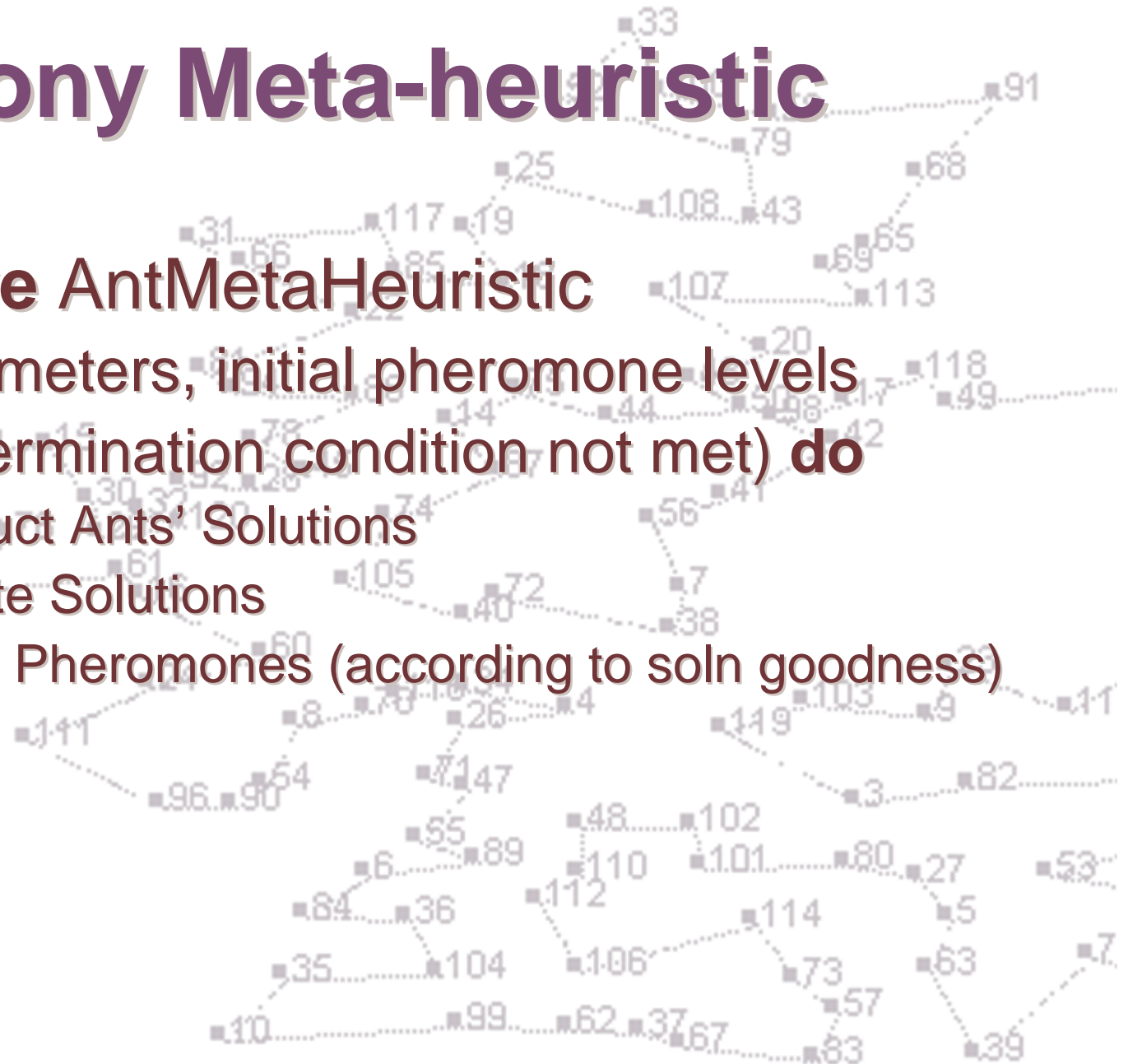# Ant Colony Meta-heuristic

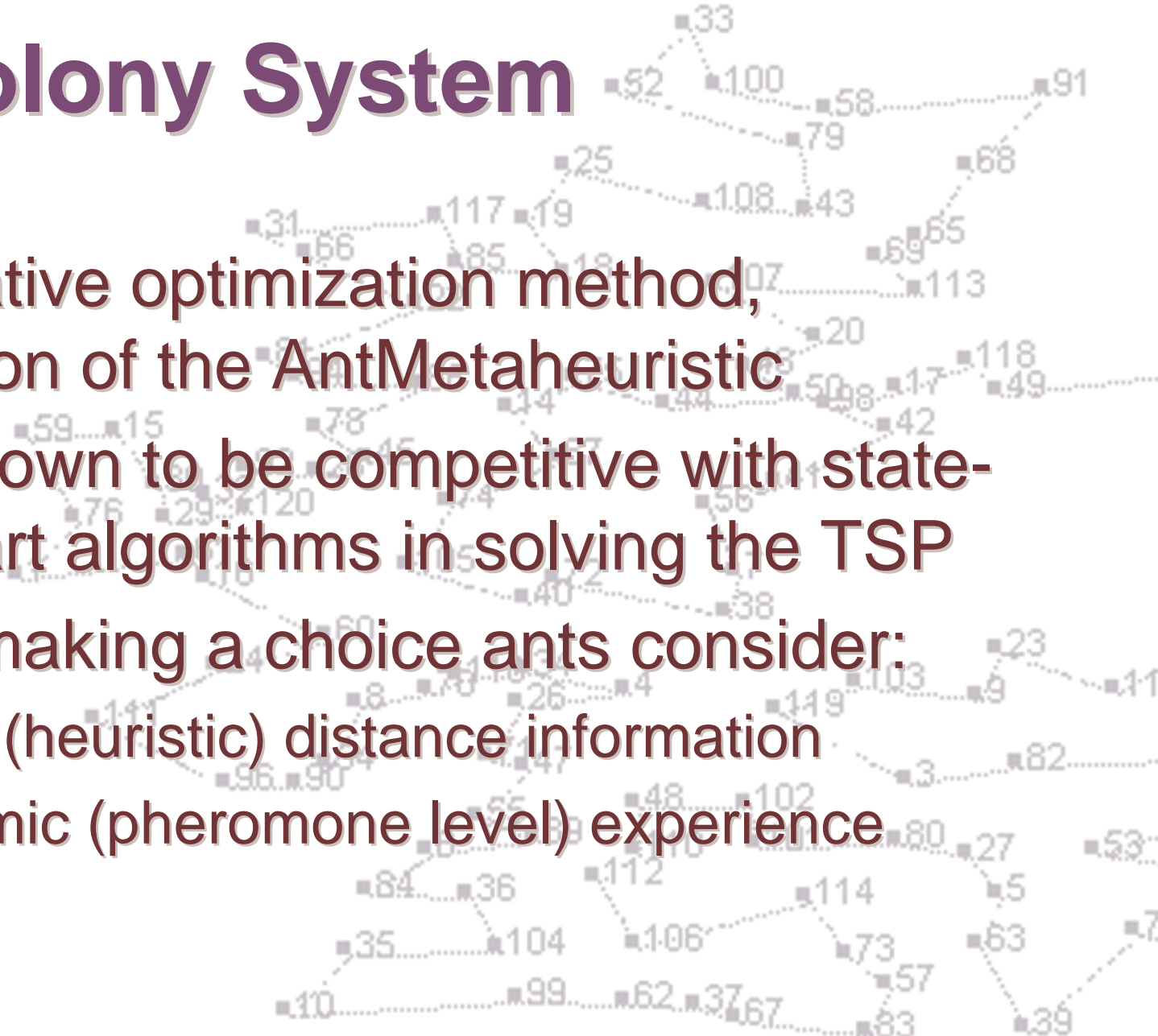- **Procedure** AntMetaHeuristic
  - Set parameters, initial pheromone levels
  - **While** (termination condition not met) **do**
    - Construct Ants' Solutions
    - Evaluate Solutions
    - Update Pheromones (according to soln goodness)
  - **End**
- **End**

Ant Colony System

- An iterative optimization method, extension of the AntMetaheuristic
- Was shown to be competitive with state-of-the-art algorithms in solving the TSP
- When making a choice ants consider:
  - Static (heuristic) distance information
  - Dynamic (pheromone level) experience

Heuristic Computation

- Ants make decisions maximizing

Heuristic = pheromone * (1 / distance)
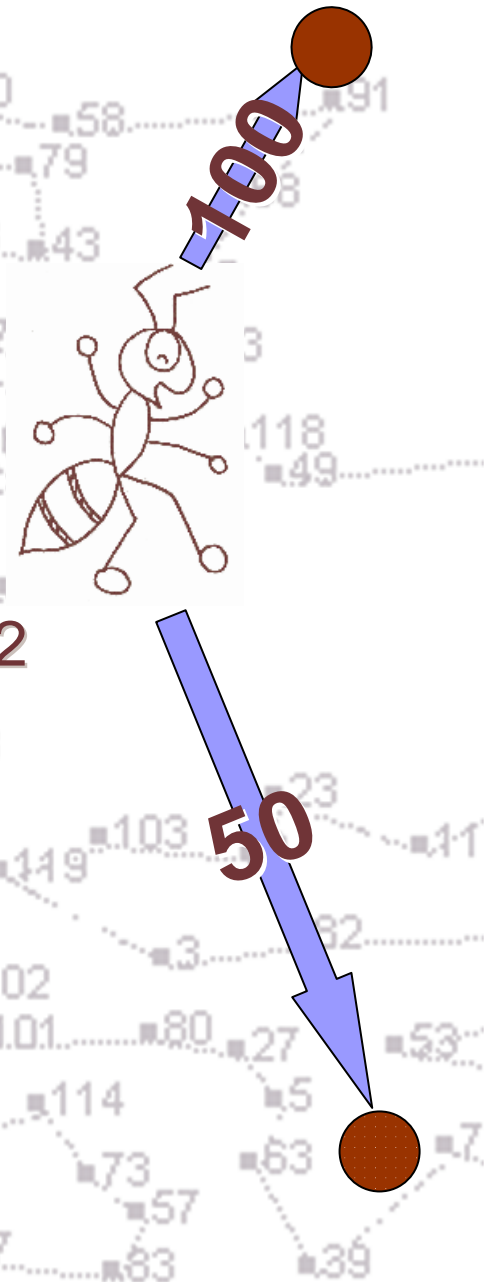
Nearness(Blagoevgrad, Sofia) = 1 / 100 = 0.01
Nearness(Blagoevgrad, Varna) = 1/500 = 0.002

Suppose pheromone on both edges is 0.5
Heuristic(Sofia) = 0.5 * 0.01 = 0.005
Heuristic(Varna) = 0.5 * 0.002 = 0.001

Heuristic(Sofia) > Heuristic(Varna)

100

50

Solution Construction

Ant is at city r.

The probability of choosing next city to be s
depends on:

1. The heuristic value (nearness * pheromone)
2. The value of a random number $q \sim (0,1)$ and a
   threshold $q_0 = 0.9$

   **If $q < q_0$**

   r = max heuristic city **(exploitation)**

   Else

   r = random proportional choice from
   non-visited cities **(exploration)**

Exploration Mode City Choice

	Pheromone	Distance	Nearness	Heuristic	Ratio
Sofia	**0.1**	**100**	**0.01**	**0.001**	**31.25%**
Varna	**0.1**	**500**	**0.002**	**0.0002**	**6.25%**
Bansko	**0.1**	**50**	**0.02**	**0.002**	**62.5%**

1. Calculate **Heuristic** for all cities

2. Normalize **Heuristic** values

3. Generate a number (0,360) and select the corresponding city
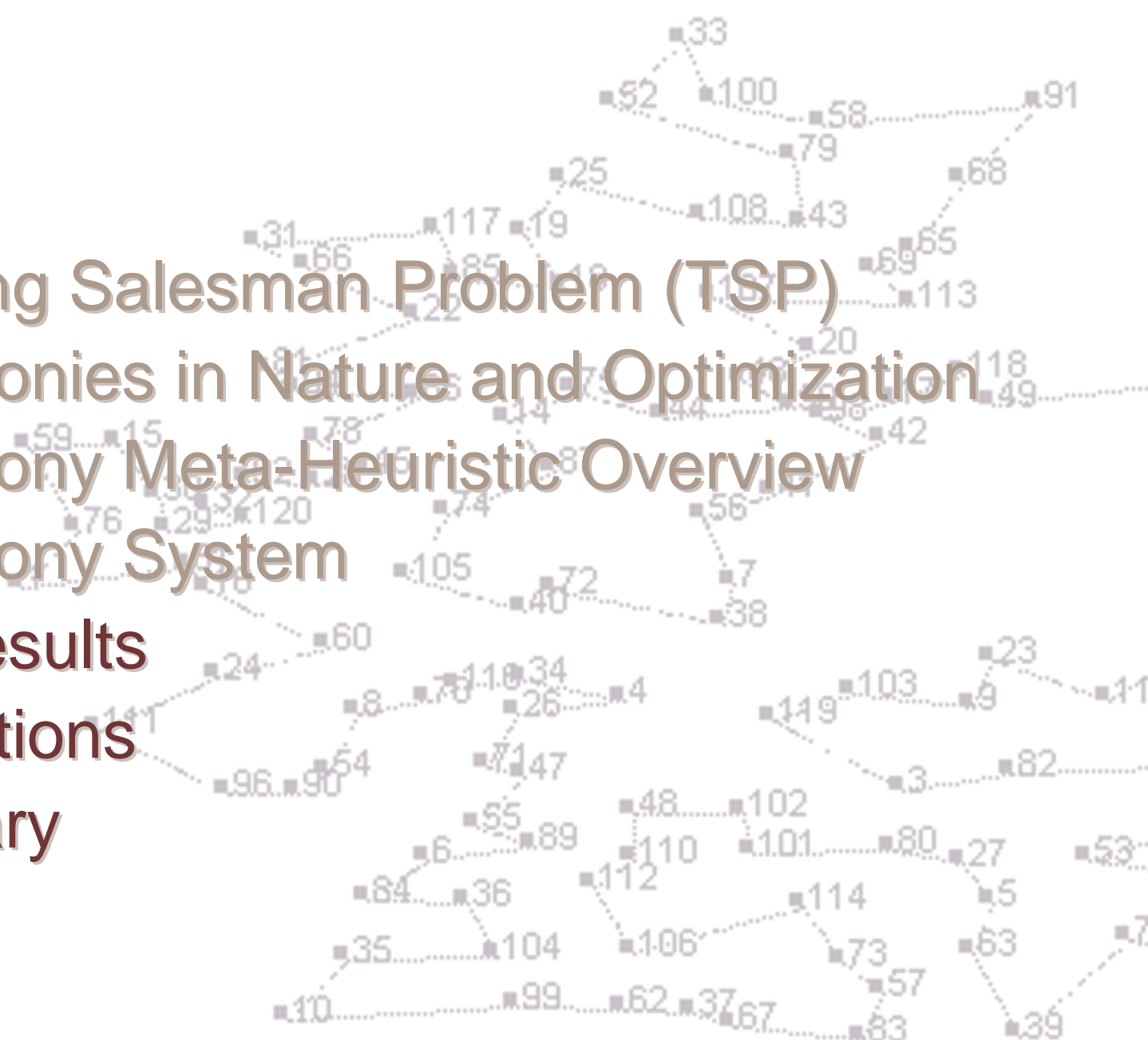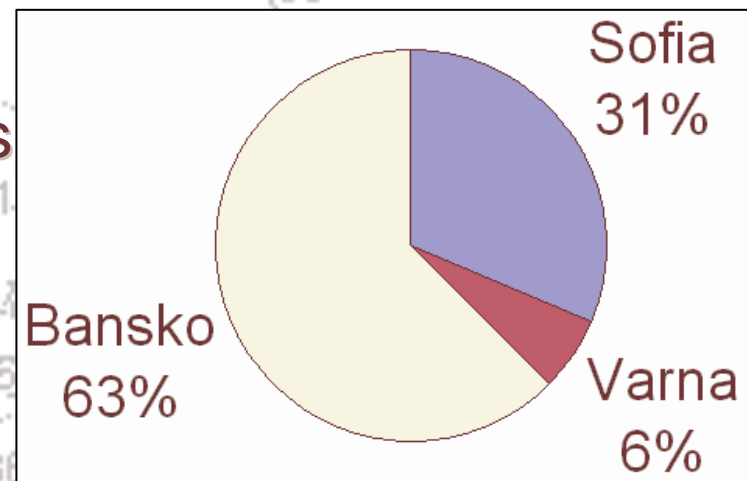
Pheromone Update Rules

- Elitist approach – only the best tour so far is used to globally update pheromone
  - Favors exploitation of the best tour so far
- Local pheromone update – weakens the pheromone trail of an edge, once an ant has traversed it
  - Prevents pheromone trail value explosion
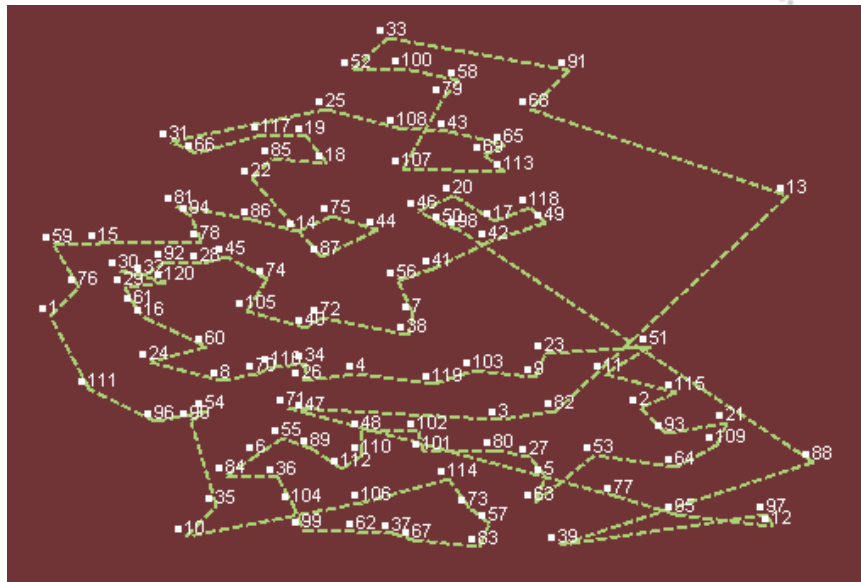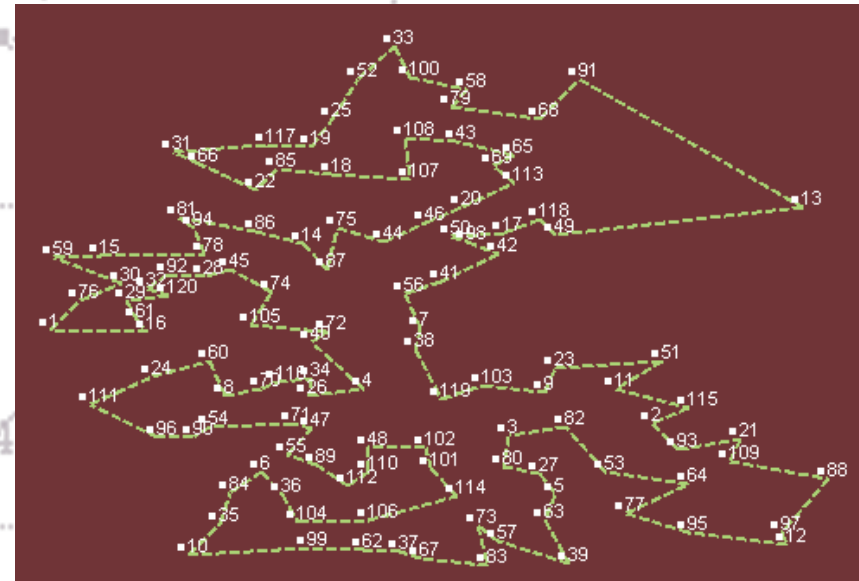 - Favors exploration and prevents premature convergence

Recap

- Traveling Salesman Problem (TSP)
- Ant Colonies in Nature and Optimization
- Ant Colony Meta-Heuristic Overview
- Ant Colony System
- Test Results
- Applications
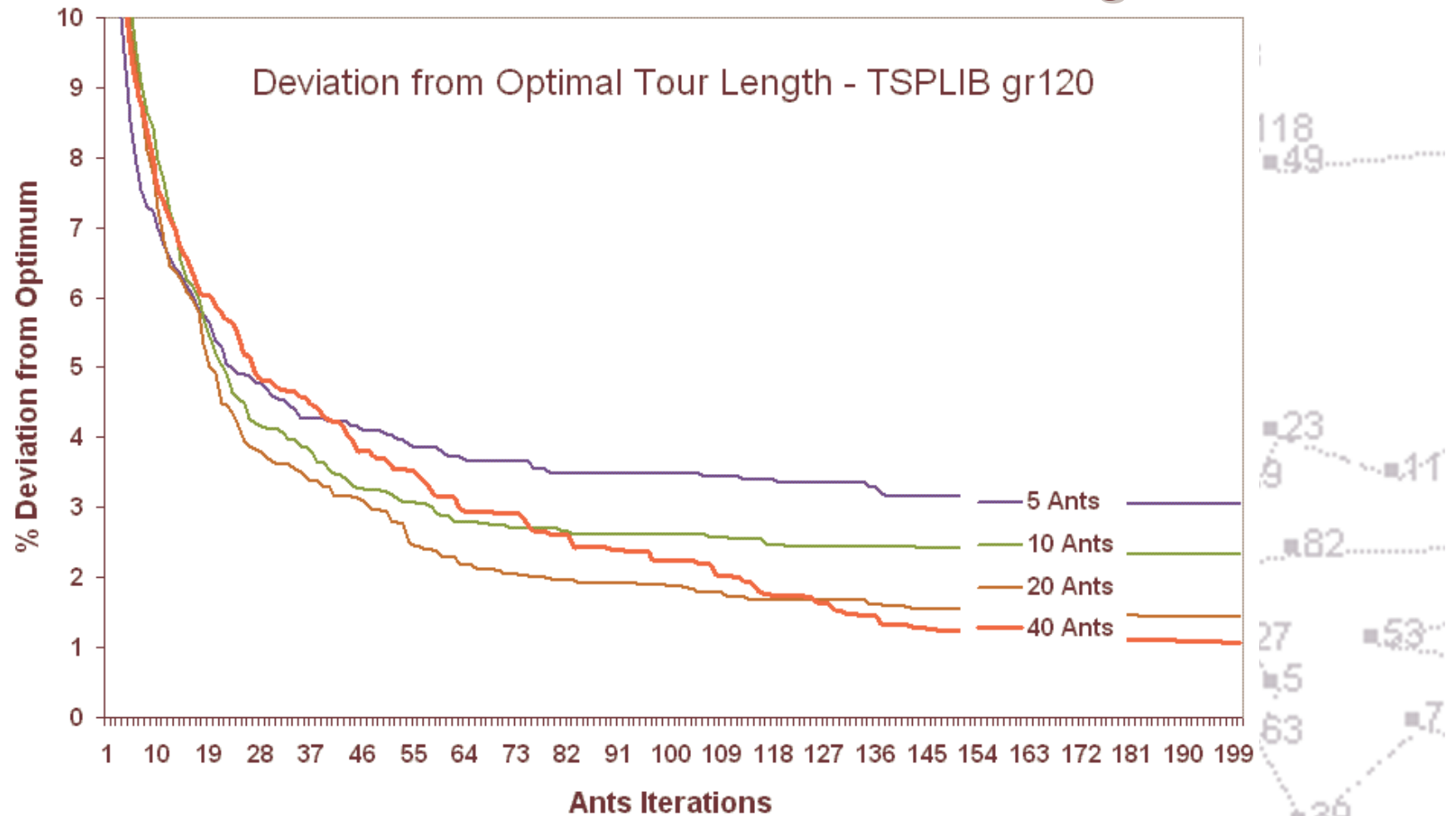- Summary

Initial and Final Tours – gr120

Initial Tour

Final Tour – 200 iterations, 40 ants

Test Results

- Different number of ants - TSPLIB gr120

Deviation from Optimal Tour Length - TSPLIB gr120

Test Results

- Different number of ants - TSPLIB pr1002

Deviation from Optimal Tour Length - TSPLIB pr1002