregation only. This procedure combines aspects of the Pacific Bell/Nevada Bell proposal and the NTIA proposal, permitting the FCC to gain experience and establish precedents on a somewhat smaller scale than the sale of all MTA licenses. Issues involving timing, bid withdrawal, and the like are discussed in the previous comments.

Two issues warrant repetition:

1. If the C and D blocks are to be offered to a restricted set of bidders, then they should be sold *before* the E, F, and G blocks are offered. Once again, the primary reasons are to obtain an efficient allocation of licenses at fair market prices, while saving applicants from the need to play strategic guessing-games. ("I'll be allowed to bid for the block-C and block-D licenses. But the E, F, and G licenses are being sold first. Should I hold back, hoping to get a better deal when the C and D licenses are sold (and risk getting shut out), or should I bid aggressively now, and perhaps pay more than would have been necessary had I waited?") By selling blocks C and D first, the FCC ensures that the later sale of blocks E, F, and G will take place on a level playing field.

2. Aggregation of spectrum should be facilitated by the selected auction procedure. A number of the filed comments suggest that competition will be facilitated by aggregation of spectrum into greater-than-20 MHz blocks; some comments suggest that such aggregation is necessary for economic viability. One way of easing the task of spectrum aggregation is to permit combinatorial bidding within a BTA across spectrum blocks.

With regard to bidder qualification for participation in the sale of block-C and block-D licenses, it seems appropriate that applicants qualifying to bid on such licenses in any BTA within an MTA should automatically be qualified to bid for licenses in all of the BTAs within that MTA; this will facilitate competition on an equal footing among all auction participants when the BTA-level licenses are offered, by providing all with the same opportunity to aggregate licenses covering contiguous BTAs. If diversity is encouraged through the use of both bidder preferences on blocks C and D, and also by relaxed payment requirements (such as installment payments), then bidding decisions will be simplified (and diversity further encouraged) by allowing qualifying bidders to elect the same payment procedures on all licenses in the block-C through block-G range.

7. Conclusion

It has been fascinating to see the concurrence of opinion on some issues (such as opposition to nationwide-only combinatorial bidding), and diversity of opinion on others (such as the contrast between simultaneous and sequential auction proposals) in the comments filed on FCC 93-455.

A reading of the various comments has expanded my own appreciation of the concerns of the many different types of institutions interested in the PCS license allocation process. However, after careful consideration of the various proposals, I find myself seeing no need to revise or amend the proposal made in the paper attached to the original TDS comments.

The original proposal has some of the flavor of several of the alternative proposals discussed above, and therefore offers the advantage of setting multiple precedents. Simultaneous ascending-bid auctions for the block-A and block-B licenses, in sequence beginning with the largest MTAs, followed by combinatorial bidding across spectrum on blocks C and D, and then on blocks E, F, and G, with simultaneous parallel auctions on an MTA-by-MTA basis, seem to provide a good and proper mix of theoretical advantages and practical implementability. Scheduling requirements are easily predictable (and therefore the FCC can pre-announce the date on which construction permits will be issued, allowing applicants to begin their planning while guaranteeing that none get a "head start" on actual development), and bidders are never confronted with an unmanageable overload of information. The ultimate goal, to provide a format for the efficient provision of personal communications services to the public, seems attainable.

Some closing remarks may be useful. Several of the filed comments suggest that experimentation with alternative procedures be carried out prior to the FCC's final decision. Personally, I consider it unlikely that small laboratory experiments can come anywhere close to capturing the richness of the marketplace in which the allocation of PCS licenses will take place; indeed, experiments which attempt to generalize from vast simplifications of the actual situation are likely to be quite misleading. And time is limited. The FCC should simply put together a procedure which it feels is appropriate, and go forward.

However, I have heard that there is some discussion of a public meeting to discuss issues involving PCS auctions. Such a meeting could be of great value. But to give it focus, I would recommend that the FCC tentatively decide upon the procedure it will use, and then call a meeting devoted solely to fine-tuning the chosen procedure. By limiting the agenda to small changes in the selected procedure, the FCC is likely to obtain much more useful commentary than if a general debate of "big" auction-design issues were allowed.

8. Author's biography

Robert J. Weber holds the position of Professor of Managerial Economics and Decision Sciences at the J.L. Kellogg Graduate School of Management, Northwestern University. Educated at Princeton (A.B.) and Cornell (M.S., Ph.D.), he was a faculty member of the Cowles Foundation for Research in Economics at Yale prior to joining the Kellogg faculty in 1979. His research generally concerns strategic aspects of economic competition, with primary focuses on auctions and electoral processes. He is the author of more than 40 research papers and has served as a consultant to a variety of private and public institutions. He has served on the editorial board of the *International Journal of Game Theory*, and wrote one of the chapters for the forthcoming *Handbook of Game Theory*.

On the academic side, Professor Weber is co-author of the seminal paper, "A Theory of Auctions and Competitive Bidding" (*Econometrica* 50, 1982), and has published several subsequent articles on the auctioning of multiple items. On the more practical side, in the mid-1980s Professor Weber served as the external consultant on auction theory on the project (sponsored by the Department of the Interior) which developed the methods used to schedule area-wide auctions of petroleum extraction leases on the U.S. outer continental shelf. In June of 1992, as a consultant to the Board of Governors of the Federal Reserve System, he co-organized (with representatives of the Fed and the Treasury Department) and gave the opening address at the public forum which led to the currently-ongoing experiment in the use of uniform-price auctions to place the Treasury's 2-year and 5-year debt issues.

9. Appendix: Procedures for the simultaneous sale, with ascending bids, of block-A and block-B licenses covering a single MTA

I. Bid increments

Even when the sale of only a single item is considered, several aspects of an ascending-bid auction must be specified. What is the minimum acceptable bid increment? What is the maximum acceptable increment? Will increments be chosen by the bidders, or sought by an auctioneer?

The choice of a minimum increment raises issues at both extremes. If the minimum increment is too small, the auction can consume an unacceptably long period of time. But as the minimum increment is increased, the auction becomes less like an open procedure, and more like a sealed-bid auction. Indeed, if the minimum increment is extremely large (e.g., greater than the largest value the item being sold is worth to any bidder), then the opening bid will never be increased: The auction becomes either a race amongst the bidders to be the first to have its bid acknowledged, or becomes an auction in which all bidders submit initial bids, and the highest bidder is immediately proclaimed the winner.

If the maximum increment is large (or if there is no upper bound on the size of the increment), then "freeze-out" bidding becomes possible: A bidder can offer a substantial increase, hoping that others will perceive this increase as signalling a determination to win at any price, and will therefore concede. (Of course, if the bidders will subsequently meet in other arenas, some might attempt to push the price higher, hoping not to win, but to exhaust the resources of a competitor, i.e., strategic "gaming" becomes an issue.) In conjunction with a moderately-large minimum increment (say, for instance, 5% of the current high bid), a large maximum increment also opens the possibility of a bidder trying to estimate the most that any other bidder would be willing to pay, and then entering a bid below that amount by a margin just a bit smaller than the minimum increment (say, 4.5% below the maximum anyone else would be willing to bid).

To avoid "gaming", to gain the full advantage of open (as opposed to sealed) bidding, and to still keep the auction moving at an acceptable pace, it is common to keep the choice of increments under the control of an auctioneer. (Of course, the auctioneer can be either human or electronic.)

II. Auction procedures

When two licenses are being offered for sale at the same time, other aspects of the auction format must also be specified. Chief among them are the choice of a stopping rule, and (perhaps surprisingly) the choice of what, precisely, is being sold.

A. One alternative is to conduct two parallel-but-linked (simultaneous ascending-bid) auctions, each of which establishes an ascending sequence of prices for one of the objects being sold. Any bidder who is not currently the high bidder for either license is allowed to increase the bid on either license, and the auctioneer brings the auction to a close when no bidder wishes to increase either currently-high bid.

[This is the approach advocated in my November 10 comments, as well as in the Pacific Bell/Nevada Bell (Milgrom and Wilson) comments.]

B. Another alternative is to conduct parallel-and-unlinked auctions. Bidders are allowed to compete simultaneously in both auctions (i.e., the current high bidder for one license is permitted to increase the

current high bid for the other license). The auctioneer closes one of the auctions when bidding activity in that auction ceases, and closes the other when activity ceases in that one, as well. If a bidder is the high bidder in both auctions, then that bidder is allowed to retract its bid for one of the licenses, leaving the second-highest bidder for that license as the winner (at the price bid by the second-highest bidder).

This alternative seems somewhat less attractive then the previous one, for reasons which were given in section 3: (1) Bidders must worry that one auction will close early (at a time when they find the current price in the other auction more attractive), and that later (when the price in the still-active auction increases) they will regret not having stayed in the now-closed auction. One can expect that, to avoid this possibility, most bidders will remain constantly active in both auctions. Yet even this gives them only partial protection: If one of the two licenses is of somewhat lower value than the other, the auction for that license might still close "too" early.) (2) At the end of the auctions, if one bidder holds the high bid for both licenses, that bidder can choose which of the two (potentially different) second-high bidders will become the other winner. The temptations for "deal-making" can be substantial (and can even ripple back into the final rounds of both auctions).

[This is the approach advocated in the PacTel (McAfee) comments.]

C. Finally, a very different approach is to conduct a pair of auctions in sequence. The first auction sells to *two* bidders the right to receive their less-preferred of the two licenses: a second auction between just those two sells the right to select which license each receives. (The two auctions can, of course, be viewed as a single auction, in which the high bidder receives the license it chooses, and the second-high bidder receives the remaining license. In this case, the natural pricing rule is to charge the high bidder the final established price — roughly the price at which the second-high bidder stopped competing — and to charge the second-high bidder the price at which the third-high bidder stopped competing.)

In general, this approach can impose a heavy strategic burden on the bidders. In the second stage, each bidder must guess whether the other has the same preference ordering for the two licenses, or the opposite ordering. (In the former case, second-stage victory holds positive value for each, but in the latter case, winning the second stage is of no value, since each bidder will eventually get its more-preferred license.) Furthermore, the decision concerning how far to compete in the first stage involves anticipating the cost — and likely result — of participation in the second stage. (For example, the decision of the currently-third-highest bidder in the first stage to compete further might depend on which of the two currently-higher bidders is expected to continue competing.)

These strategic complications are somewhat ameliorated if it is obvious to all bidders (i.e., if it is "common knowledge" among them) that one of the licenses holds higher value for all bidders than does the other license. Yet even in this case, temptations for deal-making between the final two bidders can be quite strong.

[This is the approach advocated in the Bell Atlantic (Nalebuff and Bulow) comments. They also propose that the auction be conducted electronically. An ascending "price clock" is used together with bidder "buttons", and a bidder is considered "active" as long as its button remains depressed. (This is what they call the "Japanese" method.) Practical issues needing to be resolved would include the speed at which the clock ascends, and procedures for dealing with "my finger slipped off the button by accident" objections that bidders might raise.]

Of these three alternatives, (A) seems to be the one which is strategically most "transparent", and is the one most likely to yield an efficient allocation of licenses.

III. Implementation

A primary advantage to the use of a live auctioneer (who controls bid increments) is that increments of moderate size can be sought in early bidding, and of smaller size as the pool of still-active bidders thins out. In addition, on-the-fly reduction of sought increments ("No-one will go up a million? Then how about another $500,000?") is feasible (and accepted in common practice).

However, the leeway available to an auctioneer in a private auction house might not be available to an auctioneer representing a government agency. The former is undisputed master of the auction process; the latter is subject to protests of unfairness, and to judicial review.

Programming an equivalent level of control into an electronic bidding system would not be difficult. Under method (A), one plausible procedure would be to set a fixed bid increment, and elicit bids at that increment. In each subsequent round (which need take no more than a minute or two), seek increases (at the fixed increment) to the currently-high bids. If no increases are offered for either license, halve the sought-for bid increment and re-seek bid increases. When the sought-for bid increment is eventually decreased to some prespecified amount, and a round passes with no bid increases offered for either license, declare the auction closed. (With only 10 inactive rounds — interspersed, of course, by rounds with bid increases — the sought-for increment would be reduced by a factor of more than 1000.)

While strategic considerations are simple enough to require no more than one or two minutes between rounds, the short inter-round delay is probably preferable to the use of a continuously-ascending price clock; it will give bidders a brief interval in which to reflect upon the relative prices of the two licenses, the size of the sought-for bid increment, and the identities of the current high bidders, before deciding whether and where to bid in the next round. Yet, at a very leisurely pace (say, one MTA auction every two hours, four auctions per day), all MTA licenses could be allocated in less than three weeks.