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Large-scale real-world automatic frequency planning in GSM networks using GrEA

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Outline of the talk

- Introduction
  - ❖ Motivation
  - ❖ Contributions
- Problem statement
  - ❖ GSM systems
  - ❖ Frequency assignment
- Algorithmic approach
  - ❖ Steady state GAs
  - ❖ GrEA
- Results & Discussion
  - ❖ Instance used
  - ❖ Experimentation

Motivation

- GOAL: solving a real-world optimization problem coming from the telecommunication industry using metaheuristics

- Automatic frequency assignment (AFP)
  - Well-known problem in OR: many mathematical models have been proposed (extension of graph coloring)
  - Current real-world frequency planning: GSM networks

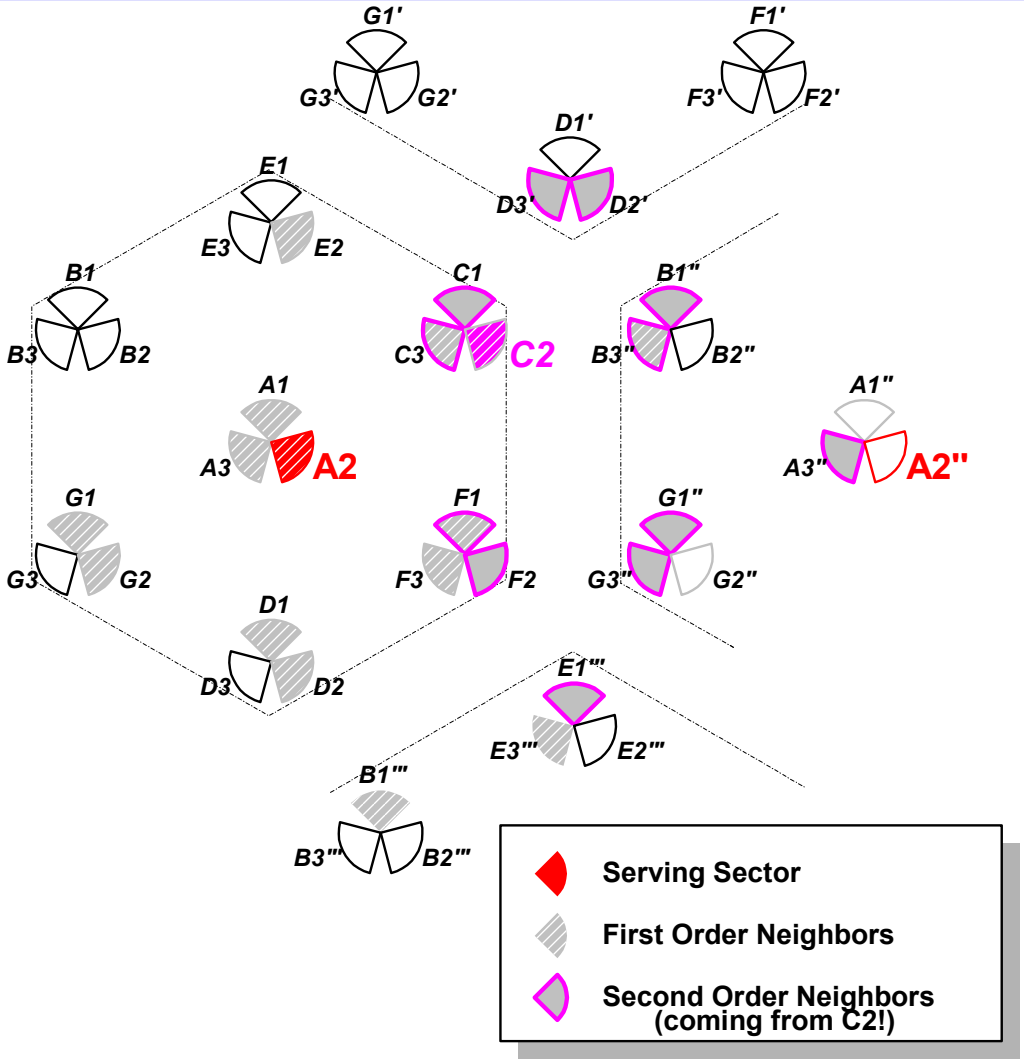
- Why are we still interested in solving AFP problems?
  - 77% of the world's cellular market is GSM
  - UMTS will be coexisting with GPRS and EDGE
  - Current GSM operators
    - Subsequent expansions/modifications of the network
    - Solve unpredicted interference reports
    - Handle anticipated scenarios

Contributions

- The AFP problem in real-world scenarios
  - ❖ Precise interference information is needed
  - ❖ Very large number of TRXs
    - → Both numerical and computational power is required
- Our approach to cope with this requirements
  - ❖ Metaheuristics
  - ❖ Grid computing
- Contributions
  - ❖ Provide the largest AFP instance ever tackled in the literature with very accurate solutions
    - → 41,923 TRXs (Los Angeles, CA)

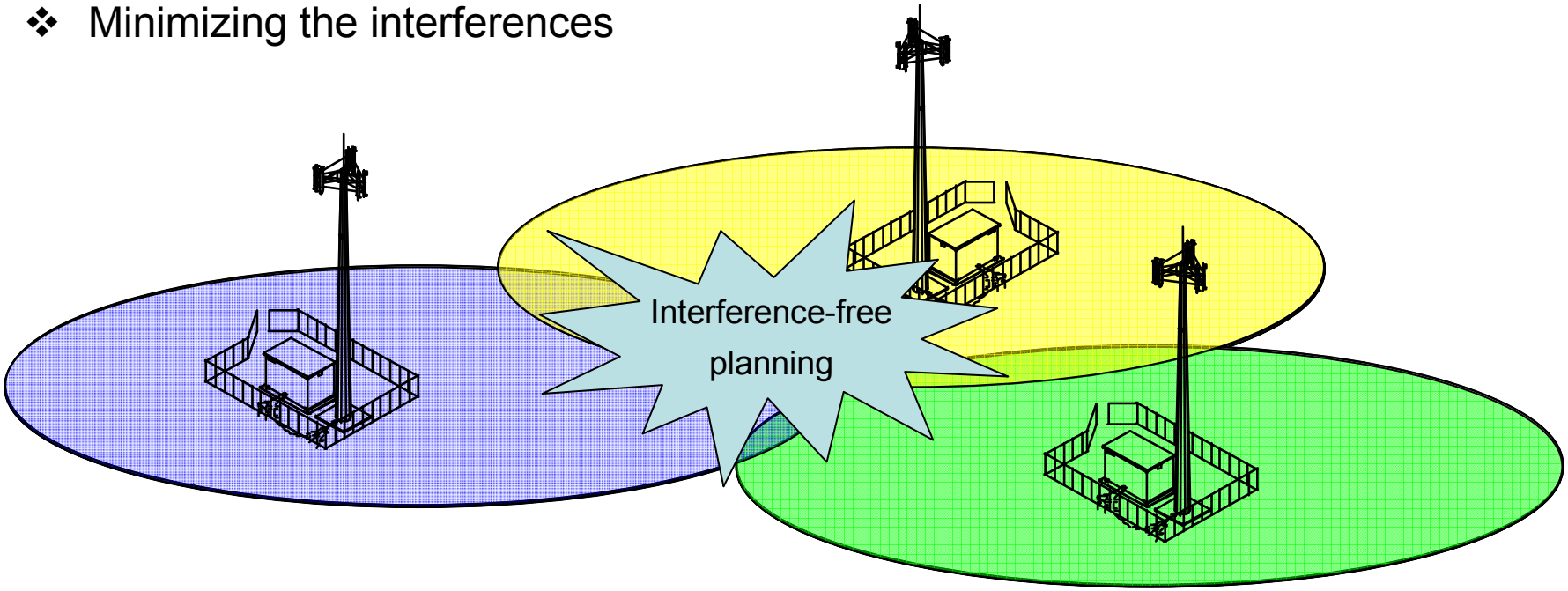
GSM components and interferences

- Components relevant to AFP
  - Base Transceiver Station (BTS)
  - Sectors
  - Transceivers
- Interferences
  - Cochannel
  - Adjacent channel



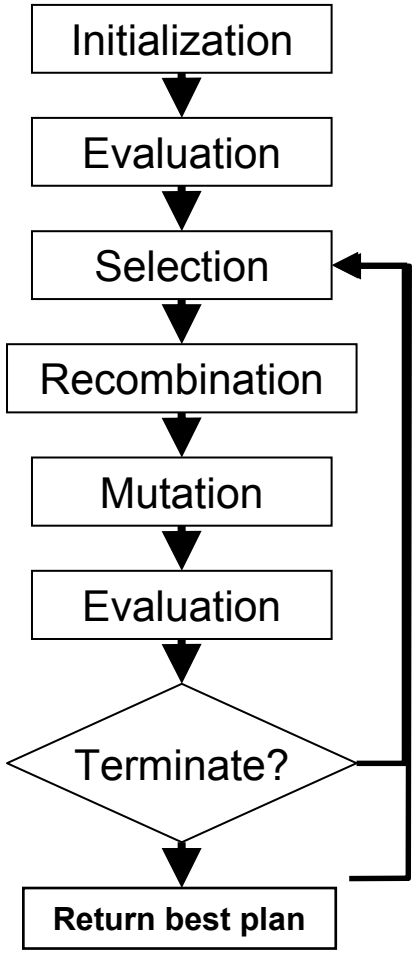
Automatic Frequency Planning

- Each cell is served by one or more TRXs
  - The number of TRXs depends on the traffic demand on a given cell
- The optimization problem (AFP) lies in
  - Assigning frequencies to TRXs
  - Minimizing the interferences



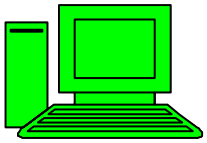
Steady-state GA

- Genetic Algorithm
  - Using a steady state scheme
  - Representation
    - Array of integers → tentative frequency plans
  - Genetic operators
    - Binary tournament selection
    - Uniform crossover
    - Random mutation
  - Hybridization with Local Search
    - Mandatory in real-world scenarios
      - "Good" solutions in short times
    - Remove the stronger interference introduced by the stochastic operators
    - Very time consuming task



Grid-based Evolutionary Algorithm (GrEA)

- Master/worker scheme
  - Java → Sparrow
  - Local Search



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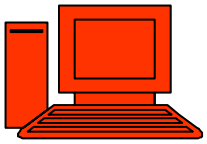
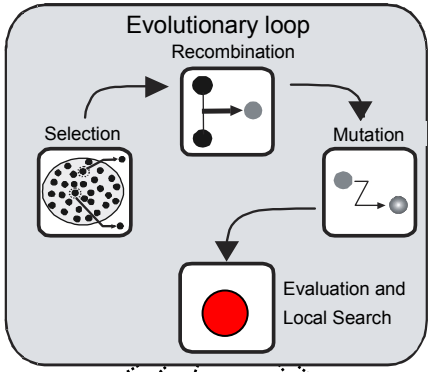
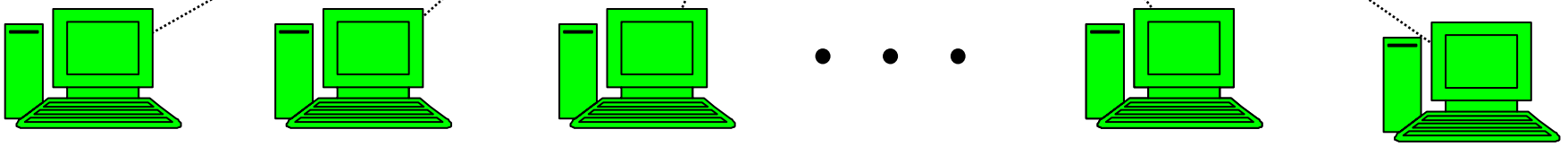


Owner

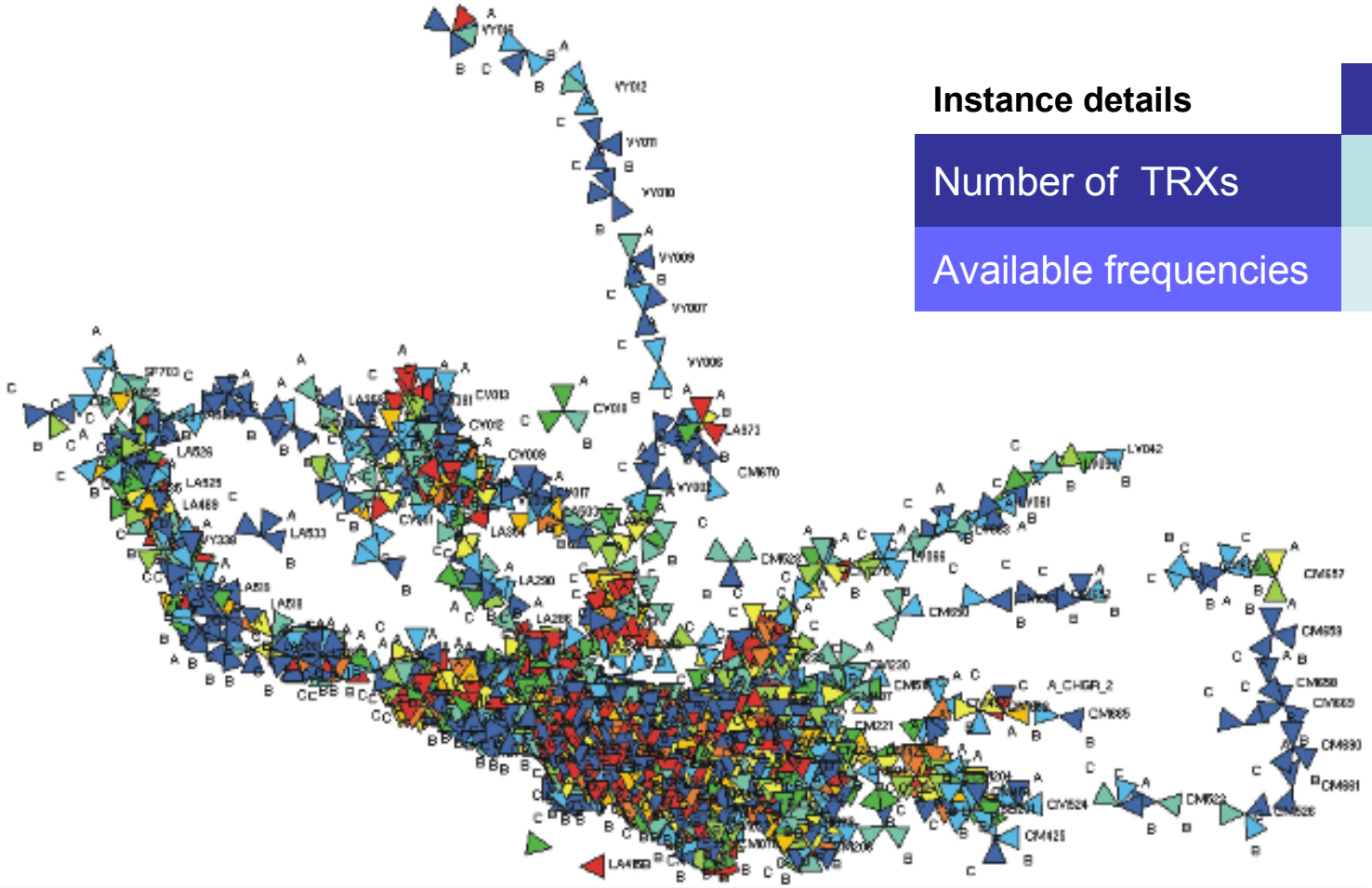


Master:

ssGA



Real-world GSM network: Los Angeles



Instance details	Los Angeles
Number of TRXs	41.923
Available frequencies	69

Local Search standalone

- Stopping condition
  - Convergence to a local minimum
- Goals
  - Comparison basis
  - Measuring its computational cost

	Cost	Time (s)	Iterations
Los Angeles	1,335,687	1,386 sec./it.	23

GrEA

- Stopping condition
  - 50,000 function evaluation
- Parallel efficiency
  - More than 75 times faster
  - Reach a 93.81%
- Efficacy
  - 24.18% lower interference than LS

	Los Angeles
Number of workers	80
CPU Time Accumulated	11,992 hours (1.33 **years**)
Wall-clock time	159 hours (6.62 **days**)
Parallel performance	93.81%

AFP planning cost	Los Angeles
Local Search	1,335,687
GrEA	1,012,651

Comments & Questions

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