Where is spectrum management headed in 2025-35?

Thomas Winslow Hazlett
H.H. Macaulay Endowed Professor of Economics
Clemson University
hazlett@clemson.edu

Centre on Regulation in Europe
Brussels, Belgium
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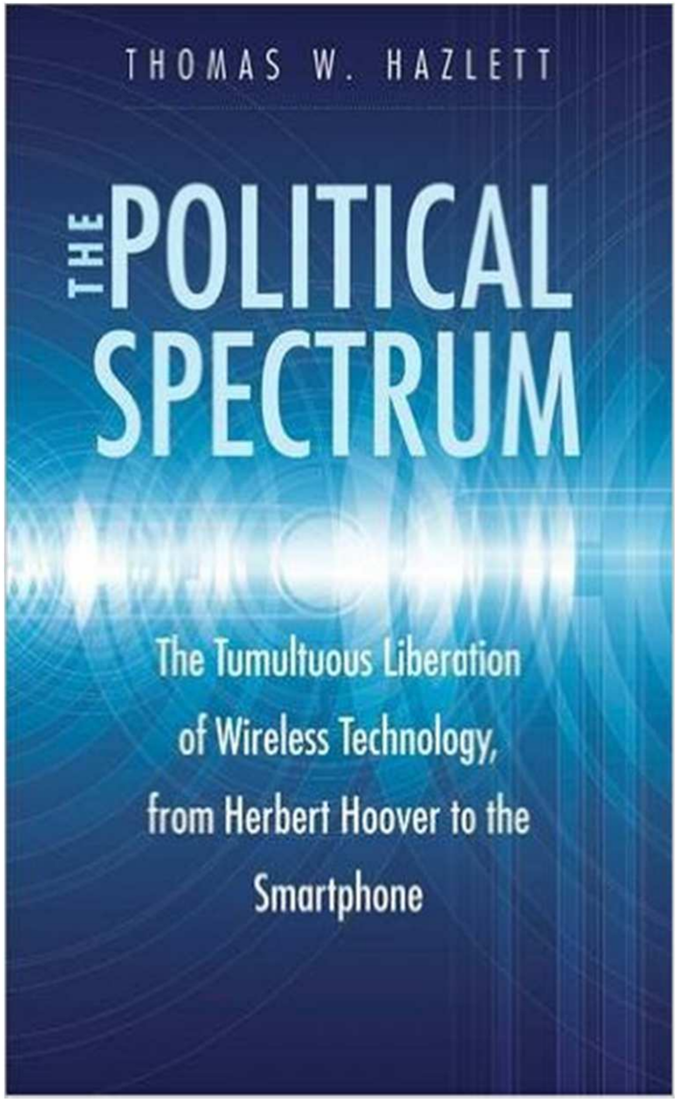


“Exclusive spectrum licensing will be consigned to the dustbin of history in the next 10-20 years.”

No.

End of Spectrum Scarcity?

- 1941
- *Radio News* wrote that as “FM becomes universal, there will be no physical limit on the numbers of stations in one town. The interference problem is solved.”

But prices and business models change

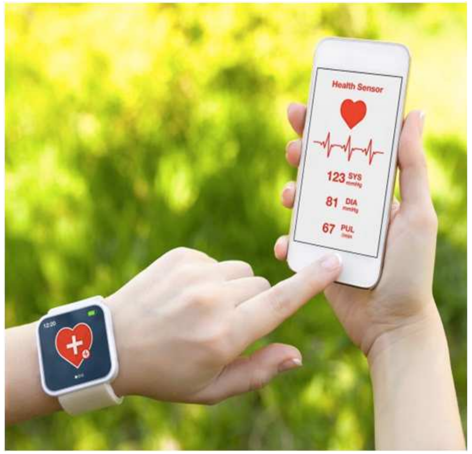
- Information revealed by prices socially valuable
- flexibility of liberal ownership rights socially valuable
- original argument for traditional reg: coordination in airspace too complex for markets (“chaos”)
  - policy reform → liberalization, delegating rights to market
  - proof of concept for competitive spectrum allocation
    - countless interfering apps managed better than alternative
  - new learning → wireless complexity *requires* decentralization

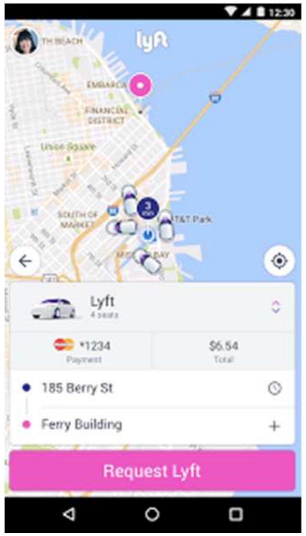
Wireless Ecosystems Flourish

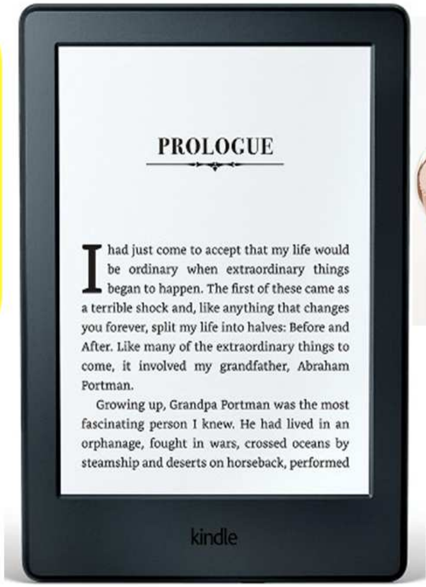
Intense Spectrum Sharing

- exclusive ownership rights → coordination
- residual claimants → financial instruments → share gains from improving spectrum use

Ubiquitous Interference







Liberalization

- flexible-use licenses
  - delegating “change of use” to market
-
-
- Secondary markets (from 1923)
  - removing borders, remedying “interference”
-
- Initial license auctions (from 1994)

Overcoming U.S. Rights Fragmentation

Commercial Mobile Radio Licenses
FCC Count

1. Sprint Nextel	21,318
2. AT&T	13,049
3. Clearwire	11,580
4. Verizon Wireless	10,436
5. T-Mobile	10,059
10. US Cellular	3220

Reboot.FCC.com (April 19, 2018).

Naked Sales are Tip of Iceberg

- efficient aggregation + vertical integration
  - Apple buys spectrum
  - Google buys spectrum
  - Facebook buys spectrum
  - Netflix buys spectrum
- sales of bundled services → network + MHz
- app ecosystems evolve
- voice to text to data to video to IoT to …

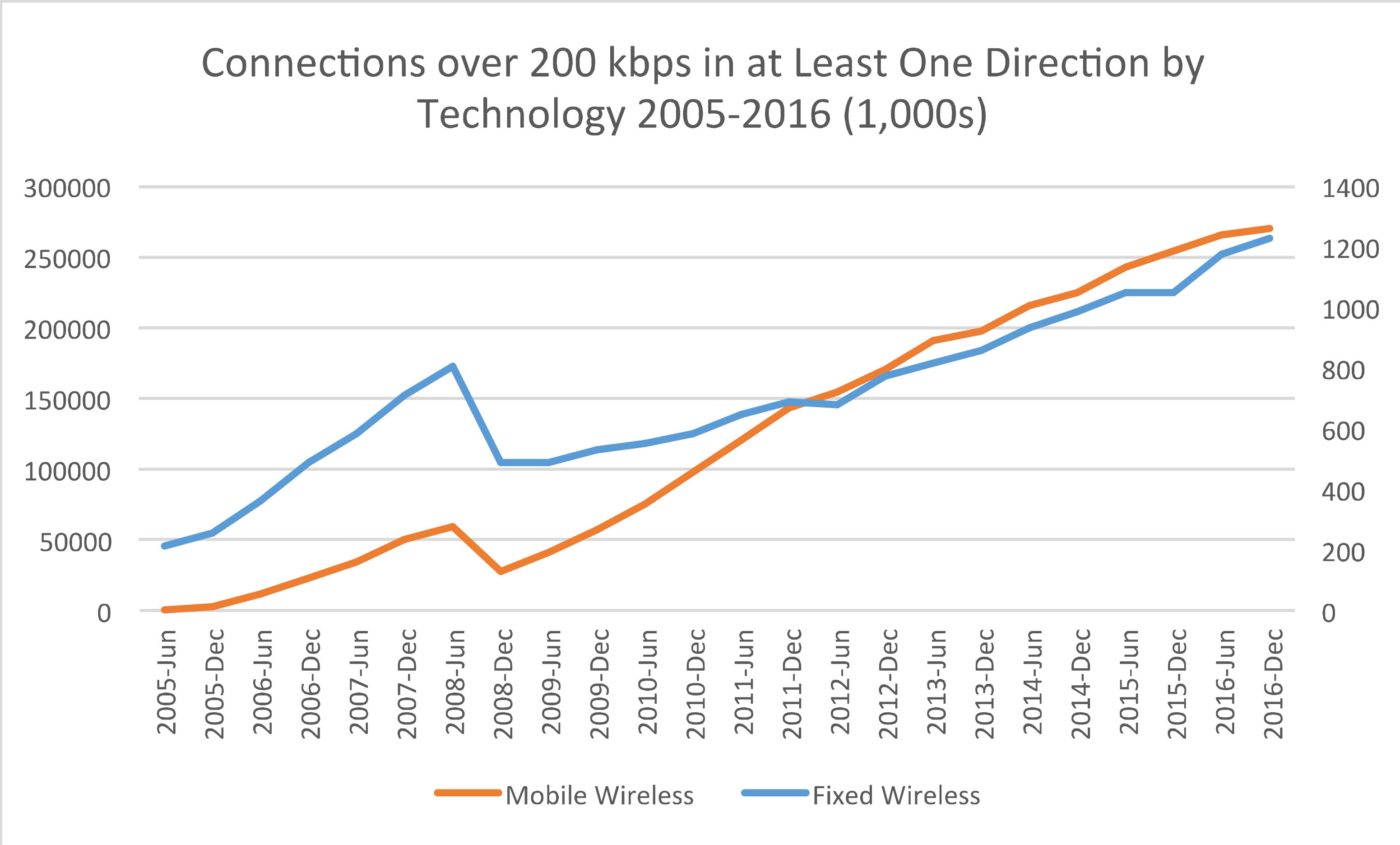
Property Rights in Spectrum

- U.S. policy failure in 3.65 GHz
- USA v. EU approaches to 3.5 GHz

3.65 GHz Allocation (2005)

- 50 MHz
- 1984 → licenses issued to FSS (space-earth)
- 2005 → FCC protects incumbents, allows fixed wireless on unlicensed basis
- alternative: overlays
    - residual claimants finance transition
- instead, non-exclusive, state-managed access
- "this Order for the 3650 MHz band should facilitate the rapid deployment of advanced telecommunications services and technologies to all Americans" (FCC 2005)

Wireless Data Subscribers, 2005-16 (FCC)



3.5 GHz

- Europe issuing liberal licenses (3400-3800)
- USA has 3-tiered CBRS system (3.55 – 3.7 GHz)
  - Grandfathering incumbents
  - Auctioning priority access licenses (PALs)
  - Unlicensed access generally (GAA)
  - Coordination via database and sensing technology
  - "create a system for shared use of the band with incumbent federal users in a way that maximizes efficient use of spectrum through the combination of small cell technology and more sophisticated spectrum management techniques through the SAS [database] designed to prevent harmful interference" (FCC 4.21.15, 36)
- Test?

Market-based Alternative

- auction CBRS rights as overlays
  - Bids by consortia? Non-profits?
- demand revelation
- residual claimants can bargain w incumbents
- fragmentation reduced, cooperation enabled

USA property rights cascade

- GAA interests as quasi-residual claimants
- arguments for extreme fragmentation
  - 2 yr license terms (continuous re-auction)
  - tiny licenses (~170,000/yr – per FCC 2018 Budget)
- Borders as transaction costs
  - CBRS rights devalued, investment incentives weak
- Strategic "Tragedy of the Anti-commons"

Prediction: Ten Years Out

- Broader rights in EU 3.5 GHz → First Place
  - I will not predict the price of the licenses
- CBRS' atomistic license regime in USA?
  - in 2028, the FCC will issue its 7th Further Reconsideration of the Report and Order
- We have seen the future -- in 3.65 GHz. Meh.

Thank you.