



Dynamic Self-Optimization in Wireless Networks

Chair: Andrea Goldsmith



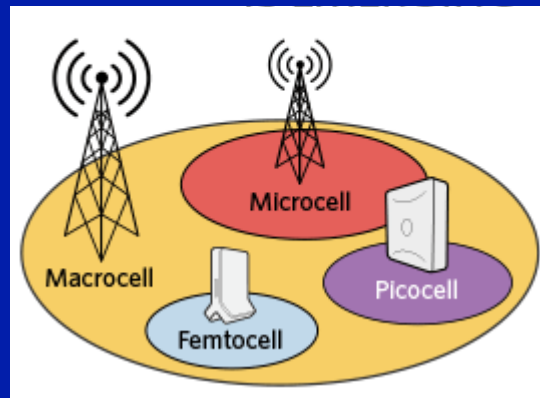


Dynamic self-optimization in wireless networks: what is it?

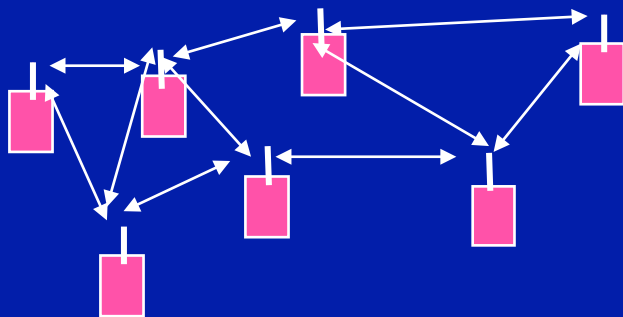
- Dynamic optimization of network nodes to maximize network performance metric(s)
- Optimization can be distributed, centralized, or a hybrid approach
- Problems often NP complete: innovation needed to tame the complexity
- Network dynamics (channels, topology, traffic) require ongoing sensing and re-optimization

Self-optimization can apply to all wireless networks

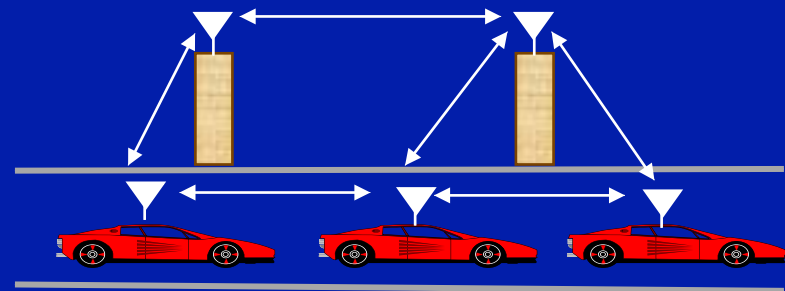
TV White Space &
Cognitive Radio



Ad-hoc networks

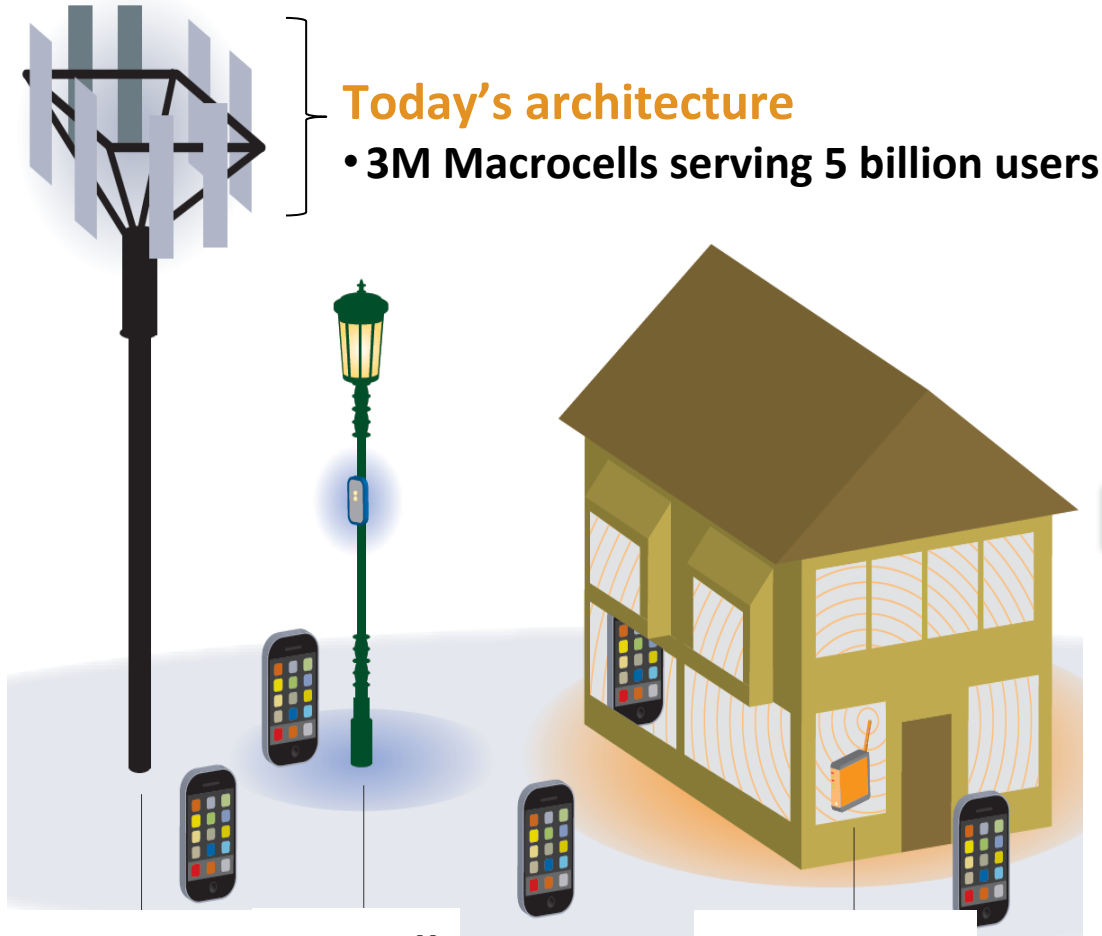


Vehicle networks



Self-optimizing networks (SoN)

The Future Cellular Network: Hierarchical



Today's architecture

• 3M Macrocells serving 5 billion users

Macrocell Picocell

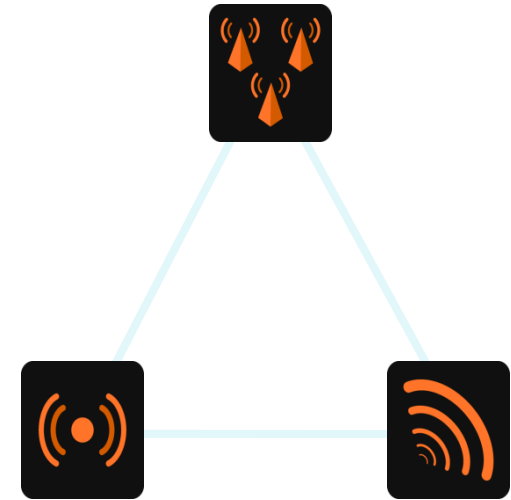
Macrocell
Radius = 2,000m
Transmit Power = 40W

Picocell
Radius = 200m
Transmit Power = 2W

Femtocell

Femtocell
Radius = 10m
Transmit Power = 0.1W

10x Lower HW **COST**



10x **CAPACITY**
Improvement

Near 100%
COVERAGE

**Managing interference
between cells is hard**

Deployment Challenges

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

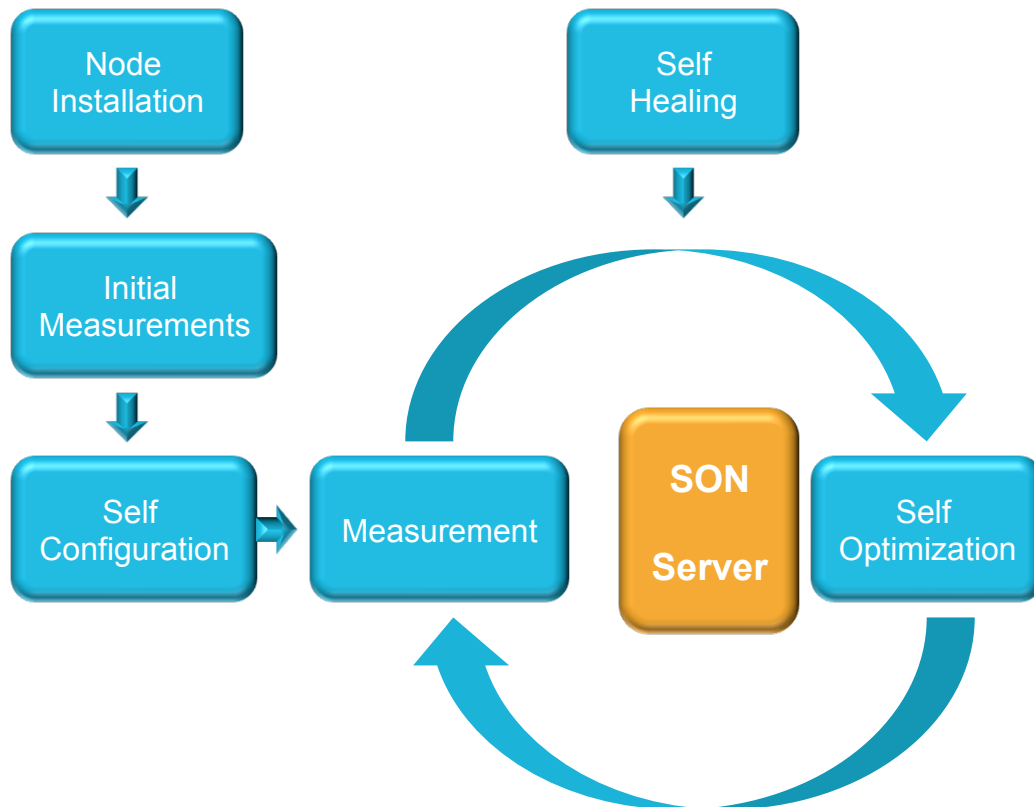


- 5M Pico base stations in 2015 (ABI)
- 37.5M Man Days = 103k Man Years
 - Exorbitant costs
 - Where to find so many engineers?

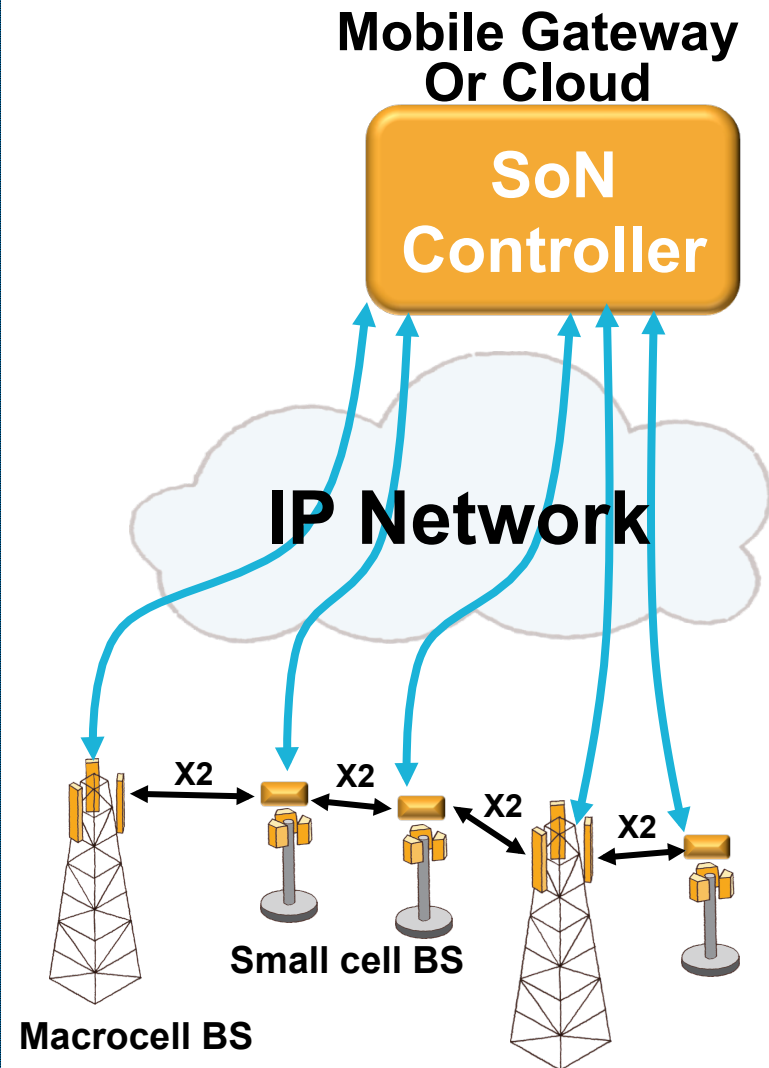
**Small cell deployments
require automated self-
configuration via software**

**Basic premise of self-
organizing networks (SoN)**

SON for LTE small cells



Part of 3GPP Standard





Open questions in SoN-for-LTE

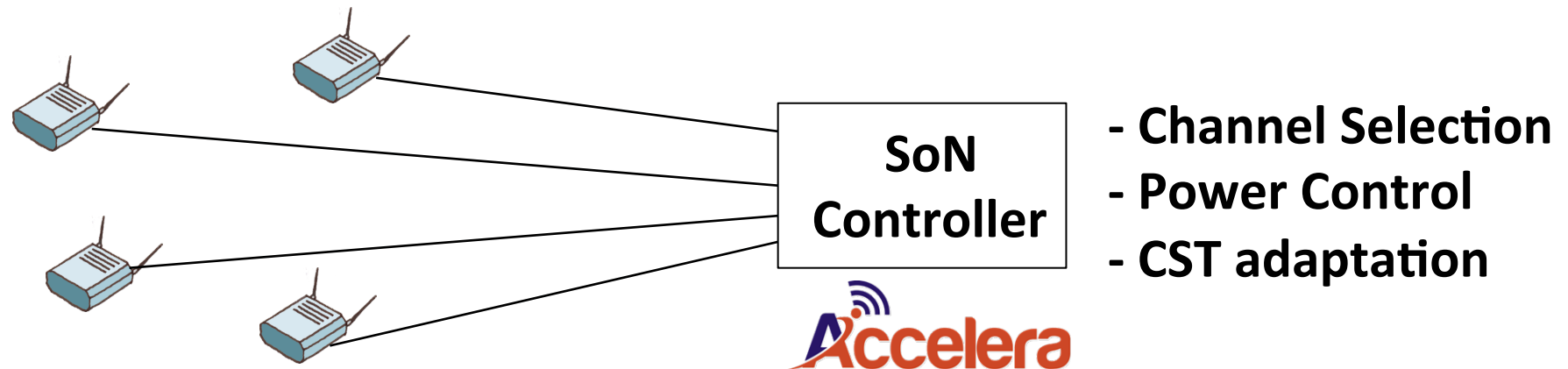
- Will small cells wreak havoc on cellular network design? When should they be used?
- Should small cell SoN be centralized or distributed?
- Should large and small cells be managed together or can they be managed separately?
- Should SoN be applied to large cells as well?
- What are the right optimization 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



- 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 heterogeneous/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.

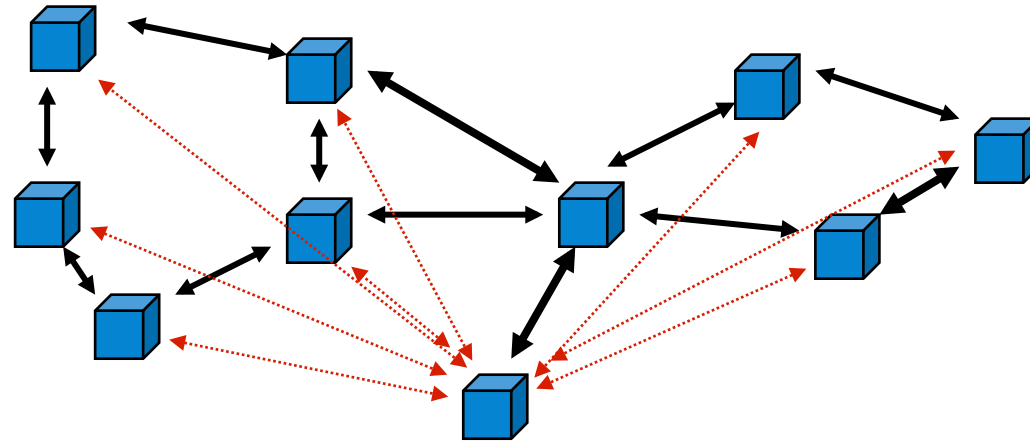


Third Talk:

- "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!

- “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*
- “Cognition in Heterogeneous Wireless Networks,” *Tony Queck, Inst. for Infocomm Research, Singapore*
- “Interference games: from power control to information theory,” *Randall Berry, Northwestern*