Wireless Networks Virtualization as an enabler of Spectrum Sharing

Marcela M. Gomez - University of Pittsburgh
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SPECTRUM SCARCITY

- Rigid and static regulation
  - Priority: Avoid harmful interference
- Increasing data generation by diverse devices and technologies
  - Demanding communication requirements
- Finding methods to overcome spectrum scarcity
- Spectrum Sharing
Spectrum Sharing

- Regulatory changes that provide flexibility
- Technologies have emerged to make sharing realizable

Wireless Networks Virtualization
*
how it becomes an enabler of spectrum sharing*

- There are also Policy and Economics requirements
  - Benefits that stem from virtualization and sharing
  - Shortcomings that need to be addressed
Spectrum Sharing Taxonomy

Spectrum Rights

Property-rights Model
Sharing among Equals
Primary-Secondary Sharing

Interaction among users

Cooperation
Coexistence

Who sets the Rules

Regulator
Licensee
Spectrum Sharing Taxonomy

**Property Rights**
- Market-driven approach
- Spectrum assigned via market forces

**Sharing among equals**
- Who sets the rules
- Regulator
- Licensee
- Unlicensed bands
- ISM bands
- Private Commons

**Primary-Secondary sharing**
- Who sets the rules
- Regulator
- Licensee
- Federal-commercial sharing
- Spectrum underlay
- Spectrum overlay
- Cognitive Radio Networks

**Users’ Interaction**
- Cooperation
  - Wireless LANS
  - Cooperative Mesh network where regulator sets etiquette
  - Virtual Networks

- Coexistence
  - Cooperative Mesh network where licensee sets etiquette
  - Virtual Networks

**Users’ Interaction**
- Cooperative
  - Authorized Shared Access / Licensed Shared Access
  - Real-time Secondary Markets
Wireless Network Virtualization

Definitions

Virtualization refers to the creation of a virtual version of something, rather than the actual thing itself.

Linda E. Doyle et al.
Cellular Clouds

"Network Virtualization is any form of partitioning and combining a set of resources, and presenting (abstracting) it to users such that each user through its set of partitioned or combined resources has a unique, separate view of the network."

Anjig Wang et al.
Network Virtualization: Technologies, perspectives and frontiers

When the sliced, partitioned and combined components are wireless networks assets, then we refer to **Wireless Networks Virtualization**

- Different types of partitions or combinations will yield distinct virtual networks
- The abstraction of each part of the network will result in a particular perspective
**Wireless Network**  
**Virtualization**

### Aspects

**Scope/Depth:**
- Network-wide vs. localized
- Granularity of virtualized resources

**Wireless Technology:**
- Very-short range (Bluetooth, Zigbee)
- Short range (WLANs)
- Medium and Large range (WiMAX, LTE)

**Client-side / Infrastructure-side:**
- Client side: lossless handover, advanced mobility management, optimized uplink allocation.
- Infrastructure side: virtualize uplink / downlink communication resources

### Perspectives

**Flow-based:**
Isolation, scheduling, service differentiation and management for uplink / downlink traffic flows that belong to different slices.

**Protocol-based:**
Isolation, customization and management of various wireless protocol instances on the same radio infrastructure

**Spectrum-based:**
Abstraction and dynamic allocation of spectrum bands to each user via spectrum reshaping and radio slicing

- Deepest level of slicing

Not mutually exclusive. Can be combined to achieve deeper levels of virtualization and larger scopes
Flexibility
From Virtualization:
• Opt for dividing different flows, protocols and spectrum resources
• Basis for establishing spectrum sharing
  • Regulation and Technology
Policy
- New configuration of licenses (e.g., technology-neutral)
- Enforcement

Technology
Wireless Networks Virtualization:
- Resource (Spectrum) Pooling
  Implications for:
  - MVNOs
  - Air-interface virtualization
  Applied to LTE-A

Economics
- Costs of flexibility based on
  - Spectrum scarcity
  - Transaction costs
  - Externalities
  - “Value” of shared spectrum vs.
    “value” of exclusively used spectrum
  - Efficiency that stems from sharing

Put spectrum to its most valuable use without regulatory delays

- Decrease Scarcity
- Spectrum Sharing opportunities
- Decoupling of InPs functions from SPs functions
- Resources available on-demand

Define Incentives (in terms of)
- Costs
- Uncertainty
- Enforcement
Conclusion

- Wireless virtualization provides increased opportunities to exploit flexibility and thus enhance spectrum sharing.
- Wireless virtualization does not only enable sharing but it is also complemented by it.
- For innovation to be successful, it needs to take into account the entire system: technology, policy and economics.
Policy and Economics:

- No complete independence of the economic and regulatory system
- Regulation can restrict some desirable transactions
  - Costly and time-consuming procedures
    - Market failure
    - Deter appealing sharing arrangements
- Flexible definition of rights constitutes the starting point for enabling the rearrangement of rights via alternative mechanisms
  - Virtualization and Spectrum sharing
Technology and Policy:

• No significant technological change will be successful and have practical value if there is no policy approach rendering it feasible

  • New technologies will alleviate scarcity, if and only if, spectrum policy is reformed to match the technology
Future Challenges

- Design policy that provides enough flexibility
- Choose the appropriate resources and functionalities to partition and slice
  - Different standards represent different requirements and pose diverse challenges
- Isolation in virtualization
- Incentives
  - Consider the value of resources and outcomes