Wireless Networks Vision: Networks without Borders

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A Sharing Economy Perspective on Future Wireless and Optical Networks

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Exploding demand

- Smartphones use 24x more data than regular phones
- Tablets use 122x more data than smartphones
- However, it is not feasible for operators to increase prices proportionally to this demand

How to deal with this?

- More efficient utilization of spectrum and other forms of resource sharing
- New wireless network architectures (small cells, seamless integration of different wireless technologies)
An evolution...
An evolution...
An evolution...
Networks without Borders

Towards a sharing economy

Networks without Borders

- Network is composed on the run from a pool of resources (spectrum, infrastructure, management services, ...)
- Some wireless resources are fungible
- Contributors to this pool range from households to small scale operators to traditional wireless providers
- Network exists, virtually, to provide specific services to a specific subscriber/user population
- Network has a transient nature
- Virtualization is a key component, leading to new entities (the resource aggregator, the virtual architect)
- New business models
Increased efficiency and lower costs through...

1. Incentives for the deployment of localized (small cell, primarily) infrastructure by medium-sized and small operators

2. The ability to provide service over infra-structure that employs heterogeneous technologies, and has different properties and ownership

3. Improved service in currently under-served areas
Coordination for heterogeneous and multi-hop networks

• Distributed spectrum sharing for multi-hop topologies and HetNets (relays, coexistence between small and large cells)

• Adaptations: channel selection, transmit power

• Goals: network-wide spectrum efficiency, fairness, network connectivity, coverage

• Cooperative game theory, coalition formation

Types of coalition in equilibrium as a function of link range


Hierarchical game for vertical spectrum sharing

1. Primary users (PUs) can charge secondary users (SUs) for access to spectrum

2. SUs distributedly select on which sub-bands to operate
   - Multiple SUs can occupy the same sub-band and cooperate in communicating

3. SUs control their transmit power

How about infrastructure and spectrum sharing?

- Relying on data from mobile operators to assess virtual networks constructed from resources belonging to multiple operators
- Picture above is from Warsaw
## Site co-location

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of cellular sites</th>
<th>Number GSM900 sites</th>
<th>Number of GSM1800 sites</th>
<th>Number of UMTS2100 sites</th>
<th>Percentage of intra-operator co-located sites</th>
<th>Percentage of inter-operator co-located sites</th>
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<tr>
<td>Warszawa</td>
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<td>20</td>
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<td>6.9</td>
</tr>
</tbody>
</table>
Potential efficiency gains in sharing

- Assessing what portion of resources is needed if we were to customize a network by combining assets from multiple MNOs, with a certain coverage goal
- Considered a mix of urban (large and medium size cities) and rural areas in Poland
- Starting to model demand for capacity, as well as coverage
• Mapping between physical resources and virtual networks over shared resources

• Economic drivers and incentives/disincentives for sharing

• Virtualization techniques and locality of resources

• Regulatory issues in spectrum and in infrastructure sharing

• Development of standard interfaces for combining resources from multiple sources

• Proof-of-concept experimentation using testbed federations (FIRE, GENI)
‘The new status symbol isn’t what you own—it’s what you’re smart enough not to own’

Lynn Jurich
Contact

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Current areas of investigation...

- Efficient distributed resource management mechanisms under imperfect information
- Virtualization of networks built on multi-provider infrastructure and heterogeneous access technologies
- Effects of new wireless network architectures on the design of the optical backhaul
- Incentive models for inter-operator cooperation
- Incorporating DSA into LTE-A and beyond