On the use of Small-world Population Topologies for Genetic Algorithms

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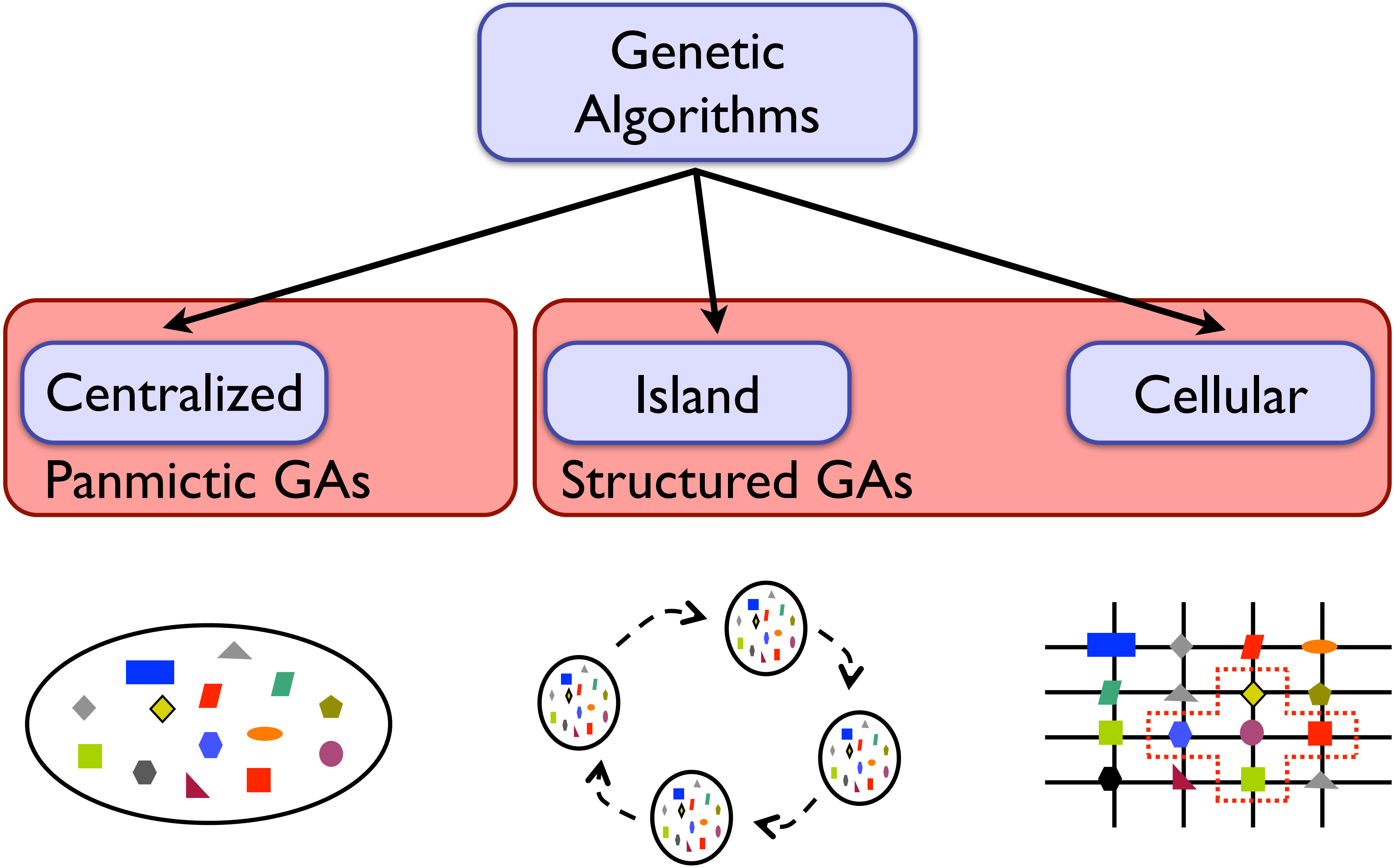
Motivations & Contributions

- Structuring the population leads to better performance in EAs
  - Distributed, Cellular, Random, Small-world, Scale-free, ...
- Good previous results for small-world topologies
  - Combinatorial optimization [Giacobini06]
  - Continuous optimization [Dorronsoro11]
  - Multi-objective optimization [Kirley06/07]
  - Population dynamics [Giacobini05] [Payne06/09]
- We propose and analyze eight different ways to generate small-world topologies for genetic algorithms
  - Rewiring/adding edges
  - Different probabilities
  - Compared versus other well-known population topologies

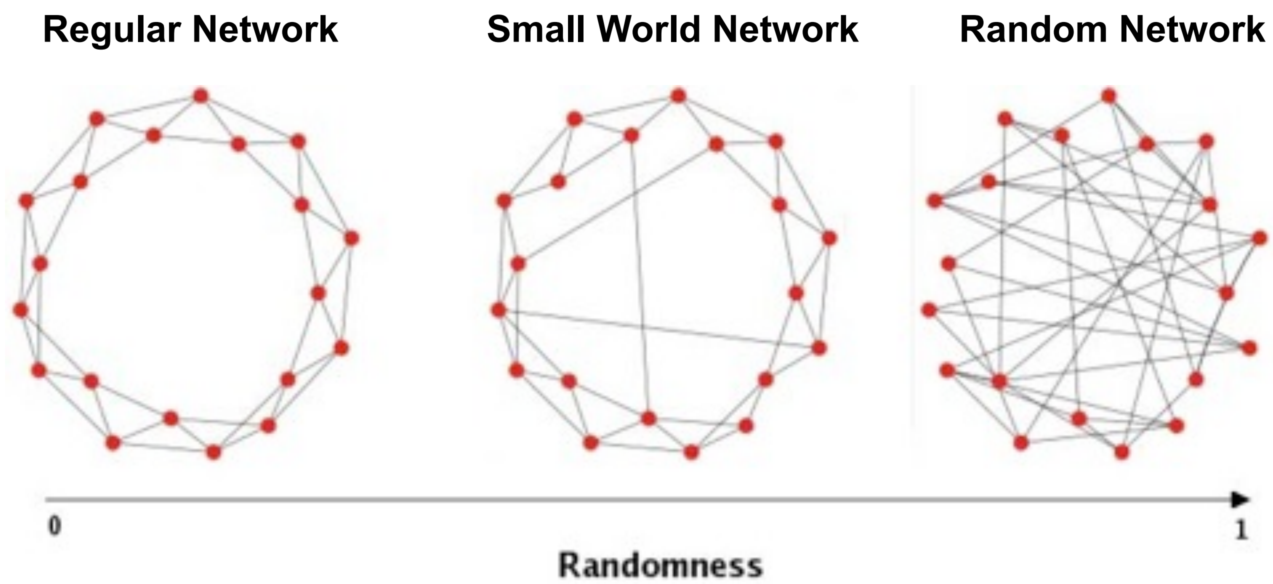
EAs with Decentralized Populations



Small-world GAs (SWGAs)

- Small world networks
  - Short charasteristic path lengh (L)
  - High clusteringt coefficient (γ)

High L
High γ



Low L
Low γ

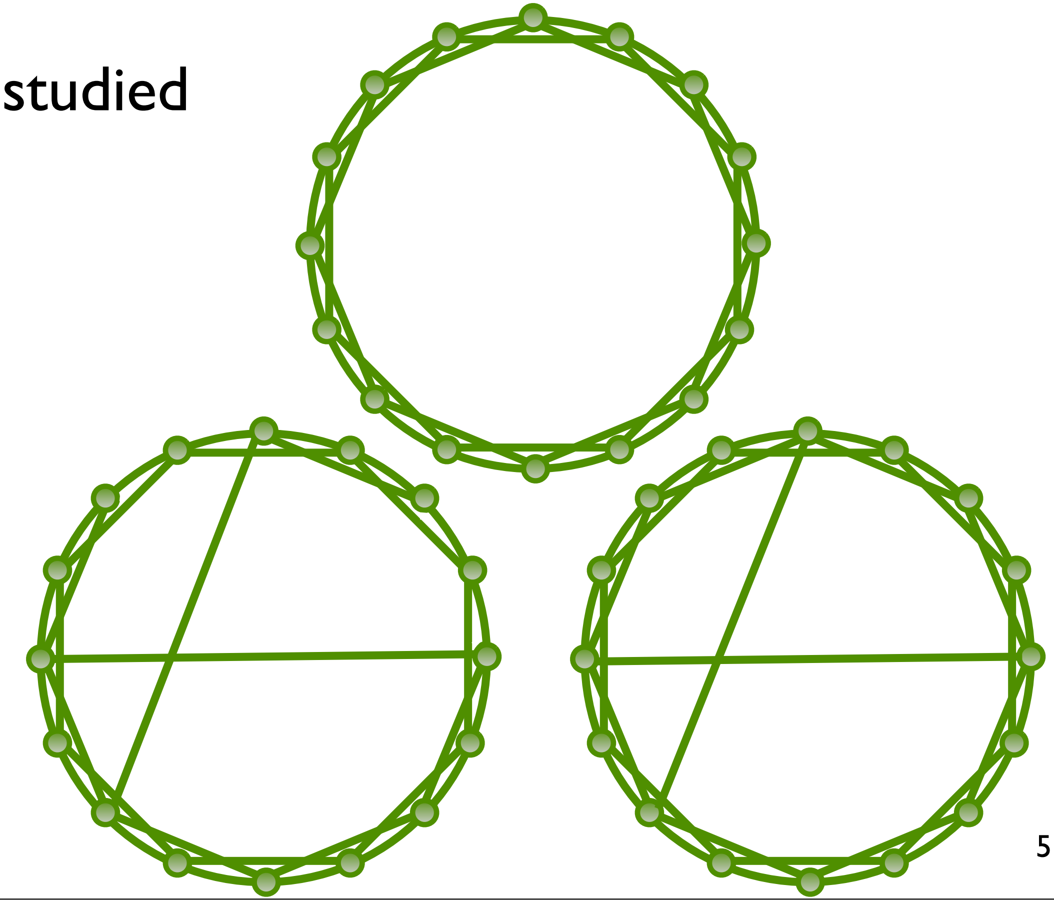
- Topology generation: Watts and Strogatz algorithm

1. Create ring topology (every individual has *K* neighbors)
2. For every edge
3. Rewire to random destination individual with probability β

Small-world GAs (SWGAs)

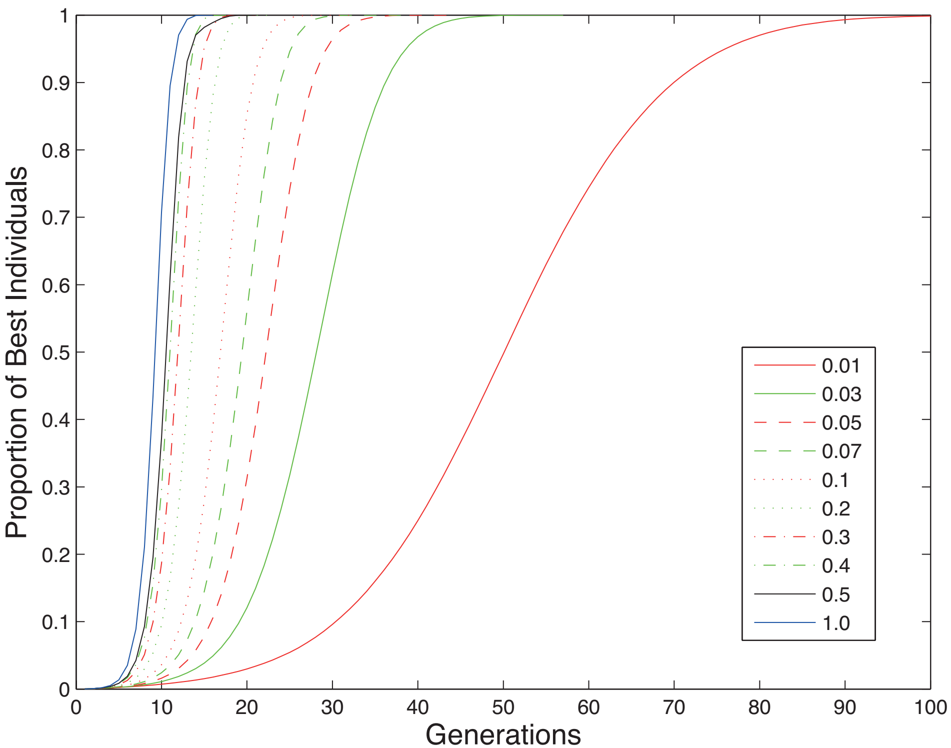
Watts and Strogatz algorithm
1. Create ring topology (every individual has *K* neighbors)
2. For every edge
3. Rewire to random destination individual with probability β

- Small-world topologies studied
  - K = 4
  - β = 0.05, 0.2, 0.5, 1.0
  - Edges:
    - Rewiring
    - Adding

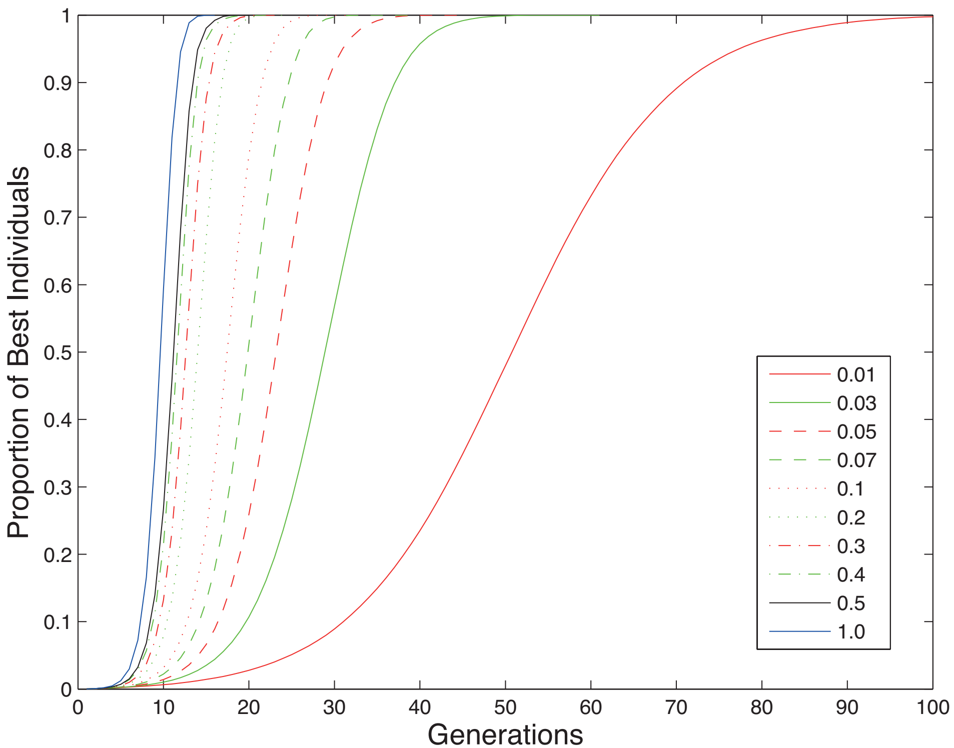


Selection Pressure

Rewiring Edges



Adding Edges



Problems

Error Correcting Code Desgin (ECC)

Number of words

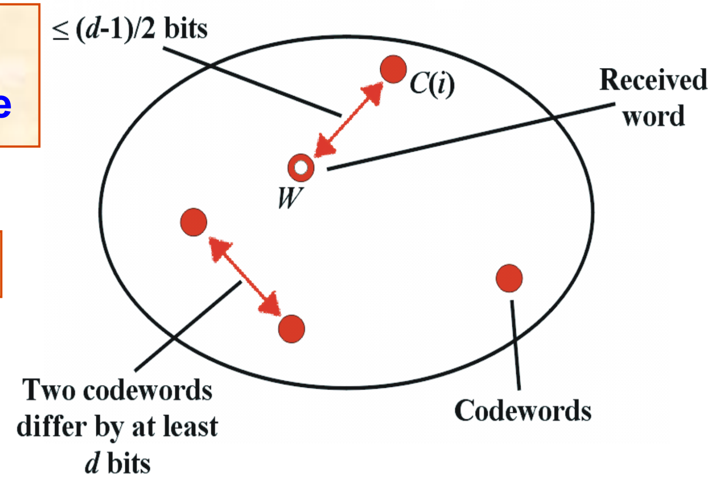
Minimum Hamming distance

☞ C = (n, M, d)

Lentgh of words

☞ Find C making d maximum

☞ Combinatorial optimization

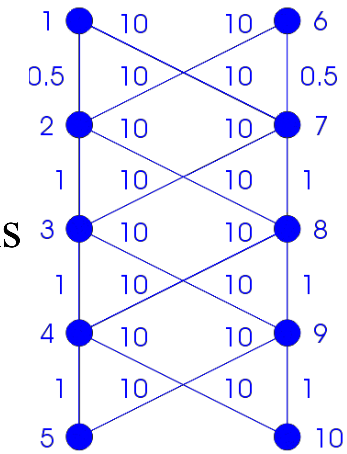


Maximum Cut of a Graph (MAXCUT)

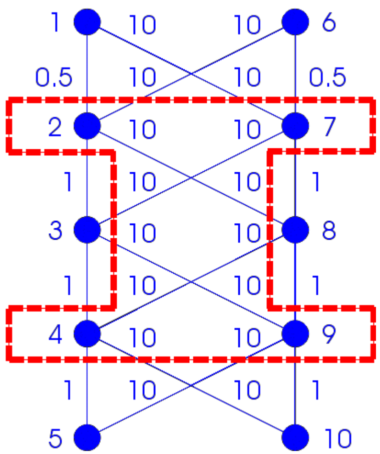
☞ Objective: Splitting a graph maximizing the sum of the weights of the edges connecting the two subgraphs

☞ Combinatorial optimization

10 vertices graph

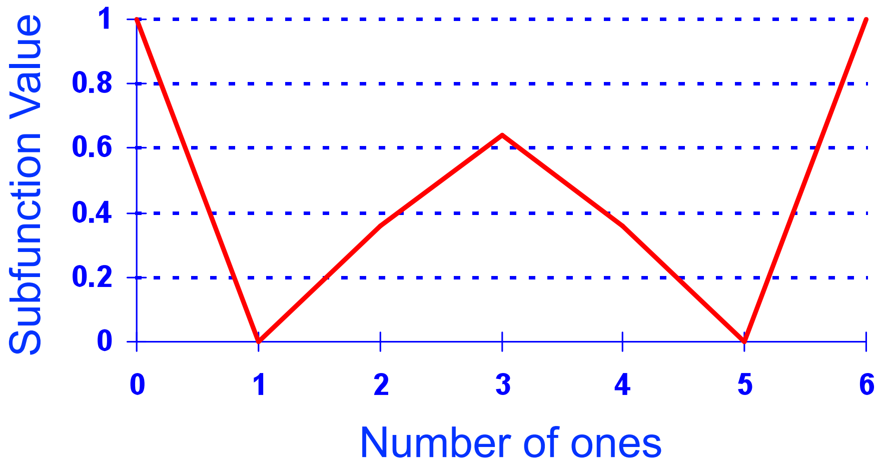


maximum cut



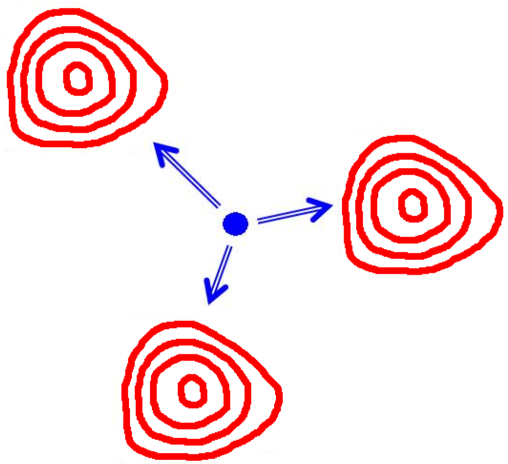
Problems

Massively Multimodal Deceptive Problem (MMDP)



- 40 subproblems of 6 bits each one (MMDP40)
- Multimodal
- Deceptive problem

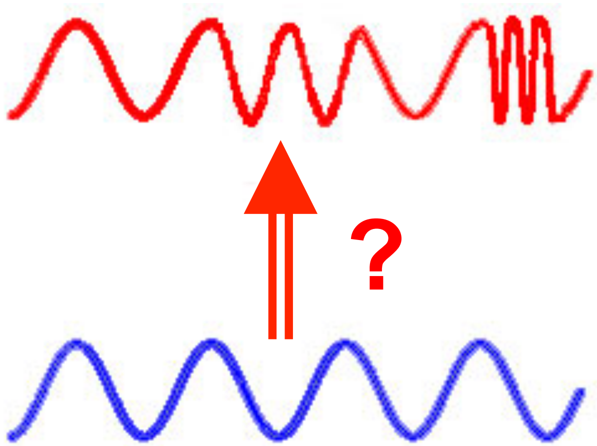
Multimodal Problem Generator (P-PEAKS)



- Problem Generator
- Find one of the P-Peaks
- Tunable degree of multimodality

Problems

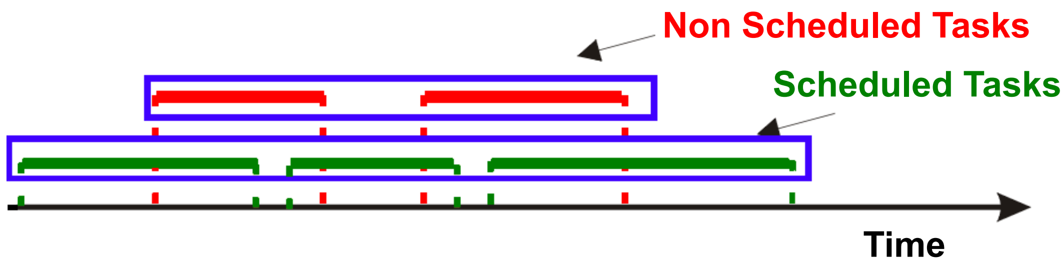
Frequency Modulation of Sounds (FMS)



- Fit two waves by adjusting six (double) parameters
- Epistatic, continuous optimization

Minimum Tardy Task Problem (MTTP)

- Tasks
  - l_i: Execution time
  - d_i: Deadline
  - w_i: Weight



- Goal: Task scheduling with maximum weight and no deadline violations
- Constrained combinatorial optimization

Problems

3SAT

$$\Phi(x_1,x_2,x_3,x_4) = (x_1 \vee x_2 \vee x_3) \wedge (x_1 \vee \neg x_2 \vee \neg x_4) \wedge (x_1 \vee x_3 \vee \neg x_4) \wedge (\neg x_1 \vee x_2 \vee \neg x_4) \wedge (\neg x_1 \vee \neg x_2 \vee \neg x_3)$$

- ☞ Goal: Find values for the boolean variables to make the formula TRUE
- ☞ 1st NP-complete problem

Experiments

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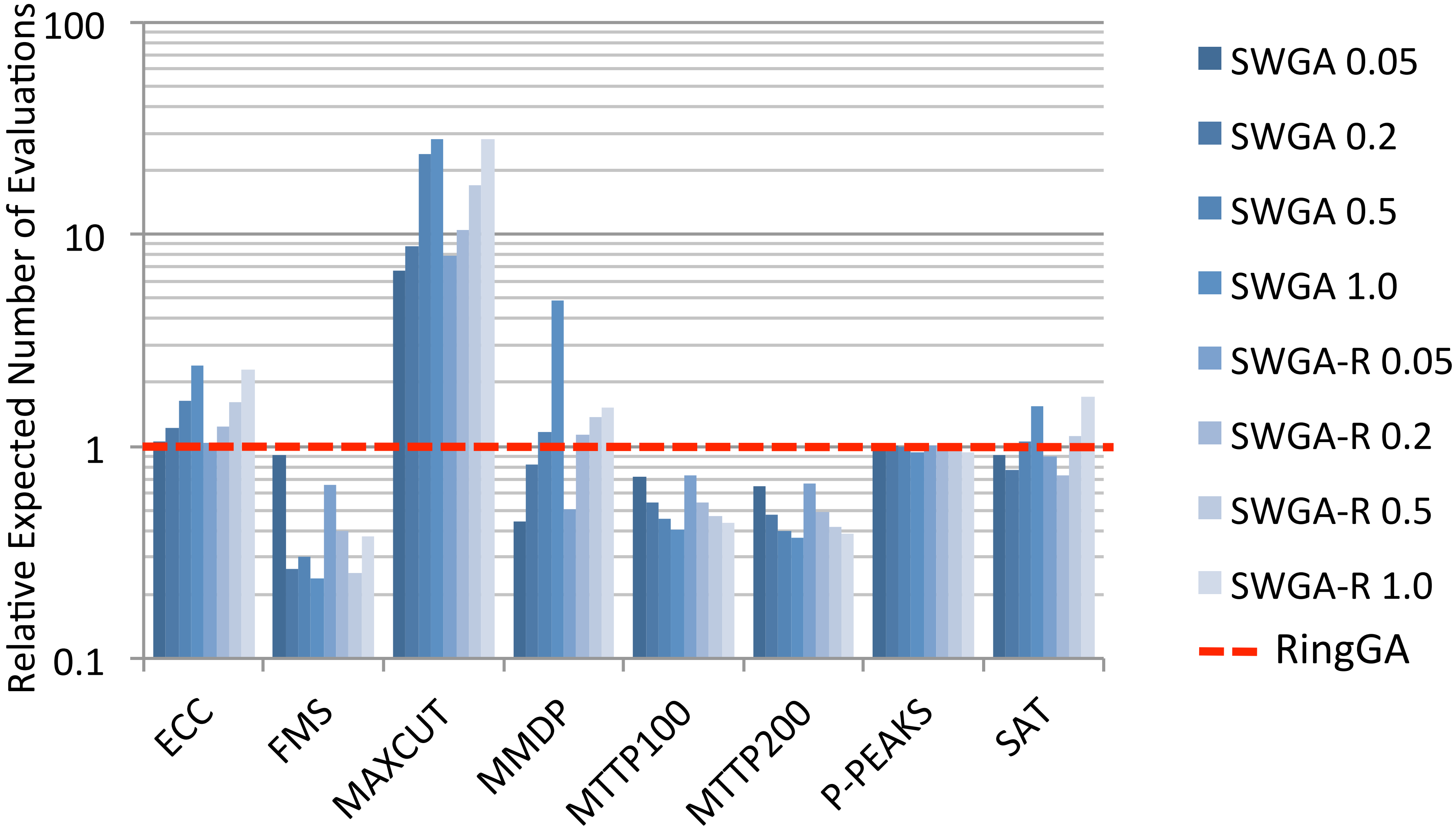
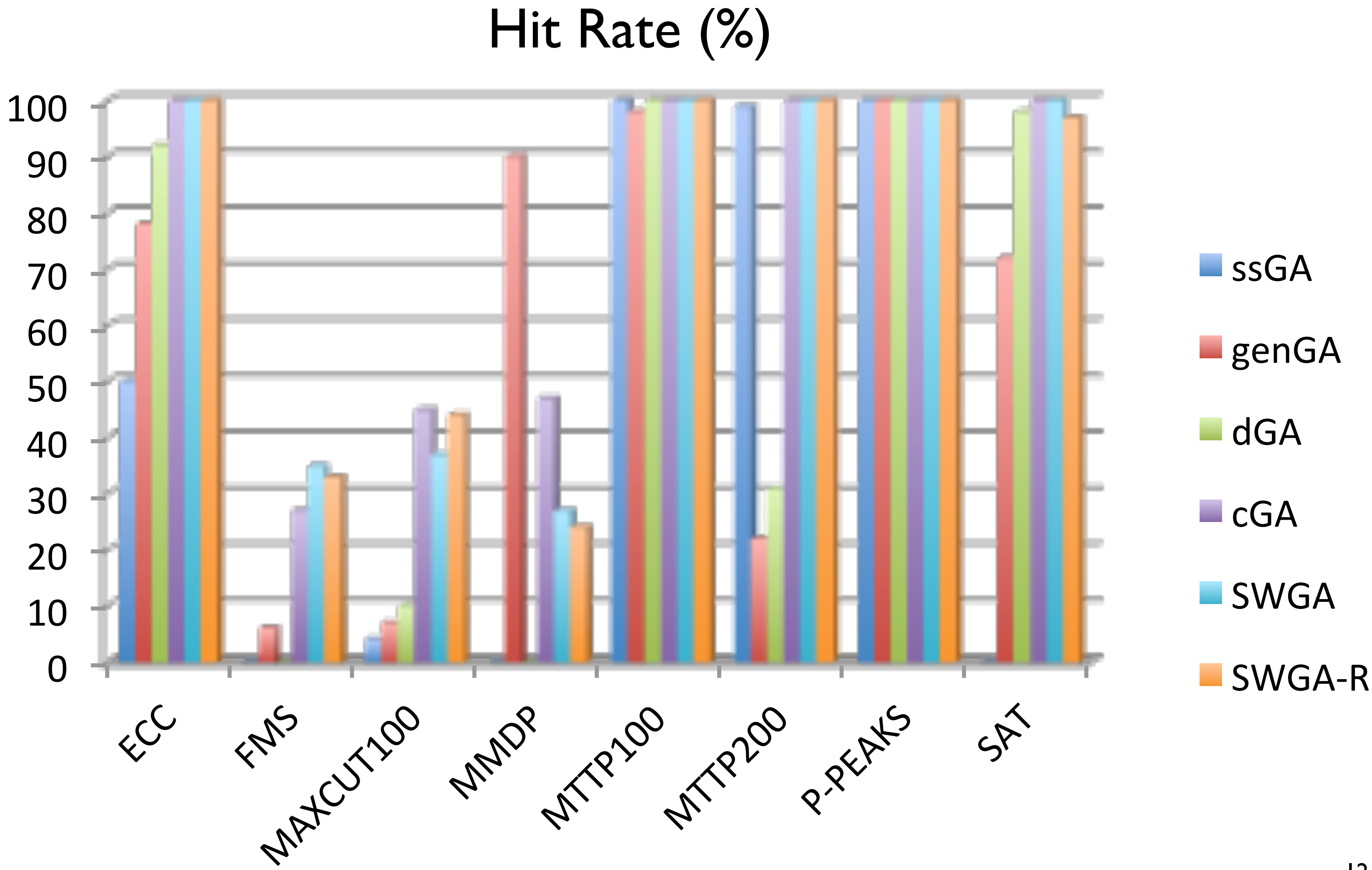
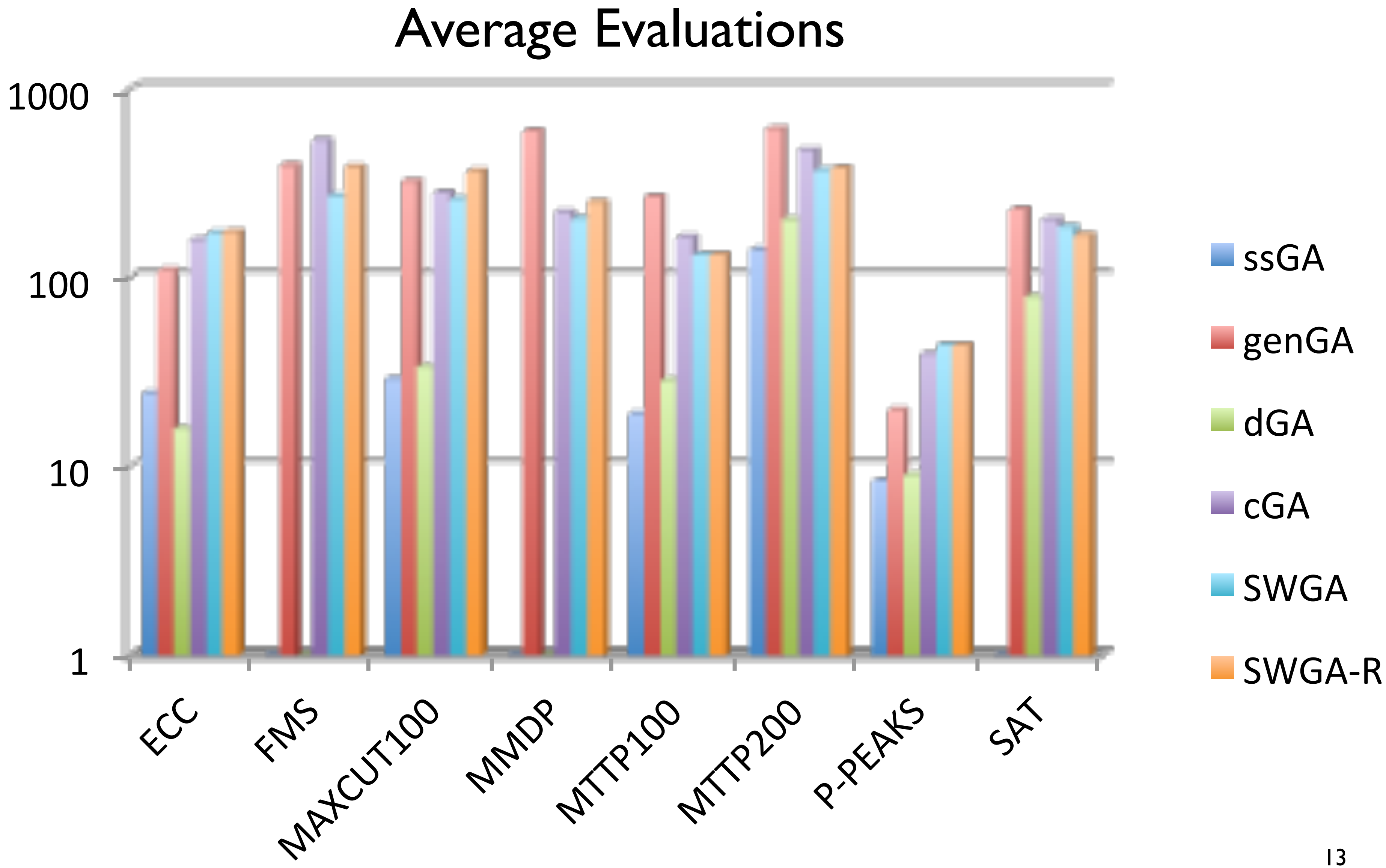


Results



Hit Rate (%)
100
90
80
70
60
50
40
30
20
10
0
ECC
FMS
MAXCUT100
MMDP
MTTP100
MTTP200
P-PEAKS
SAT
ssGA
genGA
dGA
cGA
SWGA
SWGA-R

Results



Average Evaluations
1000
100
10
1
ECC
FMS
MAXCUT100
MMDP
MTTP100
MTTP200
P-PEAKS
SAT
ssGA
genGA
dGA
cGA
SWGA
SWGA-R

Conclusions & Future Work

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- SW topologies were used in the past with promising results

- We studied different ways to generate SW topologies
  - Adding or rewiring edges
  - With different probabilities

> Best configuration: Adding edges with probability 0.2

- Competitive results with respect to the compared algorithms (both panmictic and decentralized)
  - Accuracy
  - Effectiveness

- Future work: Extend to other topologies (different initial regular matrices) and bigger benchmarks (combinatorial and continuous domains)

Thank you.

References

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