An analysis to the deployment of access points using genetic algorithms

Análise à disposição de pontos de acesso utilizando algoritmos genéticos

Rui Ligeiro
CapitalJ
rligeiro@capitaljit.com

Hugo Miranda
Universidade de Lisboa
hmiranda@di.fc.ul.pt

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

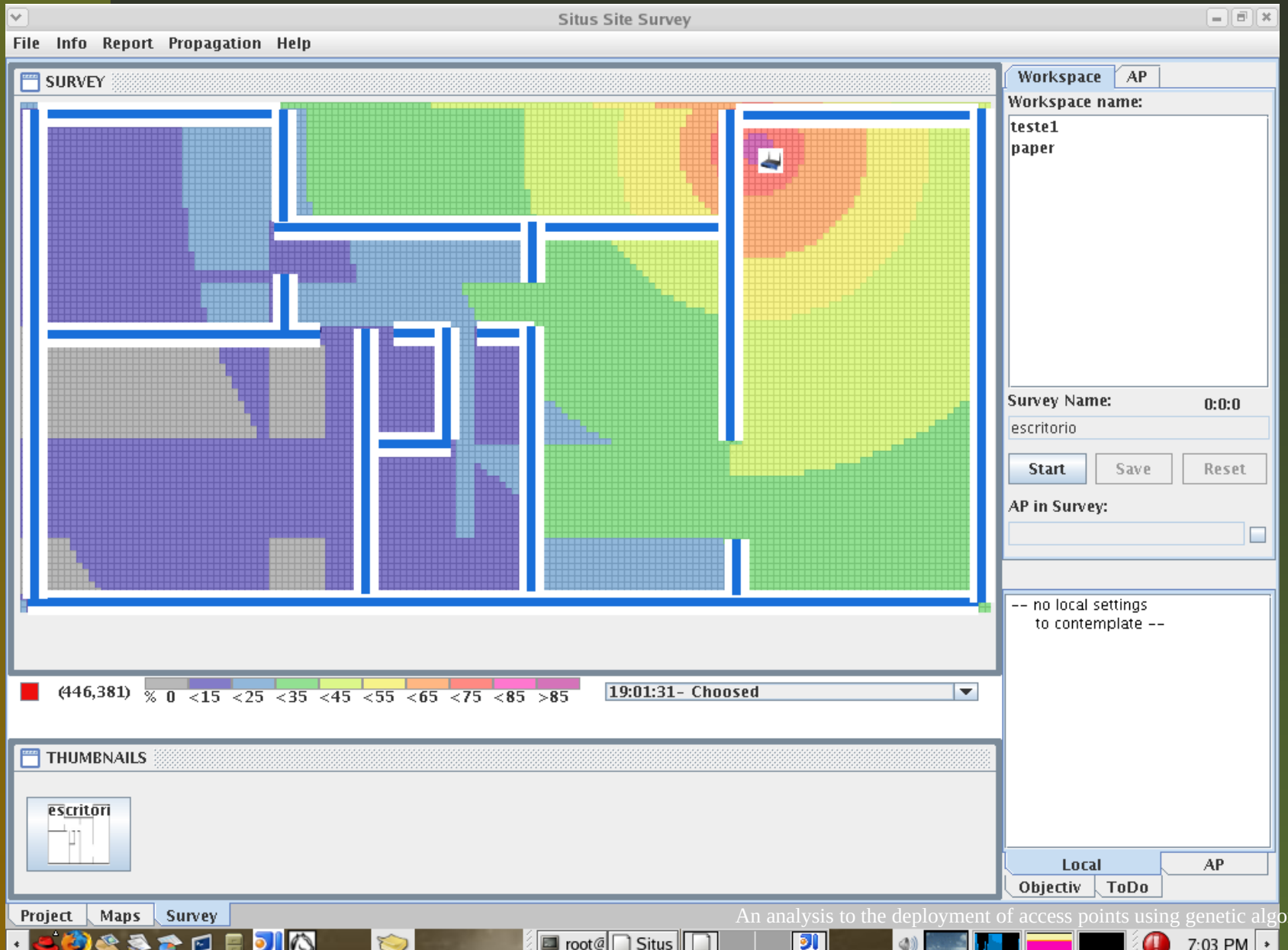
Site Survey

- 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 diagnosis 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

Situs screen-shot



Automating the Deployment of Wireless Networks

- Useful for:
  - Planing 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

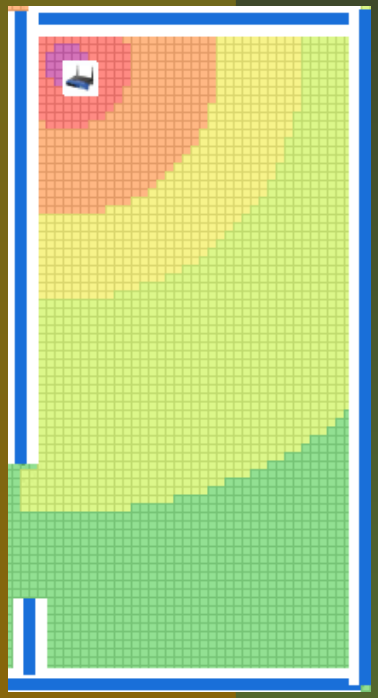
- How to find suitable locations for the APs?
  - Testing all possible combinations: resource demanding
  - Trial and error
  - Genetic algorithms

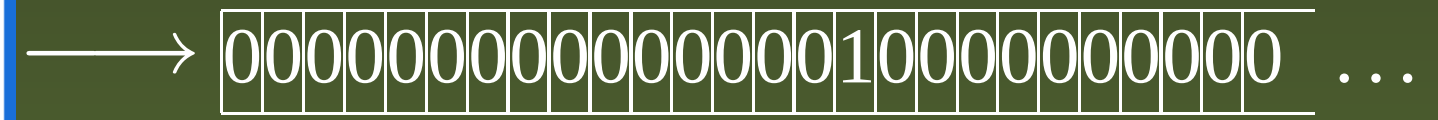
Genetic Algorithms

- 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

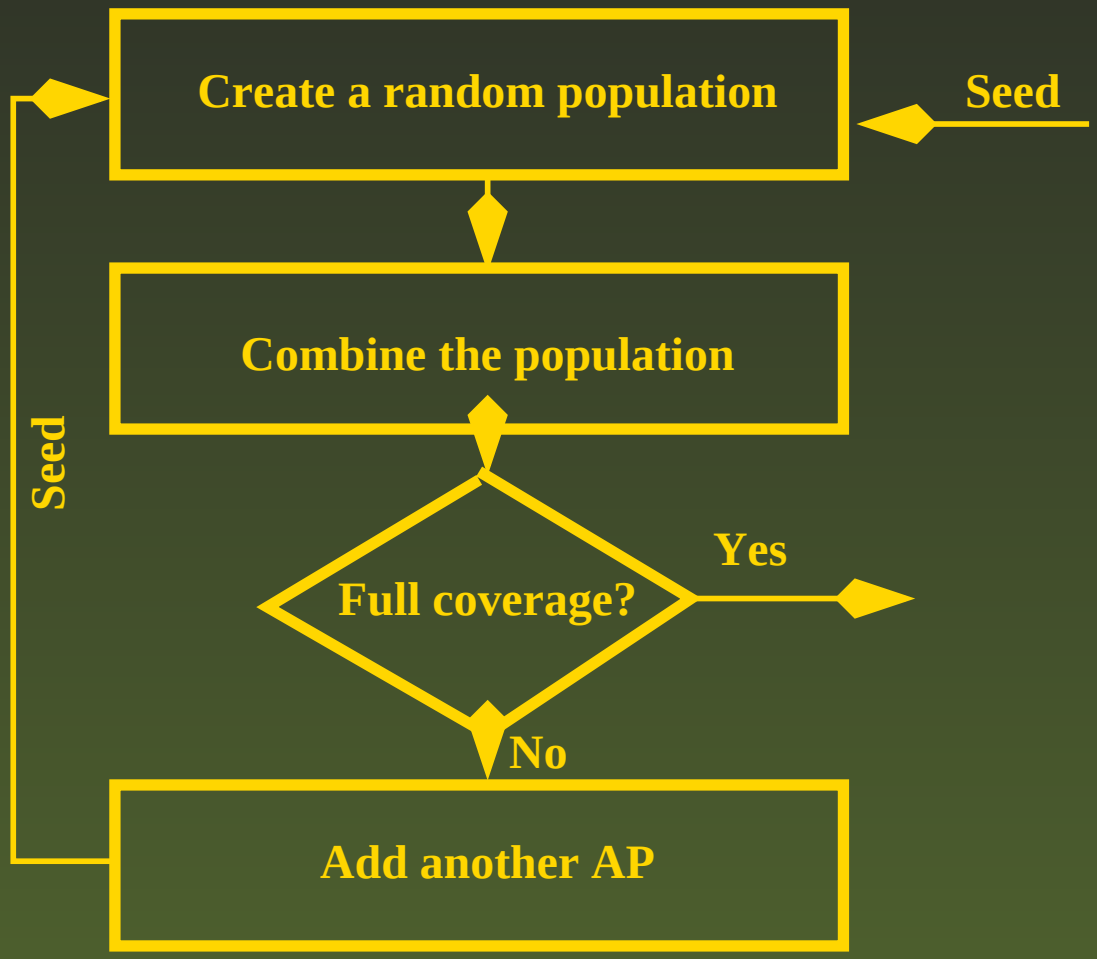




Fitness Function

- 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



Defining the initial 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

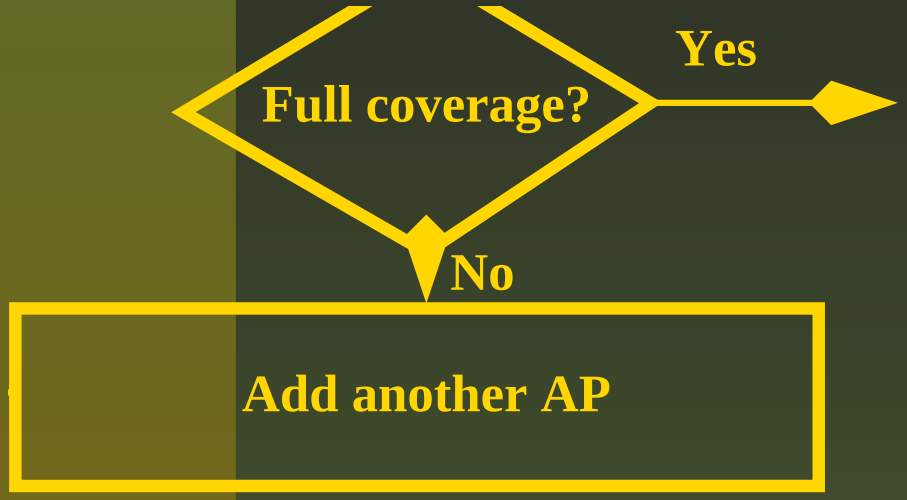
Combining the population

Combine 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

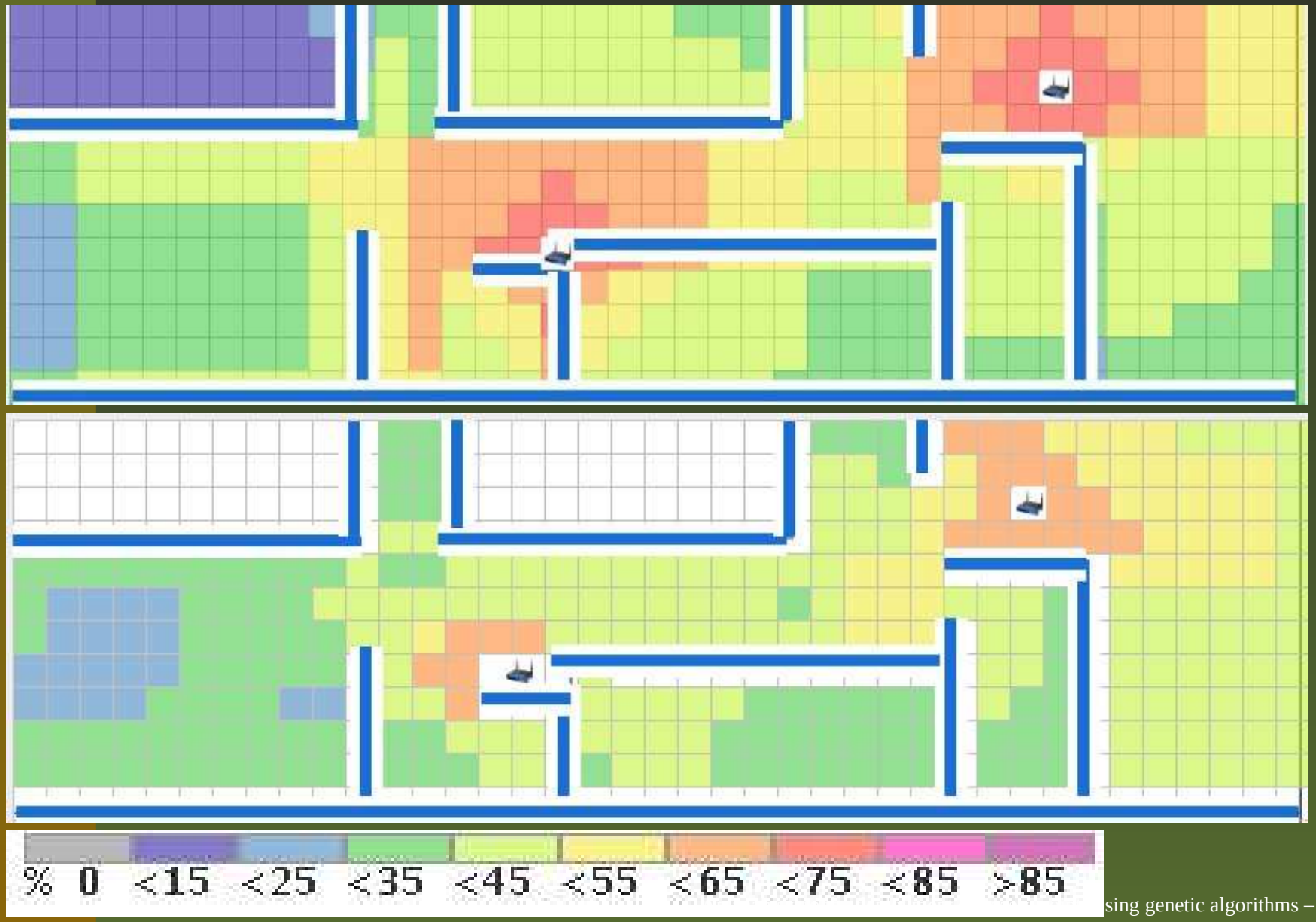
Evaluation

- 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

Example

GA Outcome

Survey



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