An analysis to the deployment of access points using genetic algorithms

Análise à disposição de pontos de acesso utilizando algoritmos genéticos

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Infra-structured Wireless Networks

- Wireless networks are usually deployed without adequate planning
  - One access point (AP) per room
  - In the most convenient place (from a user perspective)
- This approach has many drawbacks
  - Sub-optimal
    - coverage
    - bandwidth
  - More APs than required
  - Complex configuration
  - Coverage outside the desired physical limits
Site Survey

- A class of tools used to perform on-site analysis of a wireless network deployment
- Typical output includes:
  - Number, name, channel and received signal strength of APs in range
- Helps user to diagnose coverage deficiencies
- Provide a graphical interface offering an integrated view of the site
Situs

- A site survey application,
- Blueprints defined in Situs or uploaded from external applications
- Graphically displays:
  - Number of APs
  - Received Signal Strength
  - Expected bandwidth
  - Interference
Automating the Deployment of Wireless Networks

- Useful for:
  - Planning the location of points of access to the wired network
  - Home networks
  - Fix existing deployments
- Requires the estimation of signal fading
- Must account with obstacles, walls, etc.
- Propagation models are widely available in the literature
  - Free-Space
  - Motley-Keenan
  - Multi-Wall
Algorithms

How to find suitable locations for the APs?
- Testing all possible combinations: resource demanding
- Trial and error
- Genetic algorithms
Genetic Algorithms

- Chromosomes represent configurations (solutions) of some problem
- Solutions are evaluated by a fitness function
  - The fitness function selects the best individuals (chromosomes) for recombination of its genes
- Individuals have their genes recombined by operators to create new individuals
  - Crossover
  - Gene Swap
  - Mutation
Problem Representation

- Each square in the surveyed space is a gene
- Each gene has value 1 if an AP is located there or 0 otherwise
- Each individual is a map of the site

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Fitness Function

- Evaluates the “quality” of the solution represented by the individuals
  - Different fitness functions may evaluate different criteria
- Situs’ fitness function:
  - Counts the number of squares without coverage
  - Tie-break: sum the signal strength of all squares
- User may select from different propagation models
Genetic Algorithm in Situs

- Create a random population
- Combine the population
- Full coverage?
  - Yes
  - No
  - Add another AP

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Defining the initial population

Create a random population

- Selects the best of a random population of predefined size
- Add it to the population set
- Repeat until last consecutive $n$ iterations do not provide an individual better than all previous in the population set
Combining the population

1. Crosses the genes of pairs of individuals
2. Selects the best of them
3. Swaps its genes

- After each step, see if the result improves the population
Individual evaluation

- Stops if the best solution in the population provides full coverage to the map
- Otherwise, mutes a random gene to one (adds one AP) and restarts
- This individual is the first one to be added to the population on the next iteration
Evaluation

- Situs was tested in a real deployment of a wireless network
- Surveys performed with high accuracy
- Surveyed region size: 19mx6m (approx. 114m²)
- Sets of random population with 2 individuals
- Addition of individuals stop after 4 iterations without a better one
- *Multi-Wall* propagation model
Conclusions

- Situs extends existing site survey applications with tools to fix and plan infra-structured wireless network deployments.
- The genetic algorithm allowed to rapidly and correctly find a good deployment of a wireless network infrastructure.
- The Multi-Wall propagation model was a little optimistic about the coverage provided by the APs.
Future Work

- Define new fitness functions and stop conditions
  - Allow to include regions with minimal signal strength
  - Allow to guarantee that some regions will not have coverage
  - Accept user-defined trade-offs between number of APs and quality of the coverage

- Improve the genetic algorithm
  - Better understand the contribution of each genetic operator to the outcome
  - Test other genetic operators
  - Analytically define adequate values for the constants in the algorithm