

APPLIED MECHANISM DESIGN FOR SOCIAL GOOD

JOHN P DICKERSON

Lecture #25 – 05/05/2020

CMSC828M
Tuesdays & Thursdays
2:00pm – 3:15pm



COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

ALLOCATING SPECTRUM

Radio spectrum is a **finite natural resource**

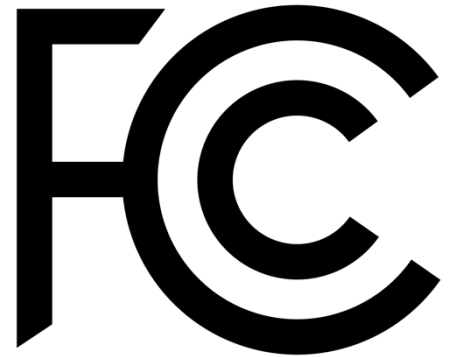
- Interference issues, not infinitely divisible

Bands are **heterogeneous but similar**

- Bands support different levels of data transfer
- Bands support different levels of transfer clarity

FCC allocates bands of spectrum to various industries and firms within those industries; wants:

- Efficiency aka maximize social welfare?
- Revenue/Profit maximization?
- Practice: can improve **both** over, e.g., lotteries



UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

- | | | |
|-------------------------------|---------------------------|--|
| AERONAUTICAL MOBILE | INTER-SATELLITE | RADIO ASTRONOMY |
| AERONAUTICAL MOBILE SATELLITE | LAND MOBILE | RADIO DETERMINATION SATELLITE |
| AERONAUTICAL RADIONAVIGATION | LAND MOBILE SATELLITE | RADIODIFFUSION |
| AMATEUR | MARITIME MOBILE | RADIODIFFUSION SATELLITE |
| AMATEUR SATELLITE | MARITIME MOBILE SATELLITE | RADIONAVIGATION |
| BROADCASTING | MARITIME RADIONAVIGATION | RADIONAVIGATION SATELLITE |
| BROADCASTING SATELLITE | METEOROLOGICAL AID | SPACE OPERATION |
| EARTH EXPLORATION SATELLITE | METEOROLOGICAL SATELLITE | SPACE RESEARCH |
| FIXED | MOBILE | STANDARD FREQUENCY AND TIME SIGNAL |
| FIXED SATELLITE | MOBILE SATELLITE | STANDARD FREQUENCY AND TIME SIGNAL SATELLITE |

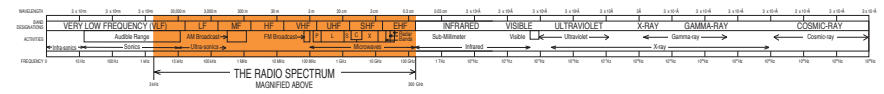
ACTIVITY CODE

- | | |
|--------------------------|----------------------------------|
| GOVERNMENT EXCLUSIVE | GOVERNMENT/NON-GOVERNMENT SHARED |
| NON-GOVERNMENT EXCLUSIVE | |

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with lower case letters

This chart is a graphic representation of the portion of the Table of Frequency Allocations used by the FCC and NRTA. As such, it does not necessarily reflect all aspects, i.e., limitations and special changes made in the Table of Frequency Allocations. Therefore, for complete information, users should consult the Table to determine the current status of U.S. allocations.



PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECIFICATION IS FOR INFORMATION PURPOSES ONLY AND IS NOT PROPORTIONAL TO THE ACTUAL ALLOCATION OF THE SPECTRUM.



PRE-1980S: ALLOCATION BY COMMITTEE

Interested firms present to an FCC committee

Pros:

- Inherently multi-objective
- Firms explicitly make a case for the public welfare

Cons:

- No revenue for the FCC
- Not a transparent mechanism
- Potentially high labor cost / slow speed
- Manipulate via backchannelling, bribery, etc.



THE 1980S: LOTTERIES

Firms apply in advance and are accepted by the FCC

FCC allocates band licenses via lottery

Pros:

- Fair – anyone can win regardless of money
- Simple and transparent

Cons:

- Rent-seeking: firm asks for more than it needs
 - Resell to other firms for profit
 - Negotiations take forever → unused spectrum
- Efficiency issues



THE FAR FUTURE: SPOT MARKETS

What about **immediate** (re-)allocation of spectrum?

Already exist: **spot energy markets**

- Some agents produce surplus energy
- Some agents require extra energy
- Market matches supply/demand immediately



What about a **spot spectrum market**?

- Hardware isn't there yet
- Carriers make huge investments in infrastructure for specific bands of spectra – long-term licenses good here

Flexible hardware → spot market that prices bandwidth for a specific location and time → more efficient (someday)

THE HERE AND NOW: SPECTRUM & INCENTIVE AUCTIONS

Rent-seeking & speculation on lotteries in the 1980s and 1990s publicized that the FCC was **giving away** a valuable commodity:

- 1993: US Congress tells FCC to implement auctions

This was a new problem!

- Prior fielded large-scale auctions: English (ascending) or Dutch (descending), and bidding on single items
- The value of a band to a firm is a function of whether or not the firm gets neighboring bands, or what other firms are doing with neighboring bands (interference!)
- **Complementarities** and **substitutes** amongst bands



THE HERE AND NOW: SPECTRUM & INCENTIVE AUCTIONS

Exposure problem:

- Not sure how much firm will spend → firms underbid
- Firms can spitefully buy up a single area (e.g., NYC) knowing that a competitor has a nationwide buy plan → artificially increase prices
- Solution: combinatorial auctions, multi-clock auctions, etc.

Implemented solution:

- Simultaneous ascending (fixed increments) auctions
- Firm #1 bids \$100k on DC, Firm #2 bids \$130k on DC and Chicago in one round; both firms see highest bids in each location, can adjust next bids accordingly



COLLUSION

Firms know that the FCC has **some** incentive to maximize revenue

- Possible workaround: backchannel aka collude to reduce competition
- Explicitly illegal

Witnessed in the 1996:

- Mercury PCS, Omnipoint, 21st Century Bidding Corp encoded license area codes into the insignificant digits of their bids
- E.g., Mercury PCS bids \$100,000,**486** to signal to competitors to stay out of license area code 486
- Settled with the FCC in 1998

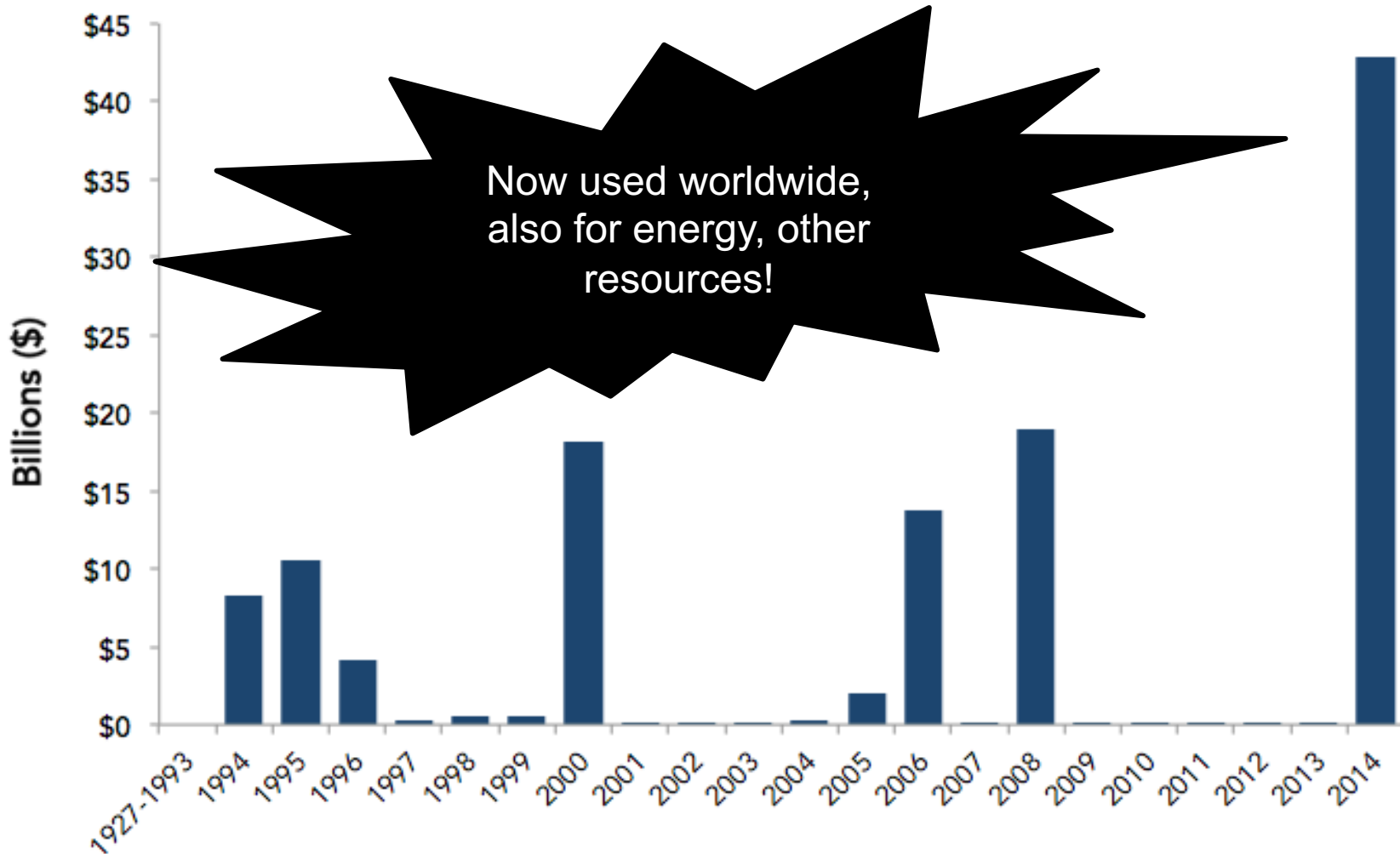
More info:

<http://www.nytimes.com/1998/11/11/business/company-news-omnipont-and-two-companies-settle-colluding-charges.html>



Over \$120 Billion in Revenue over 20 Years

Net F.C.C. Revenue in Billions of Dollars (Nominal), 1994 - 2014



THE HERE AND NOW: SPECTRUM & INCENTIVE AUCTIONS

Previously: FCC “owned” chunks of spectrum, gave them out to interested parties via chat, lottery, auction

Currently: we’re all out of spectrum → **nothing to allocate!**

Need to re-allocate spectrum from old tech to new tech:

- Forward auction: buyers compete to buy goods (prices increase)
- Reverse auction: sellers compete to sell goods (prices decrease)

Incentive auction:

1. Reverse auction to incentivize old firms to relinquish broadcast rights to the FCC, aka sell their goods to the FCC
2. Forward auction sells rights to new firms

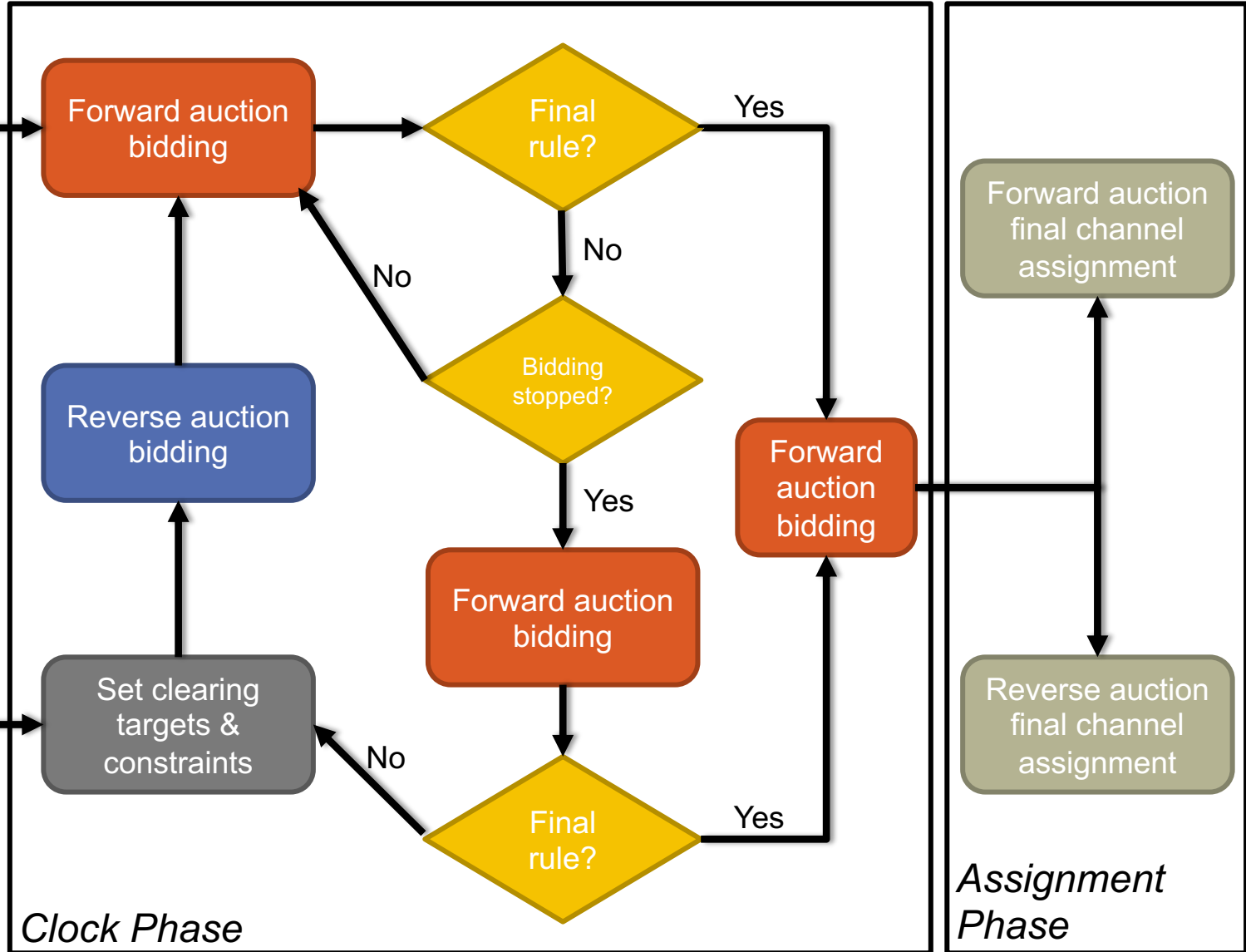
FCC INCENTIVE AUCTION

verizon[✓]

Forward Auction Applications



Reverse Auction Applications



REVERSE AUCTION

Initial iteration started in March 2016, ended June 2016!

FCC is now the proud “owner” of 126 MHz of spectrum for the measly sum of **US\$86.4 billion!**

- FCC didn't actually pay; just holding onto it for forward auction
- It's possible that they “paid” too much, might have to redo

How did they get this?

- (Second half of this lecture will talk about those details.)

FORWARD AUCTION

Ascending auction:

- Not open cry, rather ascends in fixed increments (5-15%)
- Bidders reveal how many “units” they would buy at this price
- Constraints put on bidders based on previous rounds (**activity rule**)
- Various types of bids, e.g.:
 - **All-or-nothing**: satisfy entire bid or give me nothing
 - **Switch bids**: move demand from one generic spectrum band to another one

If demand < supply, or prices won't cover reverse auction:

- Increase price in high-demand areas until bidders drop out

If bidding stops & clearing target accomplished & profitable: finish!

THE DOUBLE AUCTION

