an auction for a secondary market where sharing is allowed requires accounting for the (negative) externalities users impose on each other when they share a channel. Existing auction designs either fail to allow bidders to express these externalities, or fail to scale to realistic problem sizes. We present SATYA, a scalable, strategy proof auction algorithm that permits users able to sharing spectrum to coexist in one market with those requiring exclusive-use. SATYA considers the effect of interference on the value of an allocation to all participants. To make the system scalable, we impose structure on the expressible externalities through a bidding language. The language allows bidders to express their value for different allocations, given probabilistic activation patterns, interference, and requirements for shared versus exclusive-access spectrum. In clearing the auction, we quantify a bidder's value for an allocation in terms of the fraction of the bidder's demand that is satisfied in expectation. For this purpose, we consider local interference via an interference graph and a model for resolving device contention. Strategy proofness is a property that makes simple, truthful bidding optimal for each user. A user can report his true value regardless of the bids and characteristics of other users. Strategy proofness is an important property for distributed systems because it promotes stability. In a nonstrategy proof algorithm, as bidders learn they may have an incentive to keep changing their bids, which imposes costs on the system infrastructure. In addition, strategy proofness removes the strategic problem facing bidders. For evaluation, it becomes valid to consider true bids, which in a nonstrategy proof auction would lead to an incorrect analysis. Even without sharing, finding an optimal channel assign-ment involves solving a graph coloring problem and is NP- hard [20]. We therefore take the common approach of using a greedy algorithm to find a channel assignment. However, a key technical difficulty is that unlike in settings without externalities a straightforward greedy allocation approach fails to be monotonic. The failure of monotonicity means that it is possible that a user can submit a larger bid but receive less spectrum. Monotonicity is well known as sufficient and essentially necessary for an algorithm to be strategy proof (given suitable payments) [29]. In achieving monotonicity, SATYA modifies the greedy algorithm through a novel combination of bucketing bids into intervals wherein they are treated equally (an idea employed in Ghosh and Mahdian [16]) and a computational ironing procedure used to perturb the outcome as necessary to ensure monotonicity (an idea introduced by Parkes and Duong [30]). To evaluate SATYA we use real-world data sources to determine participants in the auction, along with the sophisticated Longley-Rice propagation model [3], and high-resolution terrain information, to generate graphs. We compare the performance of SATYA against other auction algorithms and baseline computations. Our results show that, when spectrum is scarce, allowing sharing using SATYA increases social welfare by 40 percent over previous approaches.

There has been significant work on spectrum auctions where a regulatory agency, such as the FCC, leases the right to spectrum across large geographic areas (see, e.g., [11],[12]). However, our focus on secondary-market auctions, where an existing owner of spectrum (which could still be the FCC) wishes to resell it to a large number of smaller users subject to interference constraints. Most approaches to secondary-market auctions preclude sharing among auction participants [8], [14], [17], [32], [34], [35]. VERITAS [34] was the first spectrum auction algorithm based on a monotone allocation rule, and thus strategy-proof. However, VERITAS does not support sharing. The use of a spectrum database in facilitating secondary market auctions has been proposed [19].Turning to sharing, Jia et al. [23] envision spectrum owners auctioning off spectrum rights to a secondary user when it is not being used by the owner, and investigate how revenue can be maximized. While winners share with the spectrum owner, there is no sharing among bidders in the auction. Gandhi et al. [15] use an approach that allocates many small channels, effectively enabling sharing. However, their algorithm allows sharing only among bidders who want only a portion of a channel. Thus, it cannot take advantage of bidders who are only intermittently active. In addition, the approach is not strategy proof and there is no equilibrium analysis, which makes its efficiency and revenue properties hard to evaluate. Closest to our work is that of Kasbekar and Sarkar [24], who use a strategy-proof auction and provide for sharing. But rather than providing a structured bidding language the design allows bidders to express arbitrary externalities, and their pro-posed approach is intractable.

The issue of externalities in auctions has been considered more generally. Jehiel et al. [22]

consider situations, such as the sale of nuclear weapons, where bidders care not just about winning but about who else wins. But the settings do not include combinatorial allocation problems. A number of papers have considered externalities in online advertising (e.g., [10], [16]). However, this work (and similarly that of Krysta et al. [26] on the problem of externalities in general combinatorial auctions) is not directly relevant, as the externalities in spectrum auctions have a special structure, of which SATYA takes advantage.

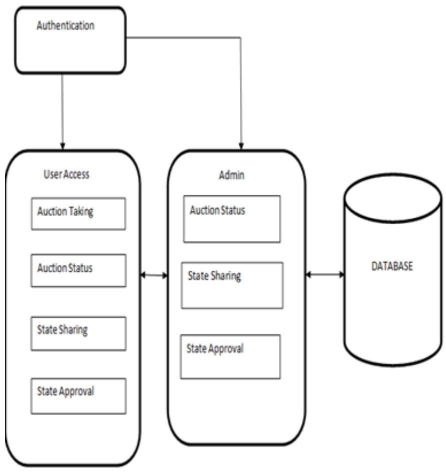

Figure 1 System Architecture

As above fig 1 represents the architecture consists of involvement of users who are bidders and admin who are managing the auction process and then database is maintained to collect all sorts of information regarding registration and strategy proof checking and auction taking process in which the bidding amount that is quoted are stored securely.After that admin takes part in viewing the auction process and decides to allocate the spectrum based on SATYA rule and quoted amount and the spectrum are shared among bidders by admin they can als view the status according to it.State approval will happen after finishing the payment by users As primary auction took part Secondary auction be taken place among those who came to auction they can quote amount in auction that will be managed by individual users who won the region of particular state.The whole process are adminstered by government securely.

II. METHODS AND MATERIAL

USER INTERFACE MODULE

If you are the new user going to access the Government spectrum Login. First if you enter your username is your Network Name or your name. Next enter your password. The user has to remember username and password which was provided at the time of registration, if login success means it will take up to Auction taking in Government spectrum page else it will remain in the login page itself. You remember your username and Password is must.

AUCTION TAKING

In this module the user can view the list of Region like North, South, East, West and you enter the amount in crores separately in each. You Score the Amount in crore reach in High level compare to other Networks or user. If you won the region. Only one region provided to you. Because all of the auction holder get the auction. The Government divided to provide the spectrum in Tera Bytes. This Module is explains about the Region such as to buy the state.. Purchase means first taking on Auctions. These Products are updated by the admin where the user can view and select the state for Auction taken.

PROOF CHECKING

In this module after the user's login the user views the list of Regions and enters its cost in spectrum auction taking page. SATYA, a scalable, strategy proof auction algorithm is followed by the Proof Checking Module. The Users have Such Valuable resources to Maintain in spectrum Resources. This Users Resource checking is completed. First come and first served for High scored amount in crores. The Government is involved in the full of Auction taking process to State Approval process. High amount Scored user who get the Spectrum and shared spectrum all the process are checked.

AUCTION STATUS

Auction status module is the finishing state of Auction. Such Time period is given to the user. The user to enter the Amount in crores for several regions. Amount wise that score the High level in each Region. That user not

Repeat for next Region. Each user gets only one Region. Auction is completed who one is scored high Amount is declared as the winning of spectrum. This winning level is handled, maintained and declared by the Government.

SHARING SPECTRUM

This Module deals after proof checking and Auction Status completed high scored spectrum winning users are come the payment Section. The network user who finished the payment to go the Region of his winning his states. And to confirmation to each state to handle and maintain the region of state. The user goes to the secondary market to sells the states of spectrum followed by the sathya proof algorithm. The Available states of spectrum to provide by that winning user. Each user get the only one Region that is the rule.

STATE APPROVAL

State Approval module is to provide the Approval certificate and Authenticate to Access in that type of Tera Bytes of spectrum to use. Available and winning states are declared to the winning of that user and government to provide to all permissions, rules and Rights of that Region. Approval letter is given to the user. Winning states are mention by that username or networks name.

III. RESULTS AND DISCUSSION

We compare the performance of SATYA to VERITAS. Since VERITAS does not permit sharing, we modify it slightly and implement VERITAS-S, which permits sharing as long as there are no externalities imposed (i.e., sharing is permitted only when the combined demands of users that wish to share do not exceed the capacity of the channel). We also implement GREEDY, a version of SATYA without bucketing and ironing that provides higher overall efficiency. GREEDY is neither strategy proof nor monotone. Thus, bids need not match their true values. However, to set as high a bar as possible, we assume they do so. Since it gets to act on the same information but has fewer constraints than SATYA, GREEDY serves as an upper bound for our experiments.

TABLE 1 :Mix of User Types Used in the Evaluation

User Type	*Act. Pro*	*Value*	*Penalty*	*Demand*
Exclusive-Continuous	1	0, 1000	10000	1
Exclusive-Periodic	0.05, 0.15	0, 1000	5000	1
Sharing-High	1	0, 1000	10000	0.3, 1
Sharing-Low	0, 1	0, 1000	5000	0.3, 1

Parameters. As shown in Table 1, all our experiments use four classes of user types bidding for spectrum, each of which is of the form described in Section 3.1. Note that, in the table, we have normalized the values so the table reflects the range of $a_i v_i$ rather than the range of v_i. Each class represents different applications. For example, a TV station serving a local community is a user who wants exclusive access for a long period of time. A wireless microphone is an example of a user who wants exclusive access but for short periods of time. A low-cost rural ISP is an example of a Sharing-High user who expects to actively use the spectrum but can potentially tolerate sharing, and a regular home user is an example of a Sharing-Low user whose spectrum access pattern varies. Note, each class of users may have different transmit powers and coverage areas than the others. Since our goal is to evaluate the efficacy of SATYA in exploiting opportunities for sharing, we assign 5 percent of the total users as exclusive-continuous, 15 percent exclusive-shared, 30 percent Sharing-High, and the remaining 50 percent Sharing-Low. With larger percentages of exclusive users, there is little opportunity for sharing and SATYA is effectively just VERITAS-S made less efficient since reports are coarsened via bucketing. Methodology. Each auction algorithm takes as input a conflict graph for the users. To generate this conflict graph in a realistic manner, we implement and use the popular Longley-Rice [2] propagation model in conjunction with high resolution terrain information from NASA [1]. This sophisticated model estimates signal propagation between any two points on the earth's surface factoring in terrain information, curvature of the earth, and climactic condi- tions. We use this model to predict the signal attenuation between users, and consequently the conflict graph. We use the FCC's publicly available CDBS [13] database to model the transmit power, location, and coverage area of Exclusive-Continuous users. Note that this information as well as the signal propagation predictions are sensitive to geographic areas. We model the presence of all other types of users using population density information. Users are scattered across a 25 mile x 25 mile urban area in a random fashion by factoring in population density information. Since each class of user has a different coverage area, we determine that a pair of nodes conflicts if the propagation model predicts signal reception higher than a specified threshold. We repeat each run of the experiment 10 times and present averaged numbers across runs. Unless otherwise specified, the number of channels is 5. In tuning SATYA, we experimented with a variety of methods for determining to which bucket to assign a user. We do not present these results for space reasons, but based on them use buckets of size 500 (β(k)=500k).

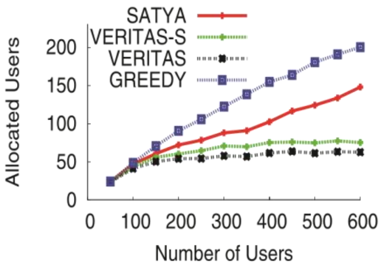

Fig. 2. Number of users allocated spectrum, as a function of the number

In our experiments, we use the following metrics
Allocated users: The total number of users allocated at least one channel by the auction algorithm.

Social Welfare: The sum of the valuations for the allocation by allocated users including the effect of any interference and preemption. **Satisfaction:** The sum of the fraction of a user's total demand that is satisfied over all users.

Spectrum utilization: The sum of satisfaction weighted by activation probability and demand. From a networking perspective, spectrum utilization is a measure of how much the spectrum is being used (similar to the total network capacity).

Revenue: The sum of payments received from users.

Figs. 2 and 3 show the performance of various algorithms as a function of the number of users participating in the auction. As we vary the number of users, we keep the mix of user types to be the same as Table 1. As seen in Fig. 2, as the number of users increases, SATYA produces up to 72 percent more allocated users when compared to VERITAS and VERITAS-S. This gain comes from being permitted to allocate users despite the presence externalities. With fewer users, all three algorithms demonstrate similar performance because almost all users can either be allocated a channel of their own or are impossible to satisfy.

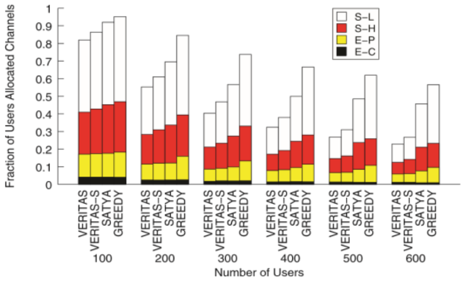

Fig. 3. Distribution of user types across winning users, as the number of

We consider social welfare the most important measure of performance: a market that finds success in the long run will allocate resources to those that find the most value. However, in our setting revenue may also be important to provide an incentive for current spectrum owners to participate in the secondary market. First, we measure the total revenue obtained as a function of the number of users bidding for spectrum without reserve prices. We do not include GREEDY in this analysis because it is not strategy proof and it is not clear what users will bid and thus what the actual revenue would be. As seen in Fig. 6, the revenue obtained by SATYA is much lower than VERITAS for smaller numbers of users. We omit VERITAS-S from the figure for readability, but its performance also suffers. Paradoxically, this is a direct consequence of sharing increasing efficiency by making it easier to accommodate users: if they would be allocated with a bid of zero they do not have to pay anything in a strategy proof auction.

To improve revenue, we institute reserve prices. While Myerson's approach in principle allows us to compute the optimal reserve price [29], our situation is sufficiently complicated that we simply empirically determine a reasonable uniform reserve price. VERITAS explored a similar opportunity to increase revenue by limiting the number of channels available.

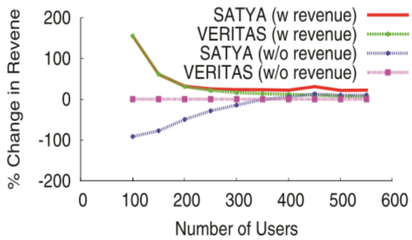

Fig. 6. Impact of revenue, as a function of number of users.

Turning to the design of SATYA, we assume that the only component of a user's type that can be misreported is vi, the per-epoch value when active, and when achieving the required share of the channel (and with exclusive-use if the user cannot share). It is reasonable that most of the other characteristics, such as the conflict graph, how often the user makes use of the channel (which requires correcting for periods when the channel was desired but occupied using our model of independent activation), how much of the channel is used when active, whether the user's devices can use a MAC, and on what channels the devices can legally broadcast, can be observed by the auctioneer, with the user punished if this information is mischaracterized by the user. This does leave open the possibility of deviations where the user manipulates rather than misreports these quantities.

SATYA ALGORITHM

SATYA achieves monotonicity by modifying a greedy allocation algorithm to combine the ideas of

1. Forbidding some allocations to shared channels using a bucketing approach, and

2. Canceling some allocations to shared channels in a post processing step using an ironing approach.

Through bucketing, fine distinctions in bid value are ignored by SATYA and small changes in bid value have no effect on the allocation, and thus do not violate monotonicity. Furthermore, users in different buckets are allowed to share spectrum in only a limited way, which prevents the greedy assignment from introducing externalities, and thus monotonicity violations. SATYA begins by assigning each user i to a bucket based on the user's bid value b_i. There are many ways this can be done as long as it is monotone in the user's bid. For example, user i with an activity-normalized bid *aibi* could be assigned to value bucket *k* with bounds $[2^k, 2^{k+1}]$.To be general, we assume that bucketing of values is done according to some function *β(k)*, such that bucket *k* contains all users with (normalized) bids *aibi* in the range *[β(k), β(k+1)]*. Once users are assigned to buckets they are assigned channels greedily, in descending order of buckets. The order of assignment across users within the same bucket is determined randomly. Let K_i denote the bucket associated with user *i*. A channel C is considered to be available to allocate user i at some step in the algorithm, and given the intermediate allocation A, if,

- The channel c is in C_i
- Assigning *i* would not cause an externality to a neighbor from a higher bucket:

for all $j \in N_i$, with $K_j > K_i$,

$$\sum_{\ell \in \{\nu_j(A,c) \cup \{i\}\}} d_\ell \le 1,$$

- The combined demands of *i* and the neighbors if *I* from higher buckets assigned to C are less than 1

$$d_i + \sum_{j \in \nu_i(A,c), K_j > K_i} d_j \le 1.$$

We refer to the second condition as requiring that the demands of each neighbor of user i from a higher bucket be satisfied. The third condition requires that the demand of user i is satisfied. This does not preclude allocations where some user has $E[S_i|F,t]<d_i$. It simply requires that, in such cases, the user is sharing with others in the user's own bucket.

Algorithm 1 High-level SATYA Algorithm

```
Generate a random permutation π of bidders
//Bucketed Allocation
for all Buckets k from highest to lowest do
  for all Users i in bucket k ordered by π do
    Assign user i to available channel that maxi-
    mizes (bucket estimated) social welfare.
//Ironing
for all Buckets k from lowest to highest do
  for all Bidders i in bucket k ordered by π that are
  assigned a channel where receive less than they
  demand do
    Rerun allocation procedure for bucket k with-
    out allocating to i.
    if there is still a channel available for i after
    allocating others in bucket k then
      Cancel allocations of i's neighbors in bucket
      k assigned to the same channel in reverse
      order of π until i receives his full demand.
Charge all bidders assigned channels their Myerson
price.
```

IV. CONCLUSION

This paper presents an auction approach that spectrum to allocate spectrum in a secondary market. These are markets where spectrum owners can either sell or lease spectrum to other parties. Unlike previous auction approaches. In this paper new algorithm Scalable Strategy Proof (SATYA) is used instead of GREEDY and FIFO, which increases the social welfare and revenue for government. These whole processes are done through use of computer.

V. REFERENCES

[1] "Shuttle Radar Topography Mission," http://www2.jpl.nasa.gov/srtm, 2013.

[2] Nat'l Telecomm. & Information Administration, US Department of Commerce, Inst. for Telecomm. Science, "Irregular Terrain Model (ITM) (Longley-Rice) (20 MHz - 20 GHz)," http:// www.its.bldrdoc.gov/resources/radio-propagation-software/ itm/itm.aspx, 2013.

[3] "Longley-Rice Methodology for Evaluating TV Coverage and Interference," OET Bulletin No. 69, Feb. 2004.

[4] "Evaluation of the Performance of Prototype TV-Band White Space Devices," FCC Press Release, Nov. 2008.

[5] L.M. Ausubel and P. Milgrom, The Lovely but Lonely Vickrey Auction, Cramton et al., eds., chapter 1, pp. 17-40, MIT, Aug 2004. [6] A. Blum and J.D. Hartline, "Near-Optimal Online Auctions," Proc. Symp. Discrete Algorithms (SODA), pp. 1156-1163, 2005.

[6] M.M. Buddhikot, P. Kolodzy, S. Miller, K. Ryan, and J. Evans, "DIMSUMNet: New Directions in Wireless Networking Using Coordinated Dynamic Spectrum Access," Proc. Int'l Conf. World of Wireless, Mobile and Multimedia Networks (WOWMOM), 2005.

[7] M.M. Buddhikot and K. Ryan, "Spectrum Management in Coordinated Dynamic Spectrum Access Networks," Proc. IEEE First Int'l Symp. New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2005.

[8] M.M. Bykowsky, M.A. Olson, and W.W. Sharkey, "Modeling the Efficiency of Spectrum Designated to Licensed Service and Unlicensed Operations," FCC OSP Working Paper Series, 2008.

[9] F. Constantin, M. Rao, C.-C. Huang, and D.C. Parkes, "On Expressing Value Externalities in Position Auctions," Proc. Sixth Ad Auctions Workshop, 2010.

[10] P. Cramton, "Spectrum Auctions," Handbook of Telecomm. Economics, M. Cave, S. Majumdar, and I. Vogelsang, eds., pp. 605-639 , Elsevier, 2002.

[11] Combinatorial Auctions, P. Cramton, Y. Shoham, and R. Steinberg, eds. MIT, 2006.

[12] "TVQ TV Database," FCC Media Bureau, http://www.fcc.gov/mb/video/tvq.html.

[13] S. Gandhi, C. Buragohain, L. Cao, H. Zheng, and S. Suri, "A General Framework for Wireless Spectrum Auctions," Proc. IEEE Second Int'l Symp. New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2007.

[14] S. Gandhi, C. Buragohain, L. Cao, H. Zheng, and S. Suri, "Towards Real-Time Dynamic Spectrum Auctions," Computer Networks, vol. 52, no. 4, pp. 879-897, 2008.

[15] A. Ghosh and M. Mahdian, "Externalities in Online Advertising," Proc. 17th Int'l Conf. World Wide Web (WWW '08), 2008.

[16] J. Huang, R.A. Berry, and M.L. Honig, "Auction Mechanisms for Distributed Spectrum Sharing," Proc. 42nd Allerton Conf., 2004.

[17] "Analysis of FCC Secondary Spectrum Markets Positions, Policies and Comments,"white paper, Spectrum Bridge, Aug. 2008.

[18] "The Secondary Spectrum Market: A Licensing and Leasing Primer,"white paper, Spectrum Bridge, Sept. 2008.

[19] K. Jain, J. Padhye, V.N. Padmanabhan, and L. Qiu, "Impact of Interference on Multi-Hop Wireless Network Performance," Wireless Networks, vol. 11, no. 4, pp. 471-487, 2005.

[20] S. Jain, K. Fill, and R. Patra, "Routing in a Delay Tolerant Network," Proc. ACM Special Interest Group Data Comm. (SIGCOMM), 2004.

[21] P. Jehiel, B. Moldovanu, and E. Stacchetti, "How (Not) to Sell Nuclear Weapons," Am. Economic Rev., vol. 84, no. 6, pp. 814-829 , Sept. 1996.

[22] J. Jia, Q. Zhang, Q. Zhang, and M. Liu, "Revenue Generation for Truthful Spectrum Auction in Dynamic Spectrum Access," Proc. ACM MobiHoc, pp. 3-12, 2009.

[23] G.S. Kasbekar and S. Sarkar, "Spectrum Auction Framework for Access Allocation in Cognitive Radio Networks," Proc. ACM MobiHoc, pp. 13-22, 2009.

[24] I. Kash, R. Murty, and D. Parkes, "Enabling Spectrum Sharing in Secondary Market Auctions," Technical Report TR-08-10, Harvard Univ., 2010.

[25] P. Krysta, T. Michalak, T. Sandholm, and M. Wooldridge, "Combinatorial Auctions with Externalities," Proc. Ninth Int'l Conf. Autonomous Agents and Multiagent Systems (AAMAS '10), 2010.

[26] J. Li, C. Blake, D.S.J.D. Couto, H.I. Lee, and R. Morris, "Capacity of Ad Hoc Wireless Networks," Proc. ACM MobiCom, 2001.

[27] V. Mhatre and K. Papagiannaki, "Optimal Design of High Density 802.11 WLANs," Proc. ACM CoNEXT Conf. (CoNEXT '06), 2006.

[28] R. Myerson, "Optimal Auction Design," Math. Operations Research, vol. 6, pp. 58-73, 1981.

[29] D.C. Parkes and Q. Duong, "An Ironing-Based Approach to Adaptive Online Mechanism Design in Single-Valued Domains," Proc. 22nd Nat'l Conf. Artificial Intelligence (AAAI '07), pp. 94-101 , 2007.

[30] A. Sridharan and B. Krishnamachari, "Max-Min Fair CollisionFree Scheduling for Wireless Sensor Networks," Proc. Workshop Multihop Wireless Networks, 2004.

[31] A.P. Subramanian, M. Al-Ayyoub, H. Gupta, S.R. Das, and M.M. Buddhikot, "Near Optimal Dynamic Spectrum Allocation in Cellular Networks," Proc. IEEE Third Symp. New Frontiers in Dynamic Spectrum Access Networks (DySPAN), 2008.

[32] J. Tang, G. Xue, and W. Zhang, "Maximum Throughput and Fair Bandwidth Allocation in Multi-Channel Wireless Mesh Networks," Proc. IEEE INFOCOM, 2006.

[33] X. Zhou, S. Gandhi, S. Suri, and H. Zheng, "Ebay in the Sky: Strategy-Proof Wireless Spectrum Auctions," Proc. ACM MobiCom, pp. 2-13, 2008.

[34] X. Zhou and H. Zheng, "TRUST: A General Framework for Truthful Double Spectrum Auctions," Proc. IEEE INFOCOM, pp. 999-1007, 2009.

[35] J. Zhu, X. Guo, S. Roy, and K. Papagiannaki, "CSMA SelfAdaptation Based on Interference Differentiation," Proc. IEEE Global Telecomm. Conf. (GlobeCom '07), 2007