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Spectrum Sharing Economics and Innovation

Johanna Dwyer

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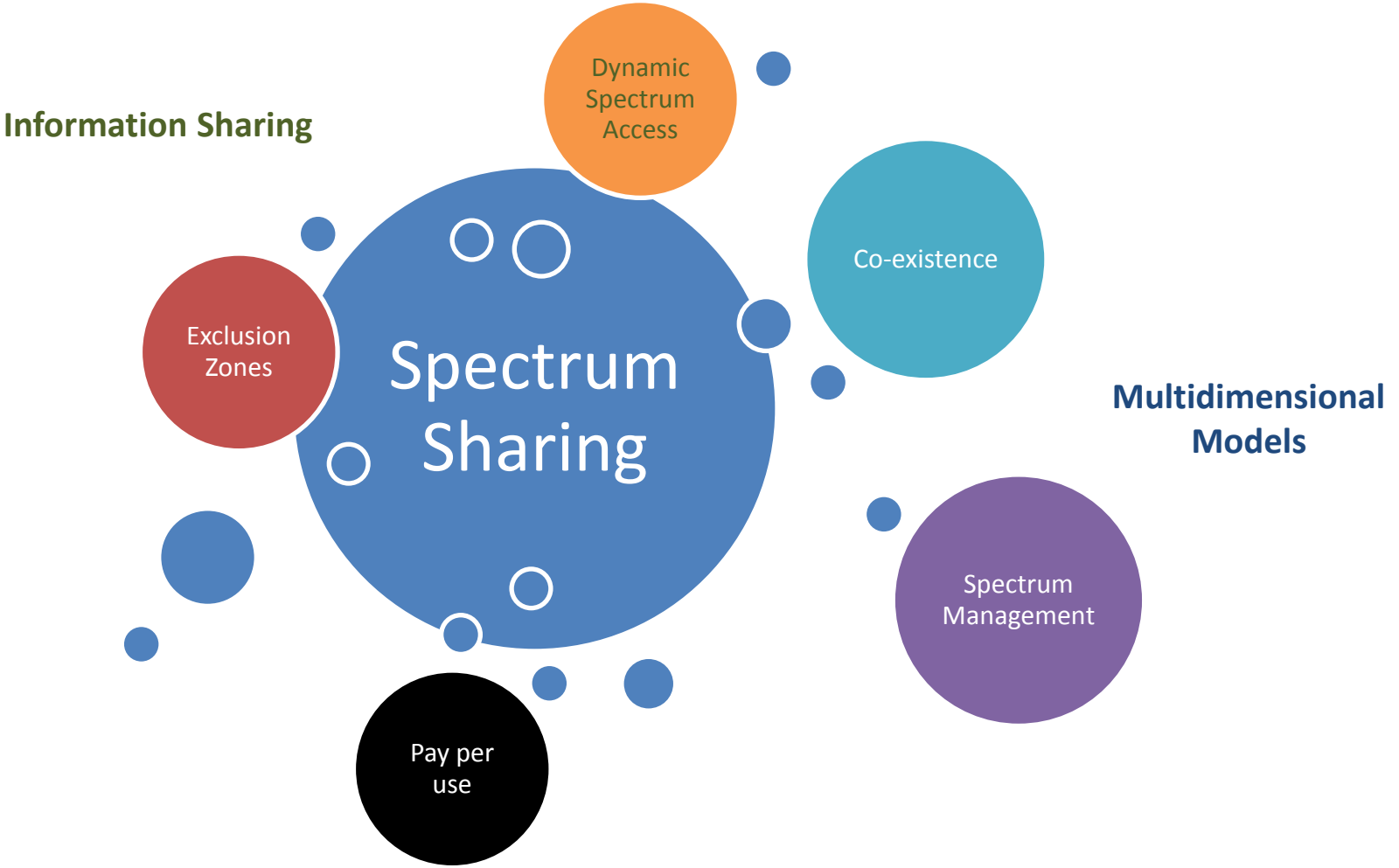
What is Spectrum Sharing?



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The Value of Spectrum to a Single User

- The value of spectrum is based on what you can do with it – unlike gold it has no inherent value of its own.

- The upper bound on the value of a spectrum license to a single user:
  - present value of the future net profits earned from the services that can be deployed on that spectrum

- The lower bound (or willingness to pay) for a spectrum license is determined by the relative value of alternative assets to provide the same services
  - Fixed infrastructure + unlicensed spectrum
  - Densification, higher frequency re-use

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What influences profits derived from spectrum?

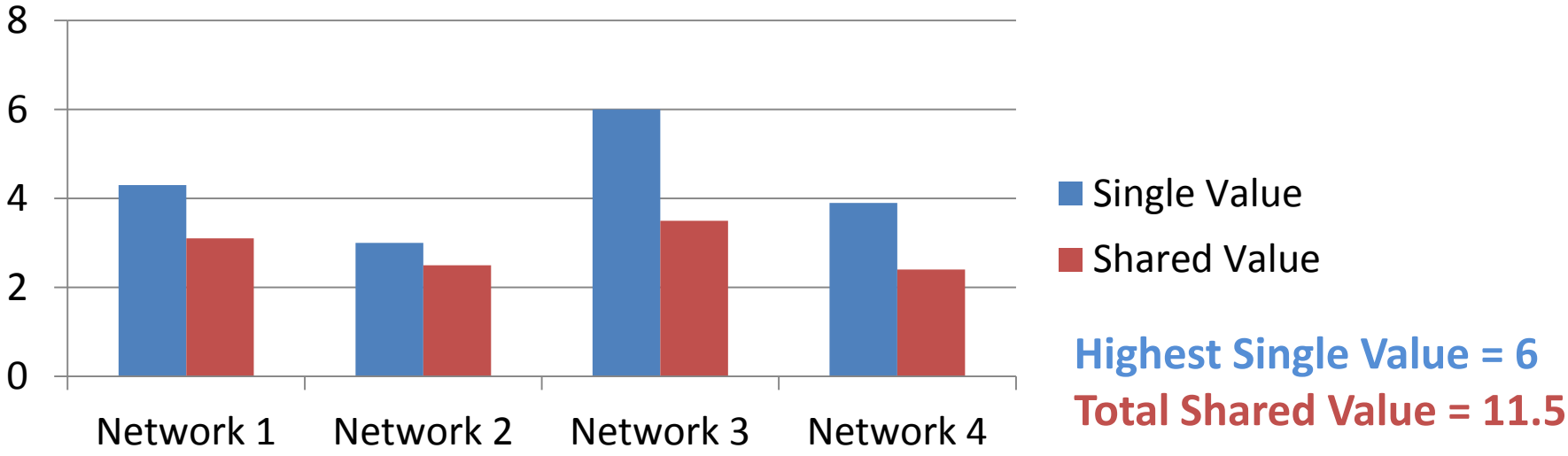
Net profits are determined by five factors

- Revenues (type of service, quality of service, scope of service)
- CAPEX (deployment cost)
- OPEX (management cost)
- The Cost of Capital (timing of revenues and costs)
- Risks and Uncertainties (interference concerns, agreements with other users, legal status/security of capital, cost of delay)

All possible types of interruption to service impact value

- Geographic exclusion zones
- Temporal Interruptions
- Rule based restrictions

The Value of Shared Spectrum to a Multiple Users



For shared spectrum, the **TOTAL VALUE** of the spectrum is the sum of the value to all users. As a spectrum user moves from exclusive use to shared use, the value they derive from the spectrum necessarily goes down.

However multiple parties can use the same spectrum at the same time.

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Is Spectrum Sharing Better?

- Each individual user will suffer to some degree compared to the exclusive use scenario
- Sharing is a good idea and is economically efficient if it can be managed such that the ***cumulative value*** of the spectrum across ***all users*** in the same band is greater than the value that any single exclusive user could achieve
- If spectrum sharing management cannot achieve this, then economically speaking, exclusive licensing should be the way forward
- Caveat - the value of some spectrum uses are difficult to quantify economically
  - Defense uses, Public Safety Uses, Social Value, …

The Incentive Problem

- Every wireless network that participates as a user of shared spectrum will experience a value that is less than what they could have had if they had exclusive spectrum rights
- From the single user perspective, sharing only decreases value because it imposes limitations on usage:
  - Altering the type of services that can be offered;
  - Reducing the scope or quality of service;
  - Increasing uncertainty about when and where the service will work.
- Costs may increase because of more expensive handsets, greater CAPEX and OPEX requirements

So what incentives need to exist for individual networks to want to progress spectrum sharing technologies and policies?

Who Has an Incentive to Share?

Spectrum Owners

If sharing is efficient, the spectrum owner could realize more value from their spectrum by utilizing it in an efficient managed shared environment then by any single user having exclusive rights. If the spectrum owner is allowed to capture that additive value, then they have an incentive to share their spectrum.

Established Network Operators with a Spectrum Shortage

If operators are not able to solve their capacity needs through better technologies and densification, then they need more spectrum. If exclusively licensed spectrum is not available, then shared spectrum may be the only alternative.

New networks or smaller networks without deep pockets

New spectrum sharing policies can exchange CAPEX (spectrum auction up front rights purchase) for OPEX (pay per use) enabling new market entrants and smaller players to offer services.

How to Promote Sharing?

Since every individual user suffers but the overall value of the spectrum as a whole is greater, **how do you incent individual users to participate?**

How do you **share the value generated by sharing** amongst the participants to ensure they want to get involved?

Are there **complimentary services or networks** that minimize the individual network degradation but still enable greater collective value?

What can the government do to help? Do they have any responsibility?

What makes a spectrum allocation decision "efficient"?

- Maximizes total social and economic value of spectrum to all users, subject to the priorities set by policymakers

The Infrastructure Investment Argument

To increase wireless capacity, you either increase the amount of spectrum used or you increasing the value of the use of spectrum.

Networks that are potential shared spectrum users compare between **acquiring spectrum (if possible and at what cost)** and **investing in additional technology or infrastructure to increase capacity on spectrum that they already have**:

- If you assume that the network is considering shared spectrum because they need increased capacity, then either the network increases capacity through investment in densification in their own network, or they increase capacity through investment in equipment that permits the use of shared spectrum bands
- **In either case, increasing capacity always requires infrastructure investment**

Why not simply add more and more small cells to the existing spectrum?

- Diminishing returns - fewer locations for transmitters, increased cost for backhaul, handover becomes more and more complex

The Impact of Government Regulations on Efficiency

Governments regulate spectrum on several dimensions:

- Flexible use vs. mandated use
- Licensed vs. open entry
- Primary and secondary usage rights
- Technology choice

The government rules lead to very different outcomes in intensity of spectrum use and in the value of spectrum use.

The best way for the government to promote spectrum efficiency is to ensure that users have flexibility, and that they realize the opportunity cost of their use of spectrum.

If users internalize the opportunity cost of spectrum use, they will make appropriate investments in capital and the introduction of new technology to improve the efficiency of their spectrum use.

Realizing the Opportunity Cost

Without heavy government regulation, market forces and economics mean that there would not be inefficiencies in the use of non-government spectrum where users face the full opportunity cost of spectrum use.

Licensees with very flexible rights of usage and the ability to recover the value from repurposing the use of the spectrum realize most if not all of the opportunity cost of their spectrum use.

They would therefore act accordingly, with investment in capital and technological transitions, and would not “hoard” spectrum inefficiently.

Should the Government Just Make Everything Fully Open and Unlicensed?

Fully open bands are a problem – if spectrum users do not have licenses then they will not realize the full opportunity cost of their spectrum use.

Example:

A first spectrum user in a fully open spectrum band invests and adopts a more efficient technology for its use.

The first spectrum user has spent money to be more efficient; that is to use less spectrum for the same services.

A second spectrum user with a less efficient technology stands to benefit from this, because more spectrum is now available to him for his services.

Conclusion:

With open entry it is difficult to get users to adopt efficient technology without some other mechanism such as spectrum fees or pay-per use policy.

What About The Government?

The GAO (2012) reports that the Federal Government is the exclusive or predominant user of 39 to 57 percent of the spectrum between 225 MHz and 3.7 GHz.

Just as commercial users' spectrum demands evolve, government spectrum users' needs are also changing over time, and they need more spectrum, not less.

Under the current regime, agencies have an incentive to hold spectrum assignments for some future objective, or utilize more spectrum in lieu of potentially more efficient alternatives. However agencies should have an incentive to relinquish assignments that they are no longer using or adjust usage to increase the overall efficiency of spectrum.

What is the problem?

Government users need a way to internalize the cost of the spectrum they use.

Do Federal Users have an Incentive to Share?

- Federal users receive spectrum allocations without incurring any significant budgetary cost.
- They also cannot benefit from value creating market transactions.
- Once they receive an assignment, the spectrum is essentially free for them, whereas other resources come at a cost. In this context, the cost minimizing way to achieve a mission objective will inevitably use more spectrum than is economically efficient.
- Also, incumbent federal users have little incentive to give up spectrum allocations or report how often they use the spectrum. As a result it is unclear which assignments are actively in use and to what extent.

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And it gets worse…

- Potential gains from spectrum sharing between two commercial users can be contractually shared by both users, which creates an incentive for both to cooperate.

- Divergent motivations, a lack of unifying incentive to share, and security concerns are likely to make negotiating between Federal and commercial uses time consuming and difficult.

And worse…

- A further incentive challenge for federal users is based on the U.S. Constitution's separation of powers. The vast majority of federal agencies that use spectrum are in the Executive branch. Since Congress has budgetary oversight over these agencies, they are not allowed to enter into independent financial relationships.

- Even if they were given permission to contract with a commercial spectrum user to share their spectrum assignment, the revenue earned may either go back to the U.S. Treasury or be deducted from their budget allocation. There is no way to guarantee that the agency would keep its share of the profit or surplus created through the sharing arrangement.

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Parting Thoughts

- Sharing is not an end in itself. Sharing should be thought of in a context of **increasing the value of the use of spectrum by increasing the efficiency of spectrum use**.
- An important role of government is **providing the public good of knowledge**. To the extent that sharing technologies require experimentation, research and risk, the government may be in the best position to **facilitate experiments in sharing that could then be adopted by private sector licensees who would benefit from the knowledge spillovers.**
- The goal from an economic perspective should be **flexible use spectrum**, meaning licensees should have technological flexibility and service flexibility.
- Subject to interference parameters of their licenses, parties should be able to implement the technology of their choosing, limited to ensuring that the change does not encroach on other licensees.

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Thank you

Johanna Dwyer

johanna.dwyer@federatedwireless.com