Exam Timetabling with Parallel Evolutionary Algorithms:

Comparison of Different Selection Methods

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Part I

Evolutionary Computation in Timetabling

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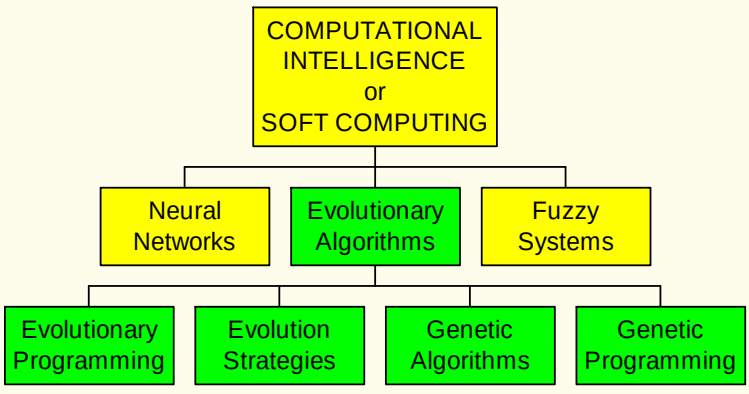
Taxonomy



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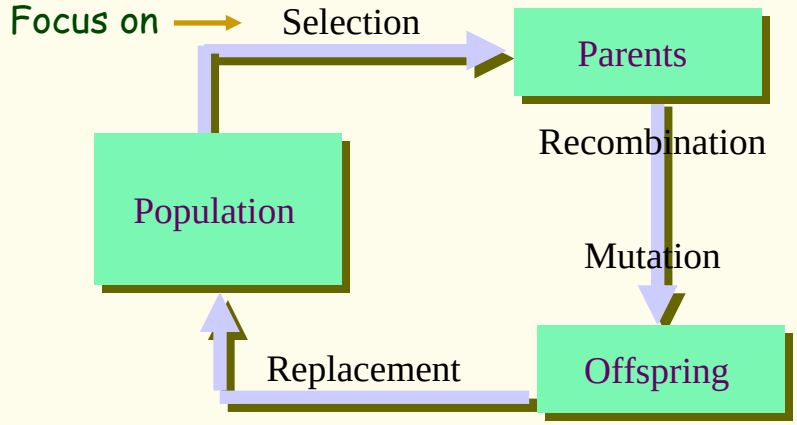
The Evolutionary Cycle



Representation

- Direct method
  - Chromosome represents timetable including all slot assignments, teacher and room assignments
  - highly problem specific
- Indirect method
  - Chromosome represents ordered list of events according to some pre-defined method
- Different results are obtained by each method

Dealing with Constraints

- Use a weighted penalty function
  - Weights reflect the importance of each constraint
- Use a two-step penalty function
  - Soft constraints are only calculated once the hard constraints have been satisfied

Constraints in Timetabling

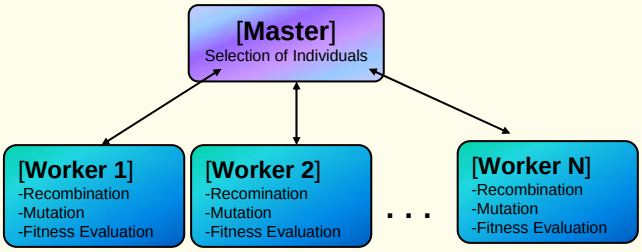
- Unary Constraints
  - Exclusion
  - Specification
- Binary Constraints
  - Edge
  - Juxtaposition
- Capacity Constraints
- Event – Spread Constraints

Part II

Parallel Evolutionary Algorithms

Parallel/Distributed EAs

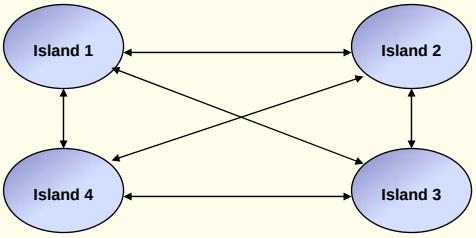
- Global or Standar Parallelization



- Decomposition
  - Fine Grained PEAs
  - Coarse Grained PEAs

Coarse Grained PEAs

- Island Model
  - An independent population is evolved on each island
  - From time to time individuals migrate between different islands



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Part III

Implementation

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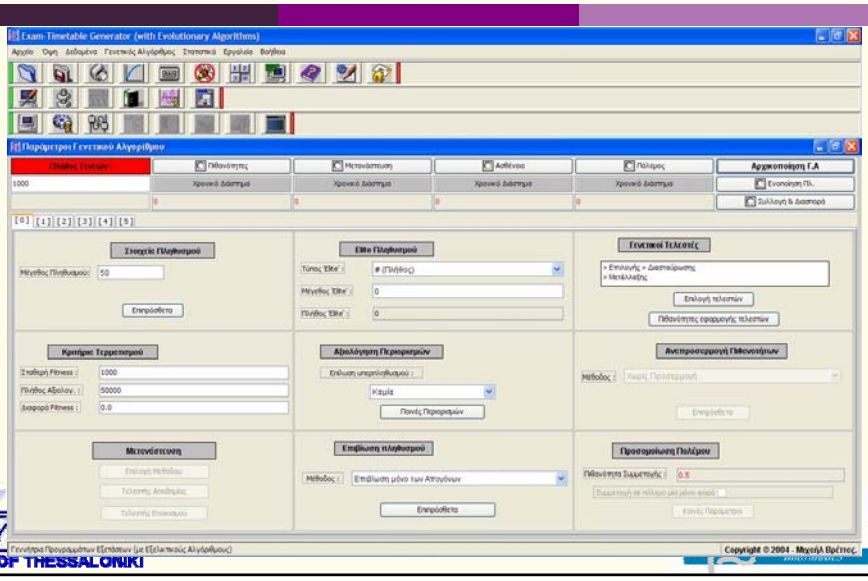
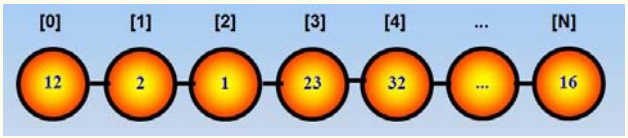
Interface



Representation

- Final representation: Direct, relief from some constraints like allocation of lessons to same room.



N: Number of lessons – Value of each node corresponds to a time slot.

- Advantages:
  - Simple design of genetic operators
  - Fast processing due to simple design
  - Minimum memory allocation in comparison with other representations
  - Some constraints are encoded in the representation

Constraints

- Total capacity of rooms for a time slot
- Check for classes that are related
- Reserve a timeslot for a lesson
- Most populated lessons examined after a break (eg. Weekends, holidays etc.)
- Optimum distance between lessons of each student
- Lessons of the same semester must examined on different days
- Lessons of one student must be examined on different time slots

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Fitness Evaluation

$$F(x) = \frac{1}{1 + \sum_{i=1}^{n} (w_i * c_i(x))}$$

- x : Chromosome
- W_i : Weight of constraint “i”
- C_i : Penalty of constraint “i”
- n : Number of constraints

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Selection Methods

- Tournament Selection
- Sequential Selection
- Best N Selection
- Ranking Selection
- Random Selection
- Roulette Wheel Selection
- Worst N Selection
- Greedy Over Selection
- Neighbourhood Selection
- FullCross Selection
- Random Walk Selection

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Problem Data

- Number of students: 1045
- Number of registrations to lessons: 5058
- Number of lessons: 52
- Number of rooms: 4
- Total capacity: 160 seats
- 40 timeslots (4 time slots per day)
- Number of invigilators: 30

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Part IV

Results

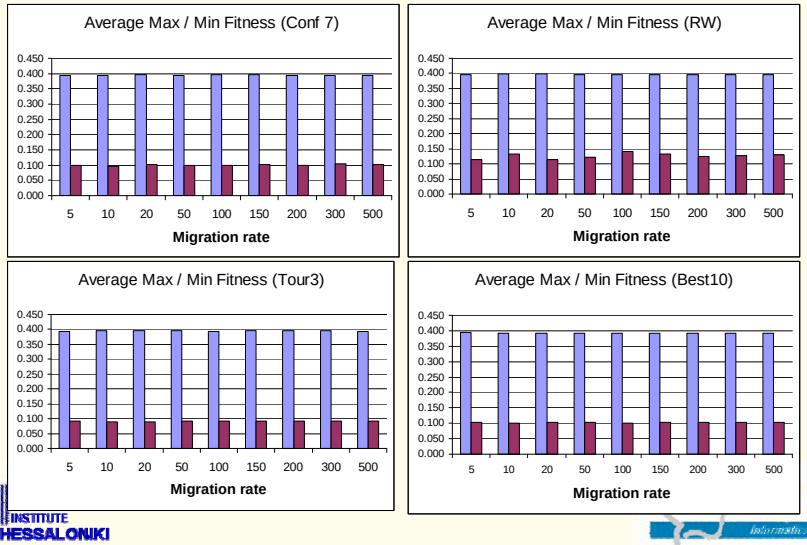
Tested Parallel Configurations

- Total of 7 different configurations.
- Each configuration with 6 islands.
- Migration of the best individual of each population to the other islands.
- Tested migration frequencies: 5, 10, 20, 50, 100, 150, 200, 300, 500 generations
- Configurations 1-6:
  - All islands use the same selection method.
  - Each configuration with a different selection method.
- Configuration 7:
  - All islands use a different selection method.

Evolutionary Algorithm Settings

- Population size: 25 and 50 individuals per island.
- Initial recombination probability: 70%
- Initial mutation rate: 30%
- Adaptation of probabilities every 5 generations.
- Termination criteria:
  - Maximum number of generations: 10000
  - Best individual does not improve for 1000 generations
- All results averaged over 50 runs.

Effect of migration frequency -1



Effect of migration frequency -2