Dynamic Self-Optimization in Wireless Networks

Chair: Andrea Goldsmith
Dynamic self-optimization in wireless networks: what is it?

- Dynamic optimization of network nodes to maximize network performance metric(s)
- Optimization can be distributed, centralized, or a hybrid approach
- Problems often NP complete: innovation needed to tame the complexity
- Network dynamics (channels, topology, traffic) require ongoing sensing and re-optimization
Self-optimization can apply to all wireless networks

TV White Space & Cognitive Radio

Ad-hoc networks

Vehicle networks

Self-optimizing networks (SoN)
The Future Cellular Network: Hierarchical

Today’s architecture

- 3M Macrocells serving 5 billion users

Managing interference between cells is hard

Macrocell
- Radius = 2,000m
- Transmit Power = 40W

Picocell
- Radius = 200m
- Transmit Power = 2W

Femtocell
- Radius = 10m
- Transmit Power = 0.1W

10x Lower HW COST

10x CAPACITY Improvement

Near 100% COVERAGE
## Deployment Challenges

<table>
<thead>
<tr>
<th>Deploying One Macrocell</th>
<th>Effort (MD – Man Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New site verification</strong></td>
<td>1</td>
</tr>
<tr>
<td>On site visit: site details verification</td>
<td>0.5</td>
</tr>
<tr>
<td>On site visit: RF survey</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>New site RF plan</strong></td>
<td>2</td>
</tr>
<tr>
<td>Neighbors, frequency, preamble/scrambling code plan</td>
<td>0.5</td>
</tr>
<tr>
<td>Interference analyses on surrounding sites</td>
<td>0.5</td>
</tr>
<tr>
<td>Capacity analyses</td>
<td>0.5</td>
</tr>
<tr>
<td>Handover analyses</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Implementation on new node(s)</strong></td>
<td>0.5</td>
</tr>
<tr>
<td>Field measurements and verification</td>
<td>2</td>
</tr>
<tr>
<td>Optimization</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total activities</strong></td>
<td><strong>7.5 man days</strong></td>
</tr>
</tbody>
</table>

5M Pico base stations in 2015 (ABI)
- 37.5M Man Days = 103k Man Years
- Exorbitant costs
- Where to find so many engineers?

Small cell deployments require automated self-configuration via software

Basic premise of self-organizing networks (SoN)
SON for LTE small cells

- Node Installation
- Initial Measurements
- Self Configuration
- Measurement
- SON Server
- Self Optimization
- Self Healing

SoN Controller

Mobile Gateway or Cloud

IP Network

Part of 3GPP Standard

X2

Small cell BS

Macrocell BS
Open questions in SoN-for-LTE

- Will small cells wreak havoc on cellular network design? When should they be used?
- Should small cell SoN be centralized or distributed?
- Should large and small cells be managed together or can they be managed separately?
- Should SoN be applied to large cells as well?
- What are the right optimization metrics?
- How to tame optimization complexity?
- When will small cells become prevalent, if ever?
First two talks:

- Near optimum association and interference coordination in HetNets with applications in SONs
  *Reinaldo Valenzuela, Alcatel-Lucent Bell Labs*

- The Dark Art of Load Balancing in Heterogeneous Networks
  *Jeffrey Andrews, UT Austin*
SoN for WiFi

- Channel Selection
- Power Control
- CST adaptation

- Dynamic self-organization software to control and optimize WiFi network performance *vs wild wild west*
- Centralized controller can also provide AP configuration and management, network analytics, and planning.
- Some WiFi APs do distributed SoN: highly suboptimal
- Enterprise WiFi controllers are closed systems: new technology provides SoN for heterogenous/embedded APs
SoN-for-WiFi Challenges

- Algorithm complexity
- Cloud-based interface to WiFi chipsets
- Lack of synchronization
- Lack of control over some APs and other ISM-band devices
SoN for Cognitive Radios

- Cognitive radios (CRs) support new wireless users in existing crowded spectrum
  - Without degrading performance of existing users

- Intelligently exploit sensed information about other nodes with which they share the spectrum
  - Information may include the channel conditions, activity, codebooks, and/or messages of these other nodes
  - Requires self-organization and advanced optimization

- CR paradigms include underlay, overlay, and interweave (white space) techniques
  - Can apply to unlicensed users in licensed bands, or to fully unlicensed/licensed users with different priorities.
Third Talk:

"Cognition in Heterogeneous Wireless Networks"

Tony Queck, Institute for Infocomm Research, Singapore
SoN for Ad-Hoc Wireless Networks

- The first self-organizing wireless network
- Distributed control with no backbone infrastructure
- Peer-to-peer communications w/ multihop routing
- Fully connected with different time-varying link SINRs

Decades of research on SoN techniques for ad-hoc wireless networks; performance still poor, few killer apps
Fourth Talk:

"Interference games: from power control to information theory"

*Randall Berry, Northwestern*
Enjoy the session!

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