Challenge 3 Self Organized Networks proposed by Fon

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Self Organized Networks

proposed by Fon

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Agenda

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- Problem description
- Study group goals and structure
- Solution proposed
- Experiments and results
- Conclusions

Wi-Fi in the Real World

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- **It is possible to have large number of WiFi hotspots within the same coverage area**
  - This number is only going to increase in the next decade
- **Hotspots may operate in interfering frequencies with different power levels**
  - User performance is affected due to the medium access mechanism imposed by the 802.11 standard

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The 2.4 GHz band [1]

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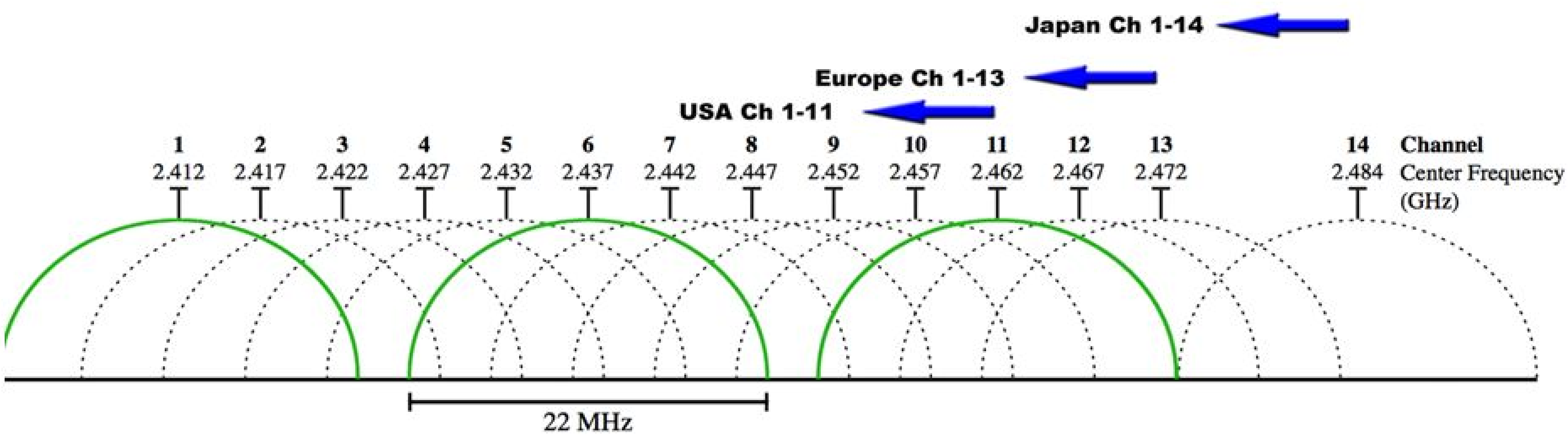

The 5 GHz band [1]

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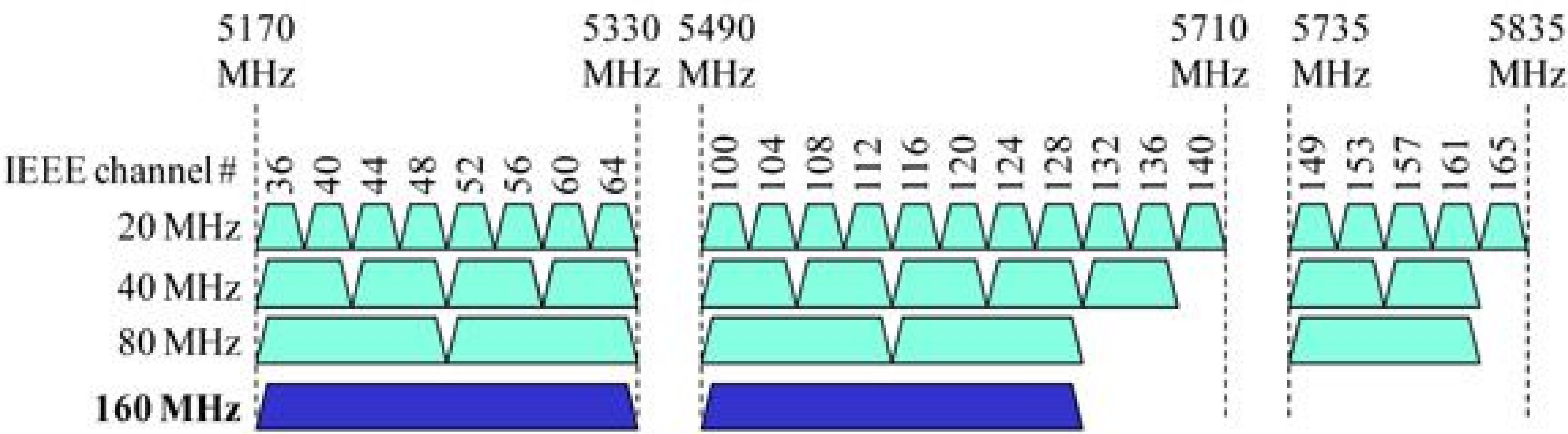

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Shared Medium Transmissions

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- **CoChannel Interference (CCI) - preferred**
  - Transmissions occur in the same frequency channel
- **Adjacent Channel Interference (ACI)**
  - Transmissions are sent on adjacent or partially overlapping channels
    - Defer ongoing transmissions
    - Corrupt transmitted frames
      - Increase number of retransmissions

Study Group Goals

- **Propose improved algorithms for frequency selection**
  - Unmanaged partially cooperative urban environment
  - Some of the hotspots are not accessible for configuration (owned by other companies/people)

Group Team Work

- **Two teams**
  - Team A
    - Algorithms (research, description, presentation)
  - Team P
    - Python (implementation, simulations, validation)

Working Methodology

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- **Short Sprints**
  - Small tasks
  - Clear deadlines
  - Teams synchronization twice a day
    - Morning
    - Afternoon

Algorithm Input-Output

- **Input**
  - List of neighboring hotspots
    - Signal level
    - Frequency of operation
    - Location (only for own devices)
- **Output**
  - List of frequency channels selection

Optimization Target

- **Interference mitigation**
  - Leading to an optimized usage of hotspots
    - Optimized spectrum usage
    - Higher bandwidth for network accessing
  - Better customer satisfaction

First Proposal

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- **Iterated Local Search**
  - Modification of local search or hill climbing
  - Modification consists of iterating calls to the local search routine
- **Initial solution**
  - Greedy start
  - Random start

First Algorithm [2]

procedure *Iterated Local Search*

$s_0 \leftarrow \text{GenerateInitialSolution}$

$s^* \leftarrow \text{LocalSearch}(s_0)$

repeat

$s' \leftarrow \text{Perturbation}(s^*, history)$

$s^{*\prime} \leftarrow \text{LocalSearch}(s')$

$s^* \leftarrow \text{AcceptanceCriterion}(s^*, s^{*\prime}, history)$

until termination condition met

end

Second Proposal

- **Reinforcement Learning based Local Search**
  - A combined reinforcement learning techniques with descent-based local search

Second Algorithm [3]

Input:
  G: a grouping problem instance;
  k: the number of available groups;
Output: the best solution S^* found so far;
for all $v_i, i = 1, 2, ..., n$ **do**
  $P_0 = [p_{ij} = 1/k]_{j=1,2,...,k}$;
end for
repeat
  $S_t \leftarrow groupSelecting(P_{t-1}, \omega)$;
  $\hat{S}_t \leftarrow DB - LS(S_t)$;
  $P_t \leftarrow probabilityUpdating(P_{t-1}, S_t, \hat{S}_t, \alpha, \beta, \gamma)$;
  $P_t \leftarrow probabilitySmoothing(P_t, p_0, \rho)$;
until Stop condition met

Solution Validation

- **Genetic Algorithm based solution**
  - Available in advance
  - Chromosomes encode Fon's hotspots channels number selection
  - Fitness function is the total interfering calculated in Fon's hotspots

Third Algorithm [4]


```
Procedure GA for FAP
Generate a population of N individuals as permutations of
the whole set of transmitters representing a chromosome.
Evaluate the fitness for each individual by using a
Sequential algorithm to generate an assignment
Store the bestSoFar fitness value
while Stopping condition not satisfied do
  while next individual in the population do
    { This individual becomes the first parent }
    { Select a second parent either at random
    or by applying roulette wheel selection }
    { Apply crossover to produce offspring }
    { Apply mutation to offspring }
    { Evaluate fitness produced by offspring }
    if offspring better than either parent then
      { Replace the weakest parent }
    else
      { Replace another weaker individual in the
      population selected at random (if any) }
    end if
    { Update bestSoFar }
  end while
end while
Select the ordering representing the bestSoFar individual
Assign channels to it using a Sequential algorithm
```

Real Data – Tokyo, Japan

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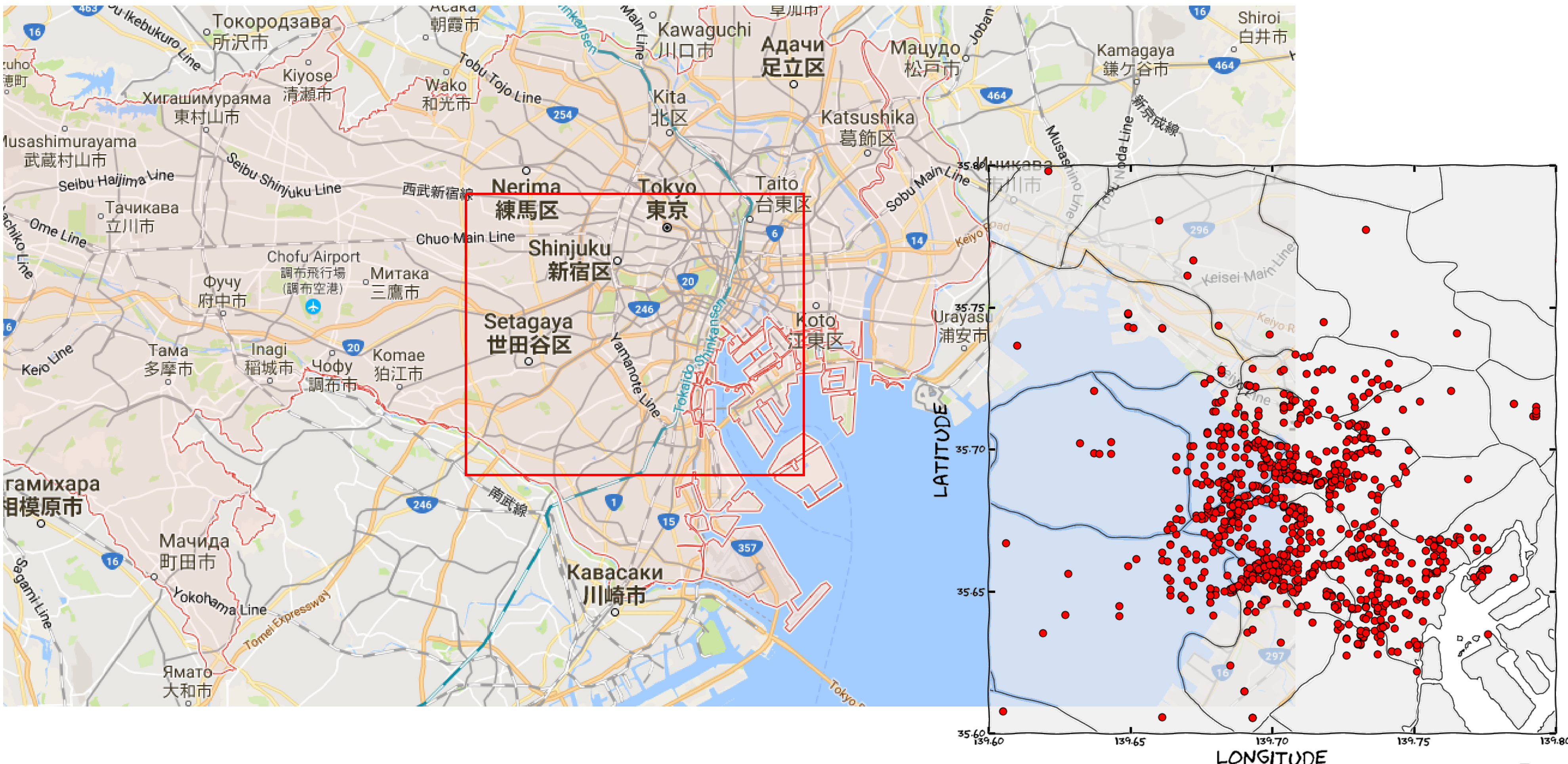

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Artificial Generated Data

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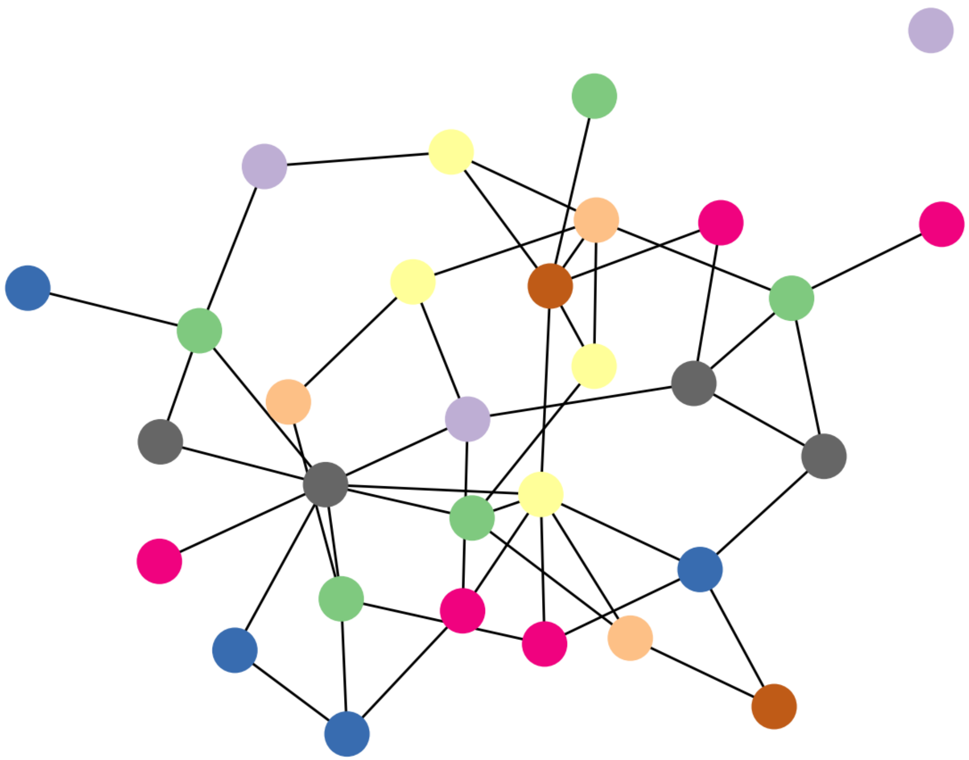

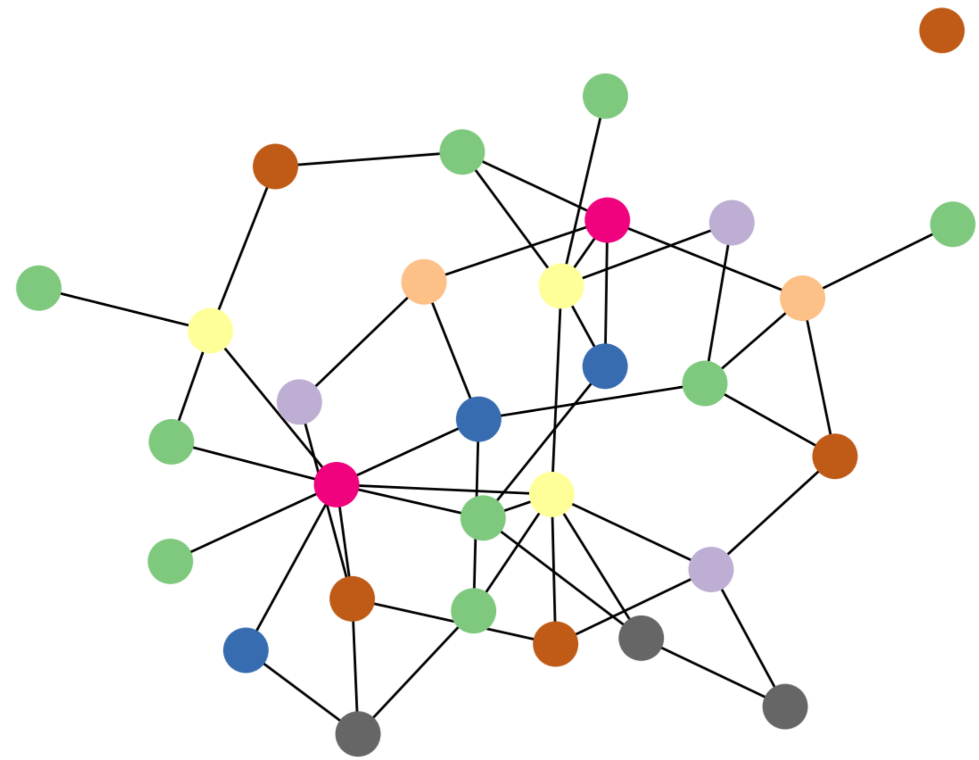

ILS – Convergence

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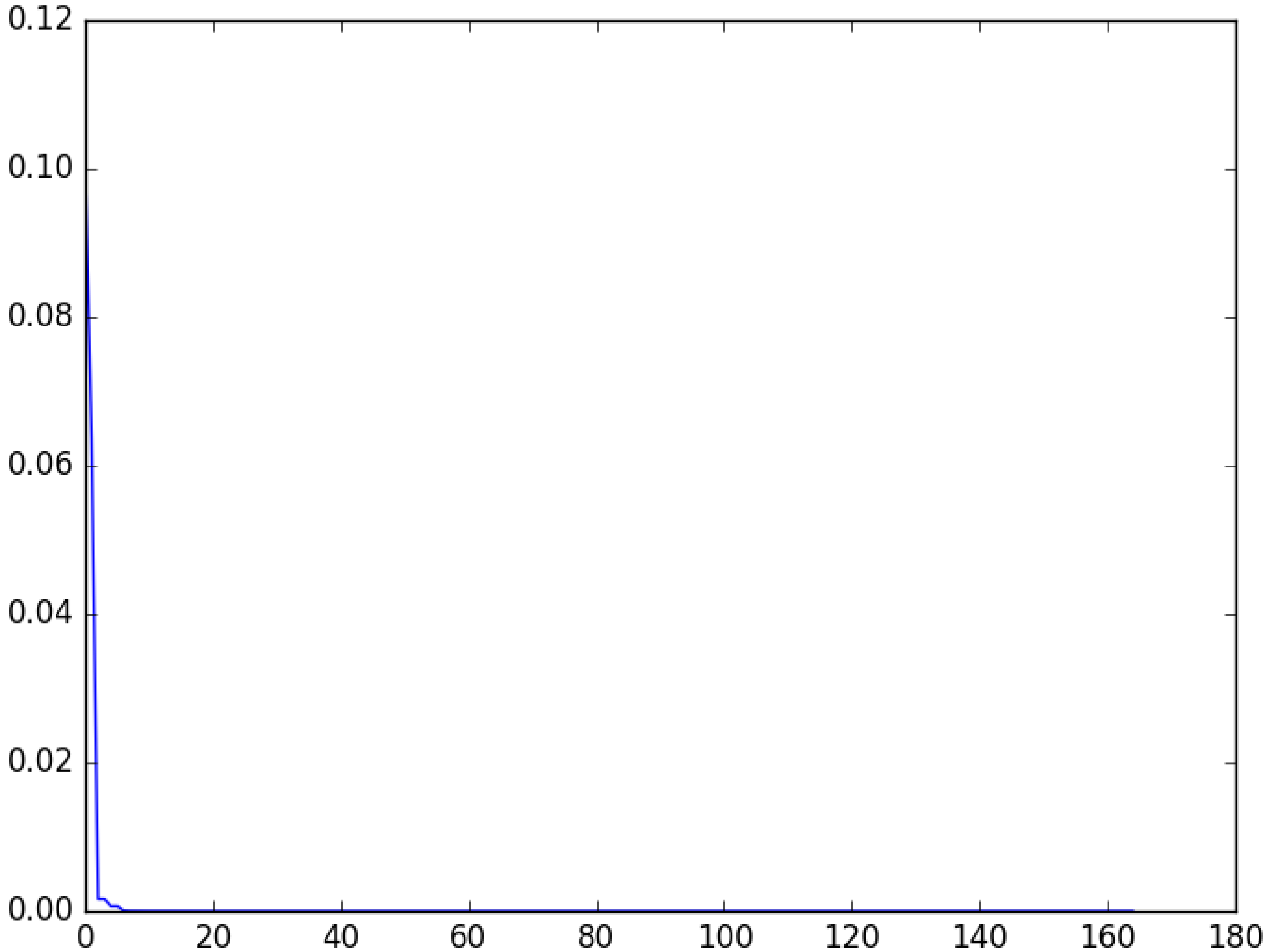
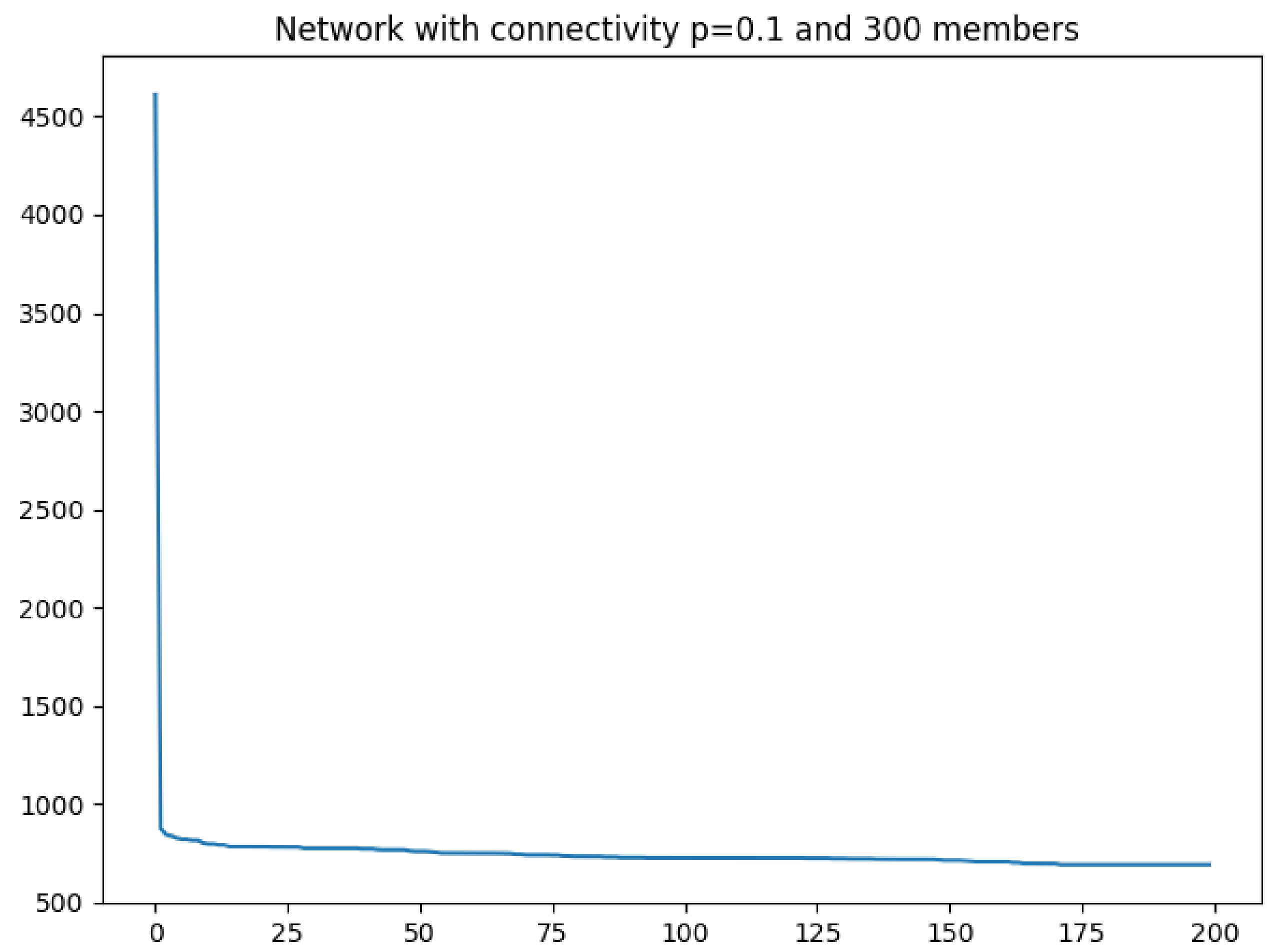


RLLS – Convergence



GA – Logarithmic Scale Convergence

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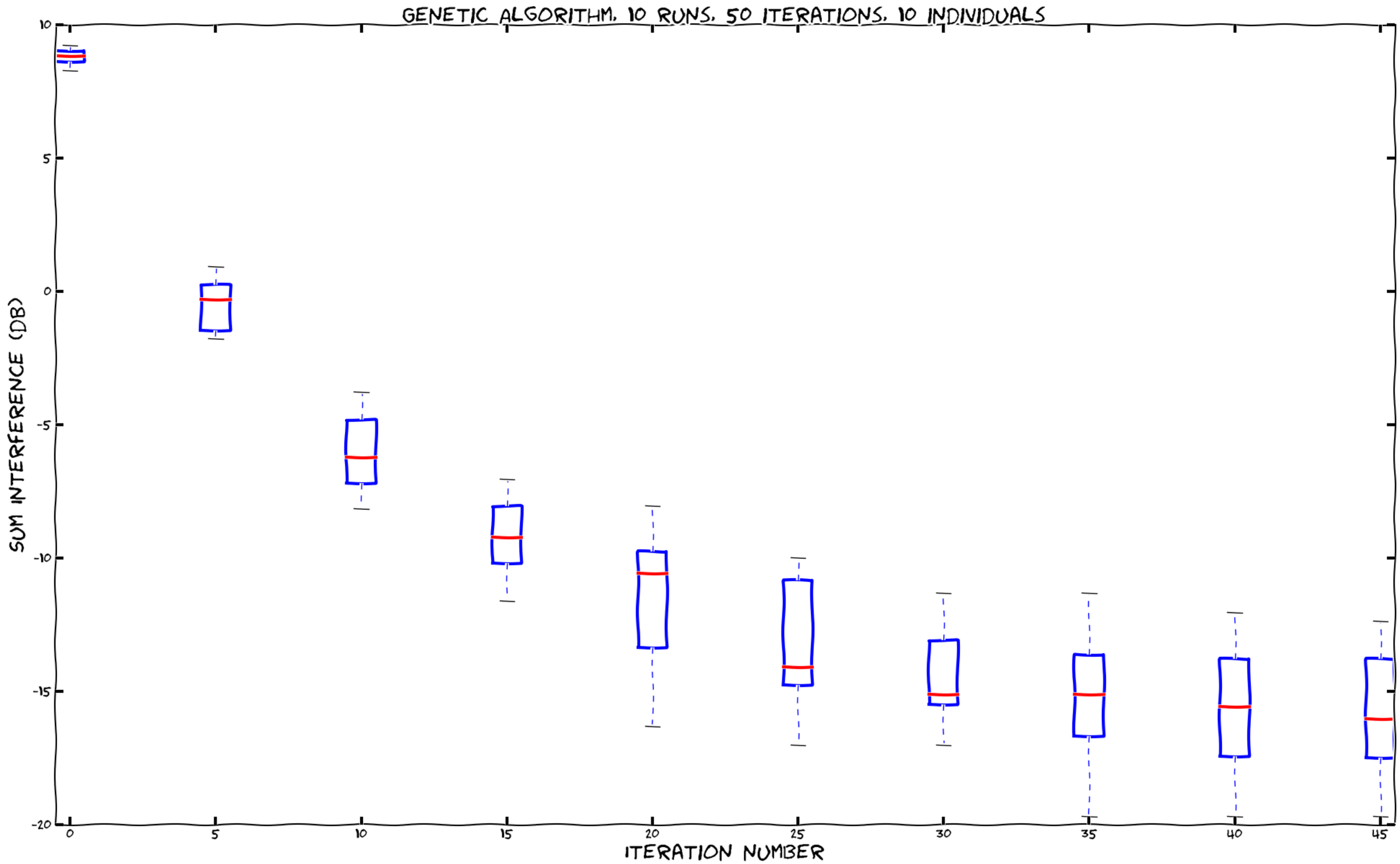

GA – Linear Scale Convergence

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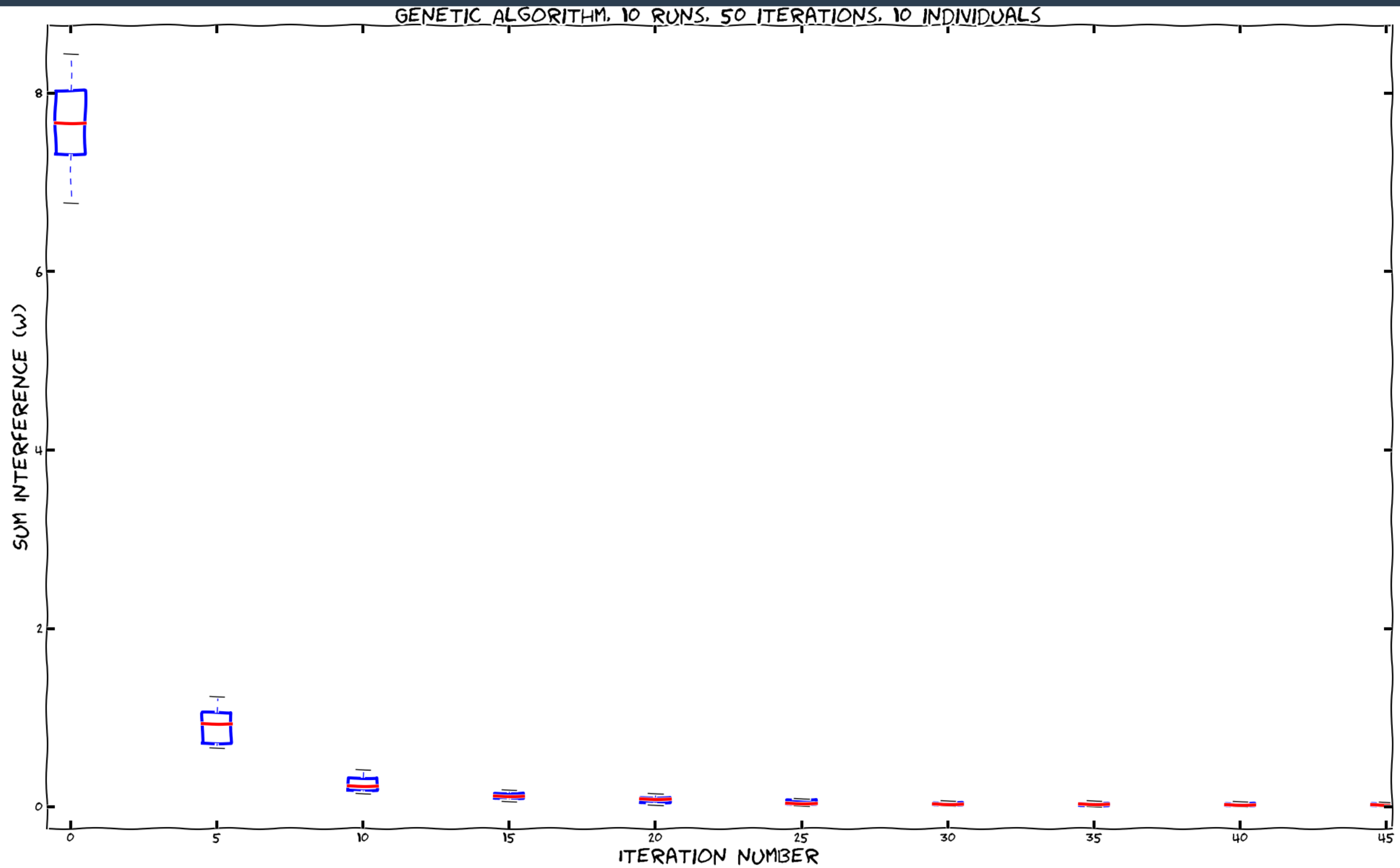

Conclusions & Further Work

- **Heuristic optimization is effective**
  - But it is time consuming
  - Python is very useful for this kind of calculations
- **As further work Genetic Algorithm can be combined with Iterated Local Search and Reinforcement Learning based Local Search**

References

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4. Gualtiero Colombo, A genetic algorithm for frequency assignment with problem decomposition, Journal International Journal of Mobile Network Design and Innovation archive, Volume 1 Issue 2, September 2006, pp. 102-112

Questions & Answers

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Thank you!