Application of Genetic Programming in Wireless Networks

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What we do

Bell Labs is the research organization of Alcatel-Lucent

Bell Labs Ireland is based in Dublin, with a total of 54 researchers working on a diverse range of topics in telecommunications networks and systems

- **Wireless + Green**
  - RF hardware, small cell autonomies

- **IP Routing**
  - Thermal management

- **IP Platforms + NADS**
  - Analytics, cloud systems
Small Cells
Providing Capacity for Future Networks

Demand for wireless capacity increasing exponentially

Small cells offer the 100X targeted capacity increase:
• high spatial reuse of radio resources
• enables use of high frequencies
• placed where demand is needed → antennas close to users

98% of mobile operators believe small cells are essential for the future of their networks.

Future network topology → Small cells deployed to provide capacity, macrocells for coverage.

Alcatel-Lucent Small Cells: residential and enterprise femtocells, indoor and outdoor metrocells
Small Cell Research
The need for intelligence

Macrocell-style manual cell planning and optimization is slow and costly, doesn’t scale when applied to the large numbers of small cells.

Small cells needs to become smarter, and self-configure and self-optimize their parameters autonomously for wide-scale deployments to be feasible.

Femtocells in particular needs significant self-organizing network (SON) functionality to make them plug-and-play deployed by end user, in unpredictable environments, and in high densities.

Currently, femtocells have SON algorithms designed to configure a wide array of parameters.

Is there a way to automate the design of SON algorithms themselves?
Planning and optimisation is performed manually through network planning engineers and drive testing.

Algorithms for auto-configuration and self-optimisation are developed manually, and used to automate the network configuration and optimisation.

Algorithms are generated using automated means, (genetic programming). Design process is done offline, and resulting algorithm is implemented in the network.

The algorithm generation process is now distributed and performed locally and continuously by the network nodes themselves. Nodes now have ability to autonomously specialise their individual behaviour according to environment.

Objective  Model  
Algorithm  
measurements  
BS  
Network Planners  
measurements  
drive testing  

Past  Now  Future  

Objective  Model  
Algorithm  
measurements  
Automated Program Generation (offline)  

Objective  Model  
Algorithm  
measurements  
Automated Program Generation (online)  

Objective  
Model  
measurements  
Automated Program Generation  

The design process is done offline, and resulting algorithm is implemented in the network.
Genetic Programming
Collaborating with UCD

Collaboration with UCD Complex and Adaptive System Lab (CASL) to apply Genetic Programming in wireless networks

• Discussions initiated with invited talk by Prof. O’Neill at Bell Labs, leading to...
• Post-doc (Erik Hemberg) spending time at Bell Labs for 1 year, funded by SFI

Aim was to investigate the feasibility of online evolution of algorithms, applied to femtocell coverage optimization

Good match of complementary expertise, and exchange of ideas

• Bell Labs → femtocell network optimization, detailed modelling of scenario.
• UCD → optimization of genetic programming evolution, grammar.
Outcome

Online evolution of femtocell coverage optimization algorithm that matches the performance of brute force search.

Addressed an important problem (business relevance) using a new approach (scientific impact):

- 1 jointly filed patent application granted
- 1 book chapter, 1 journal & 2 conference publications

Subsequently through an Investigator award to Prof O'Neill, we have received additional funding from SFI to deepen the collaboration: new Post-doc (Mike Fenton) and PhD (David Lynch) started this September