Karlsruhe Institute of Technology

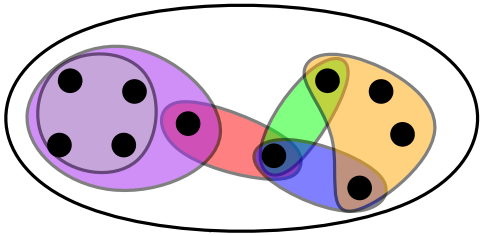
Evolutionary Hypergraph Partitioning

Presentation · December 7, 2017

Robin Andre

INSTITUTE OF THEORETICAL INFORMATICS · ALGORITHMICS GROUP

KaHyPar - Multilevel Partitioner



Coarsening:

- H is reduced to a smaller problem H_C
- only one node is contracted per step
- until H_C is sufficiently small

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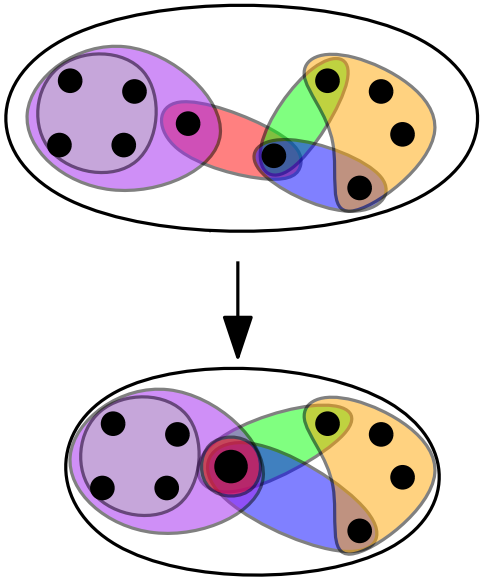
KaHyPar - Multilevel Partitioner



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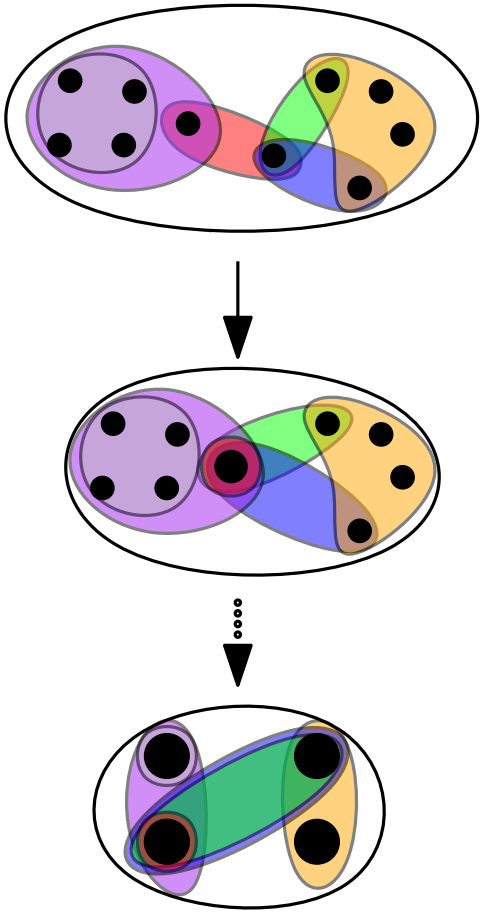

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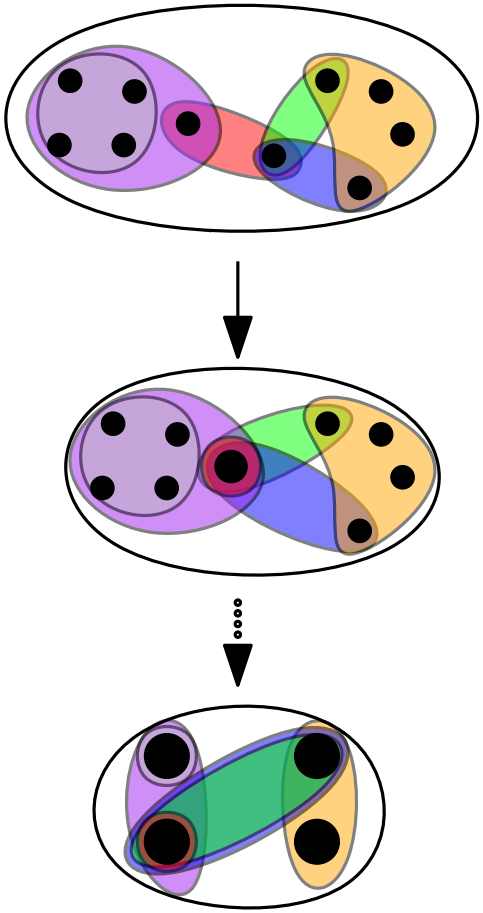
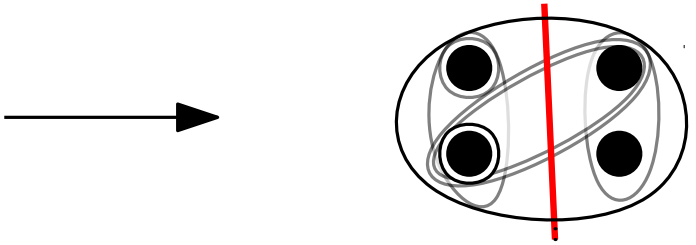


Initial Partitioning:

- An algorithm generates an Initial Partitioning for H_C



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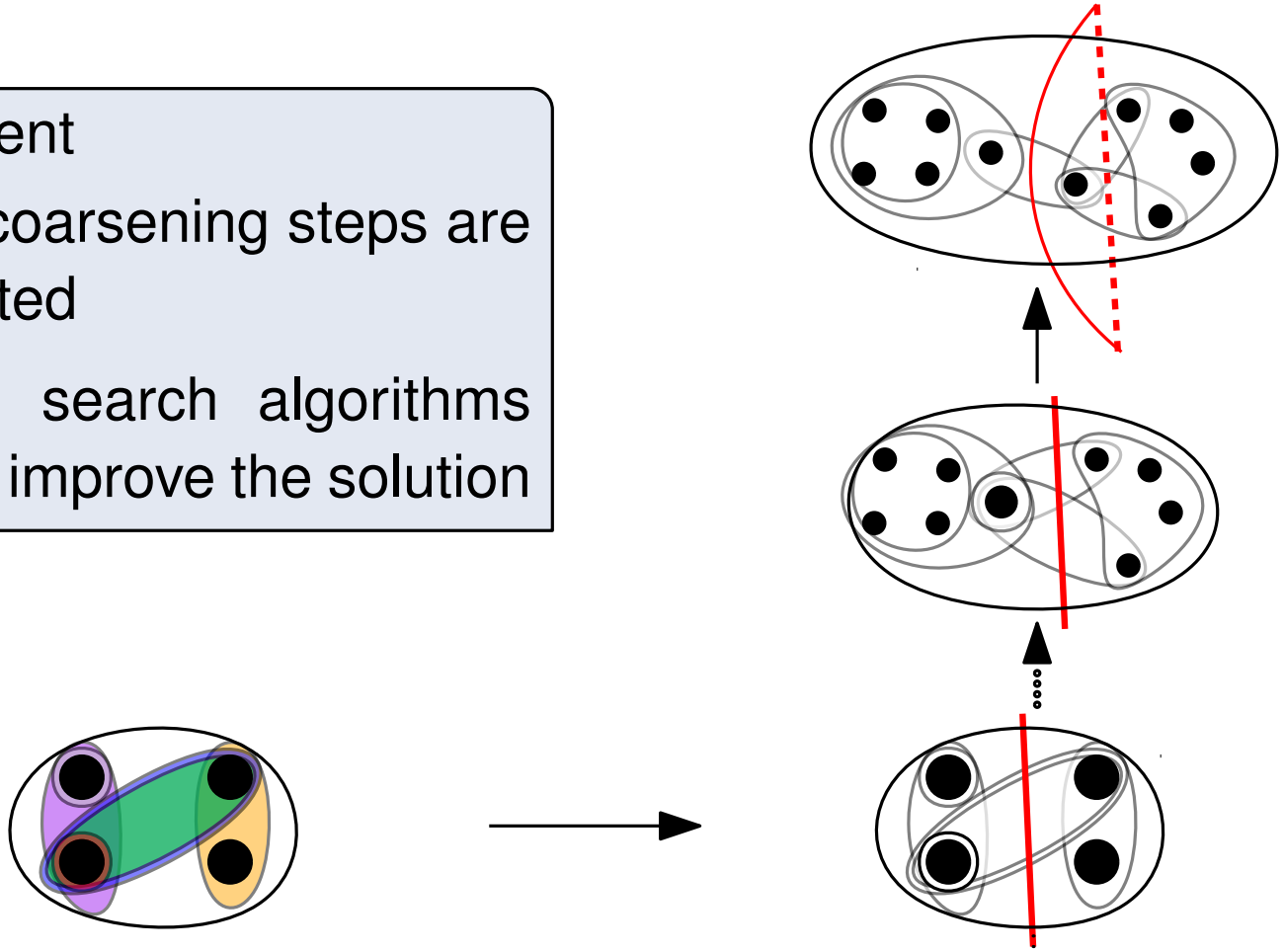
KaHyPar - Multilevel Partitioner

Refinement

- The coarsening steps are reverted
- Local search algorithms try to improve the solution



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Evolutionary Algorithm

KaHyPar generates multiple partitions

dynamic allocation $\delta = 15\%$

Evolutionary Algorithm

3.1s $time = 100s$ ⟶ $\sim$ 5 iterations

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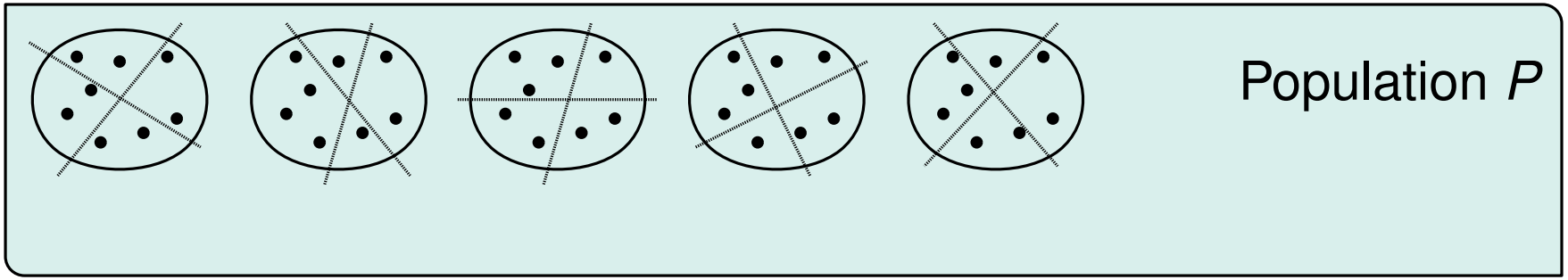
Evolutionary Algorithm



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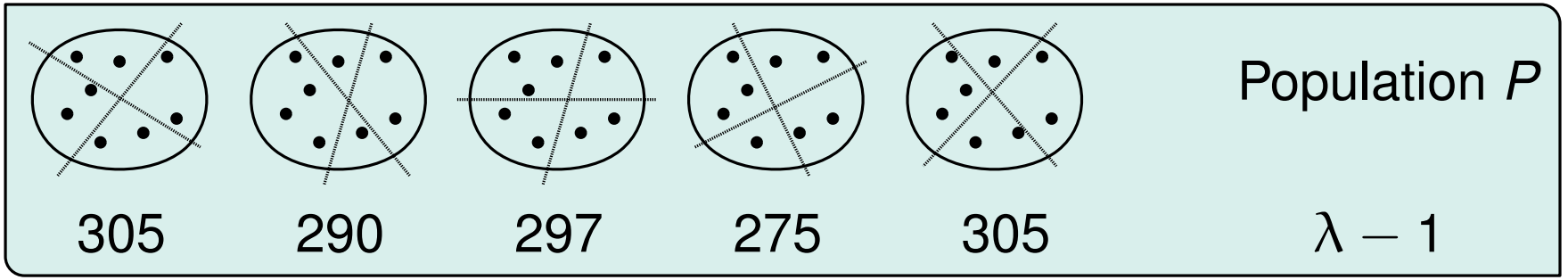
Evolutionary Algorithm



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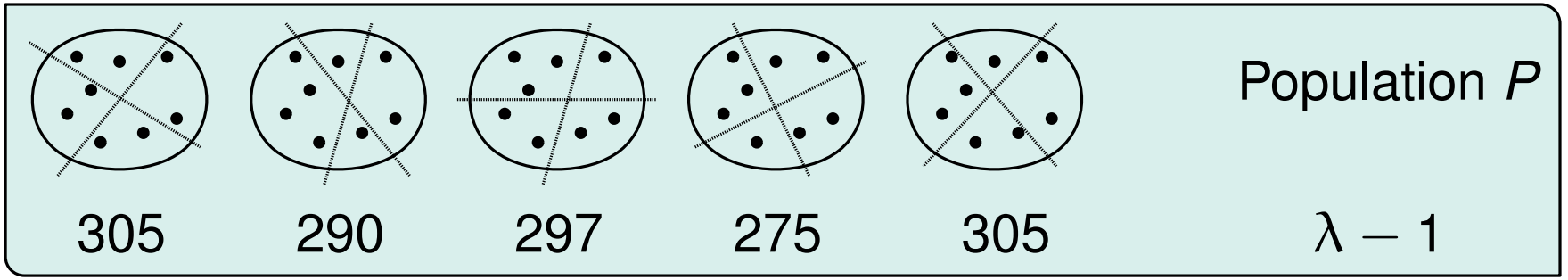

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dynamic allocation $\delta = 15\%$

balances time/hypergraph size

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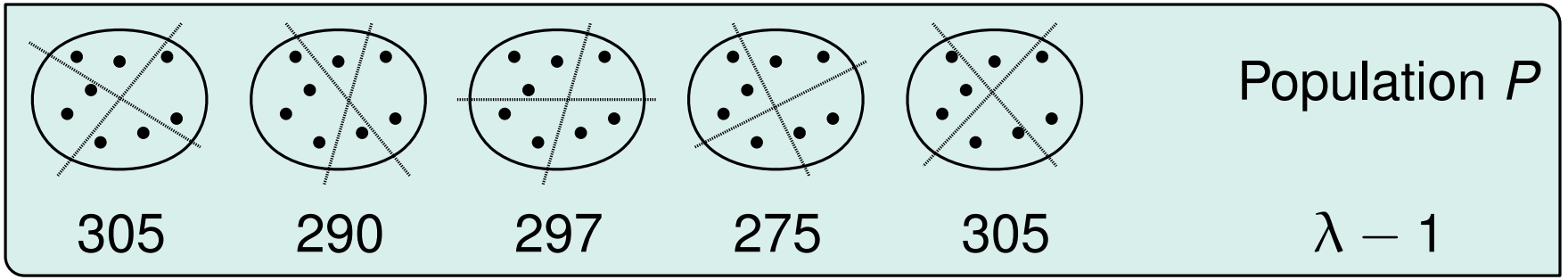
Evolutionary Algorithm



3.1s $time = 100s$ ⟶ $\sim$ 5 iterations

KaHyPar generates multiple partitions

dynamic allocation $\delta = 15\%$

high quality solutions

balances time/hypergraph size

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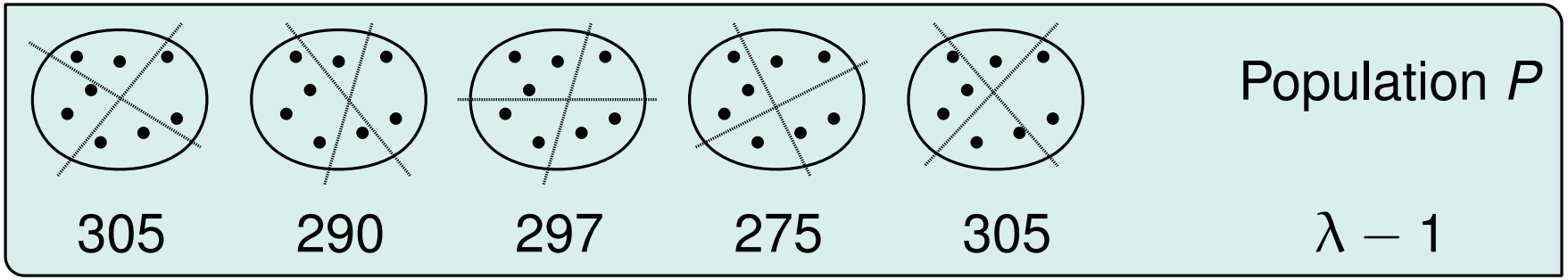
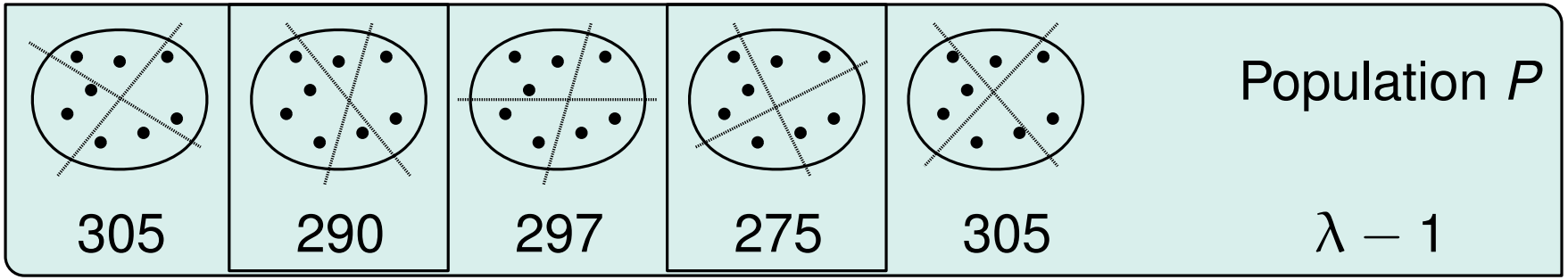
Tournament Selection

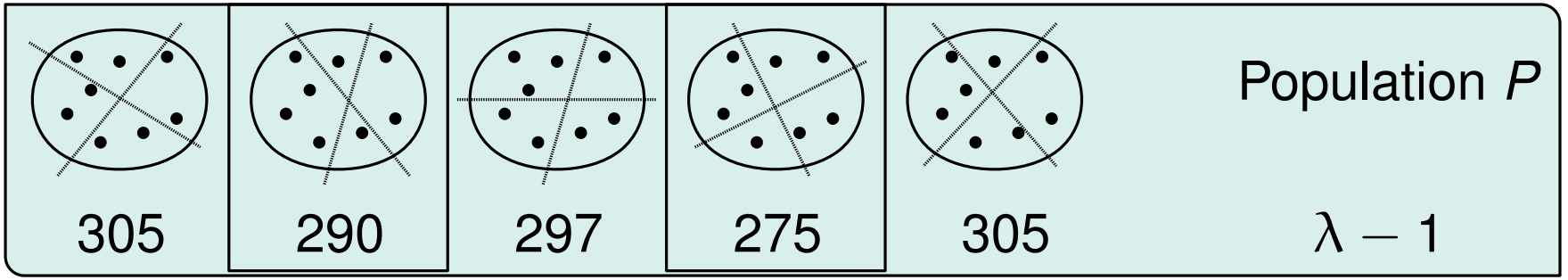


Tournament Selection



select 2 random Individuals

Tournament Selection



select 2 random Individuals

compare their fitness

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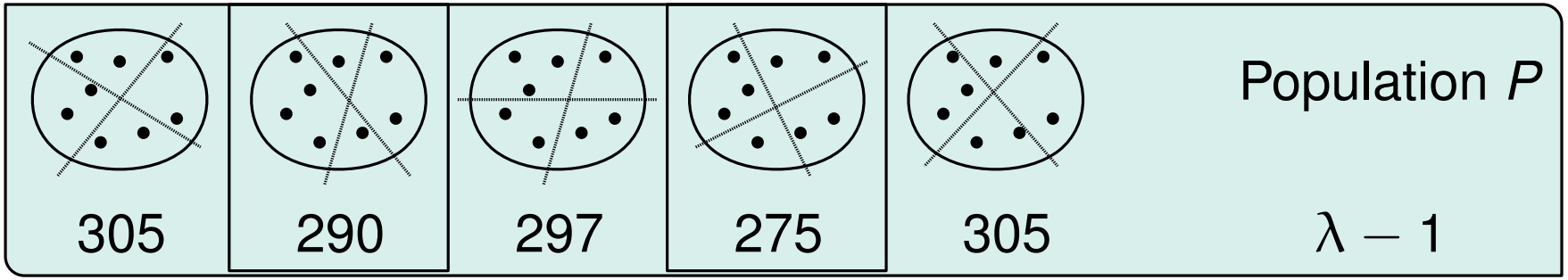
Tournament Selection

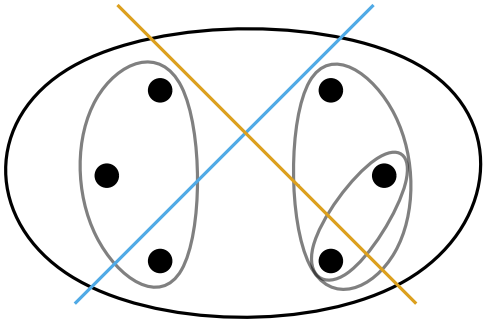


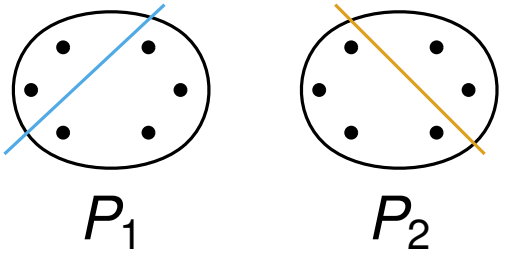
select 2 random Individuals

compare their fitness

choose the better Individual

Combine Operator

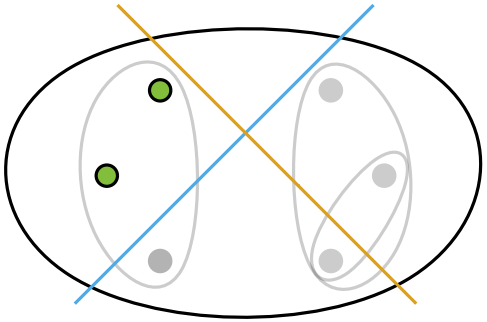


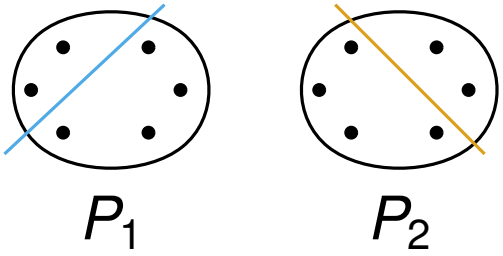


Coarsening:

- contractions must respect P_1 & P_2
- does not change solution quality

Combine Operator





Valid Contraction

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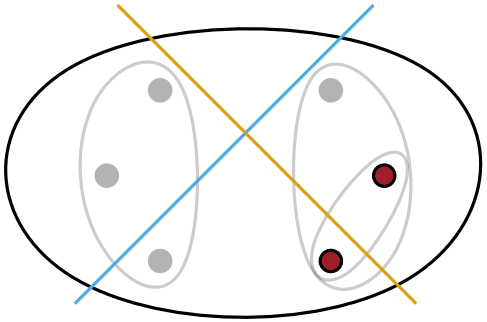

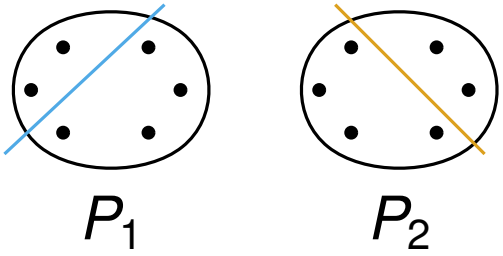

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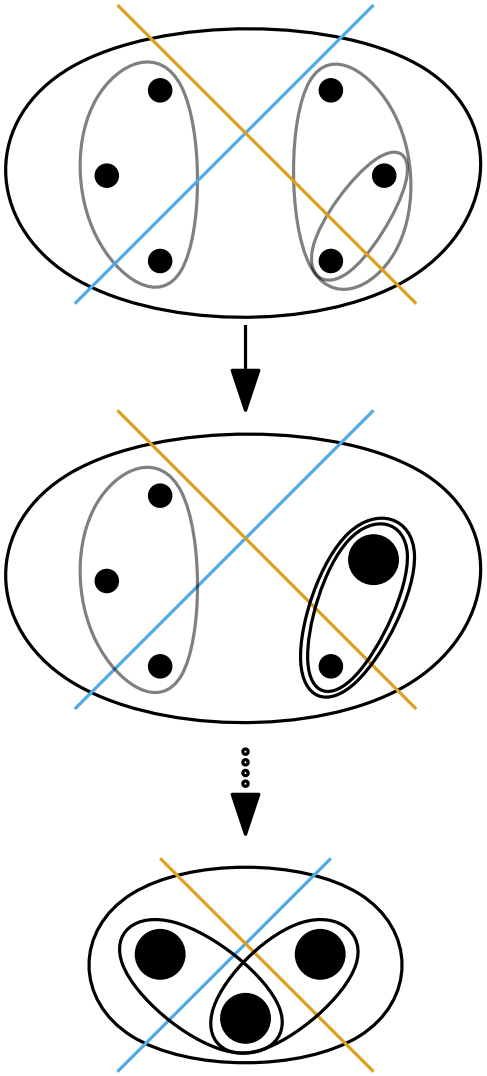

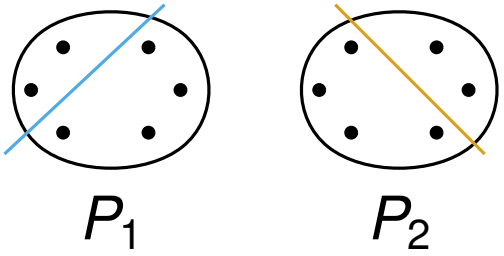

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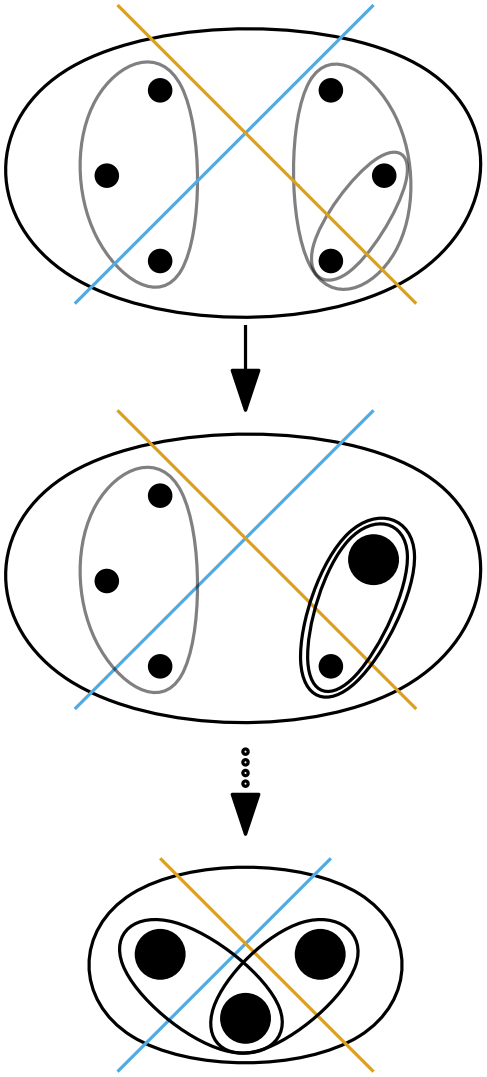
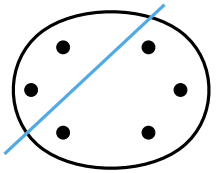
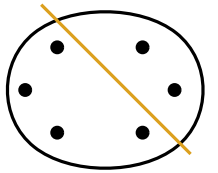




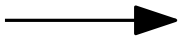
P_1

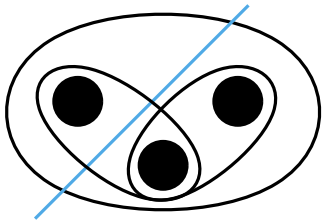


P_2

Initial Partitioning:

- Use the better parent partition (P_1)
- Maintains solution quality

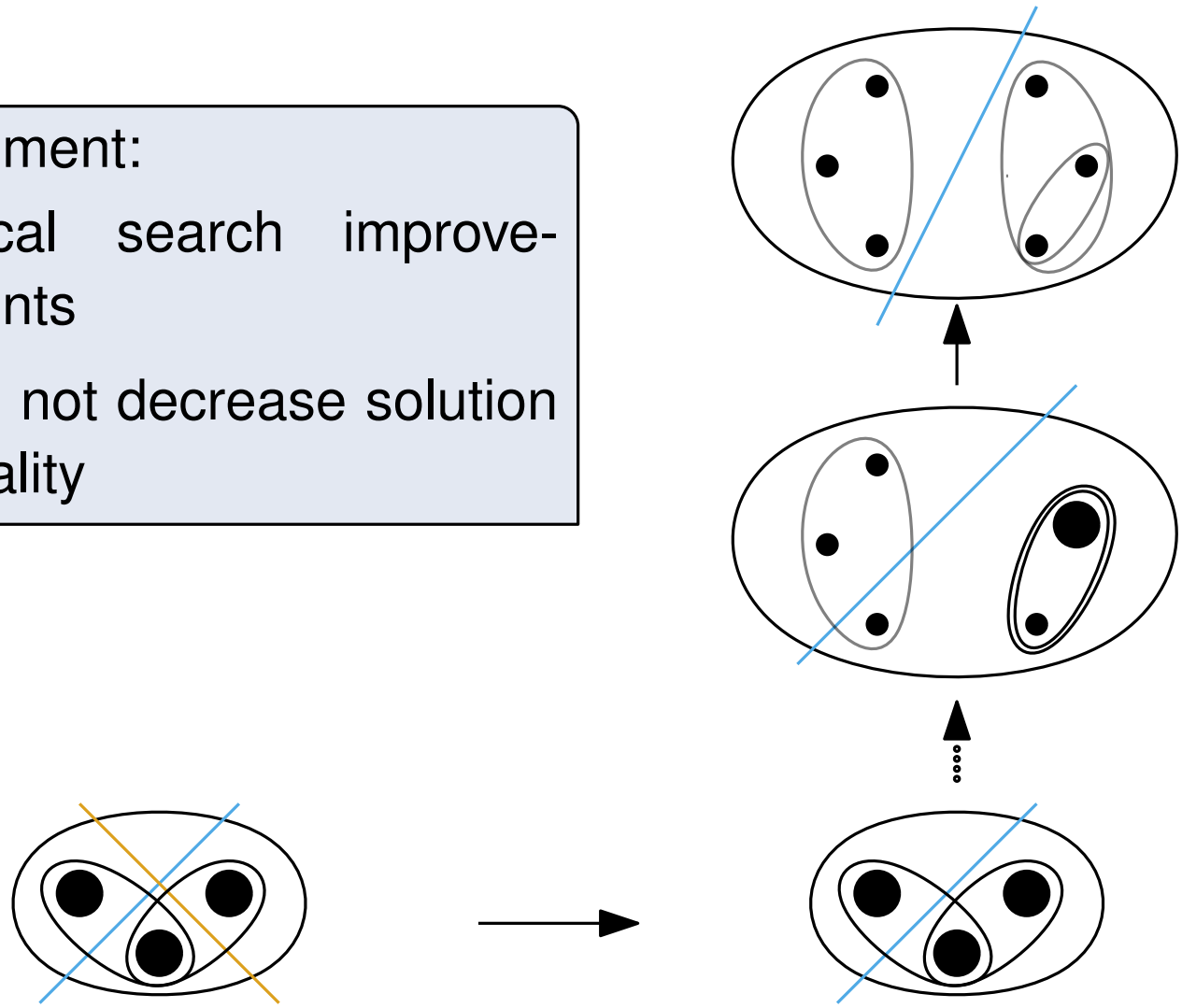




Combine Operator

Refinement:

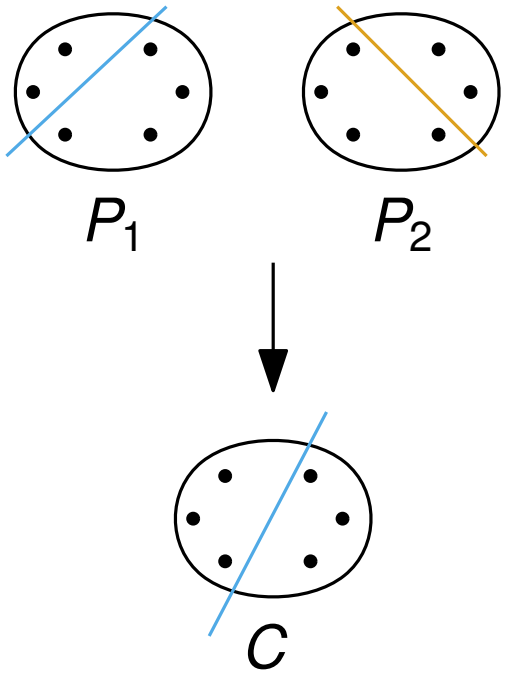
- Local search improvements
- will not decrease solution quality



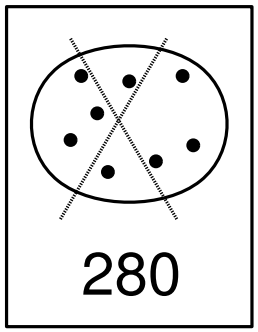
Combine Operator

Benefits:

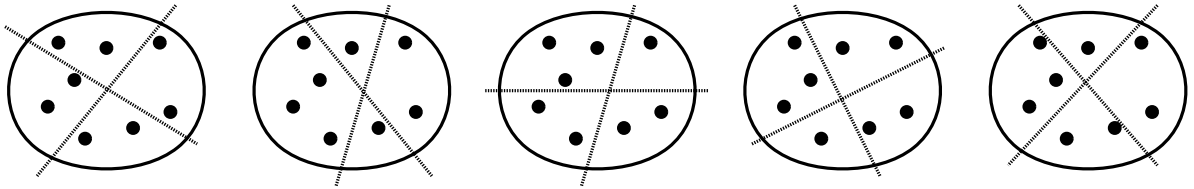
- local search
- structure preservation



Replacement Strategy



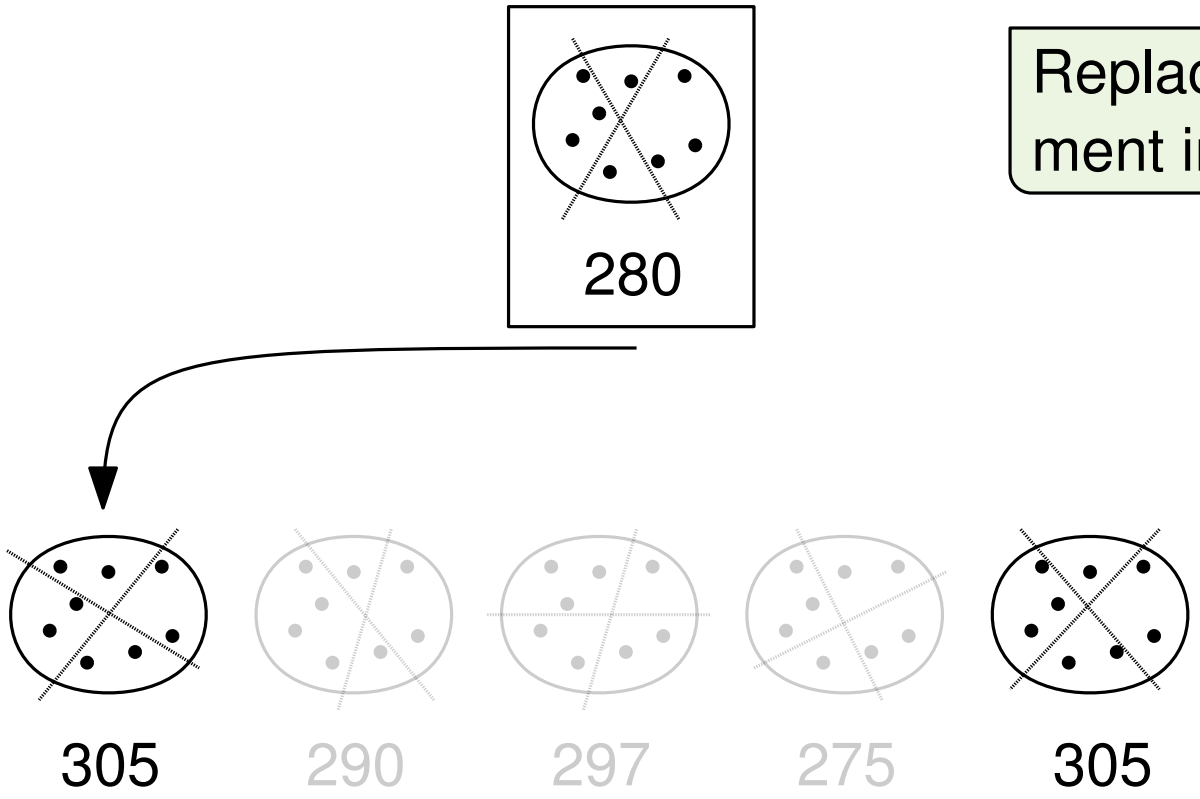
New individual has to be placed in P



Population P

$\lambda - 1$

Replacement Strategy

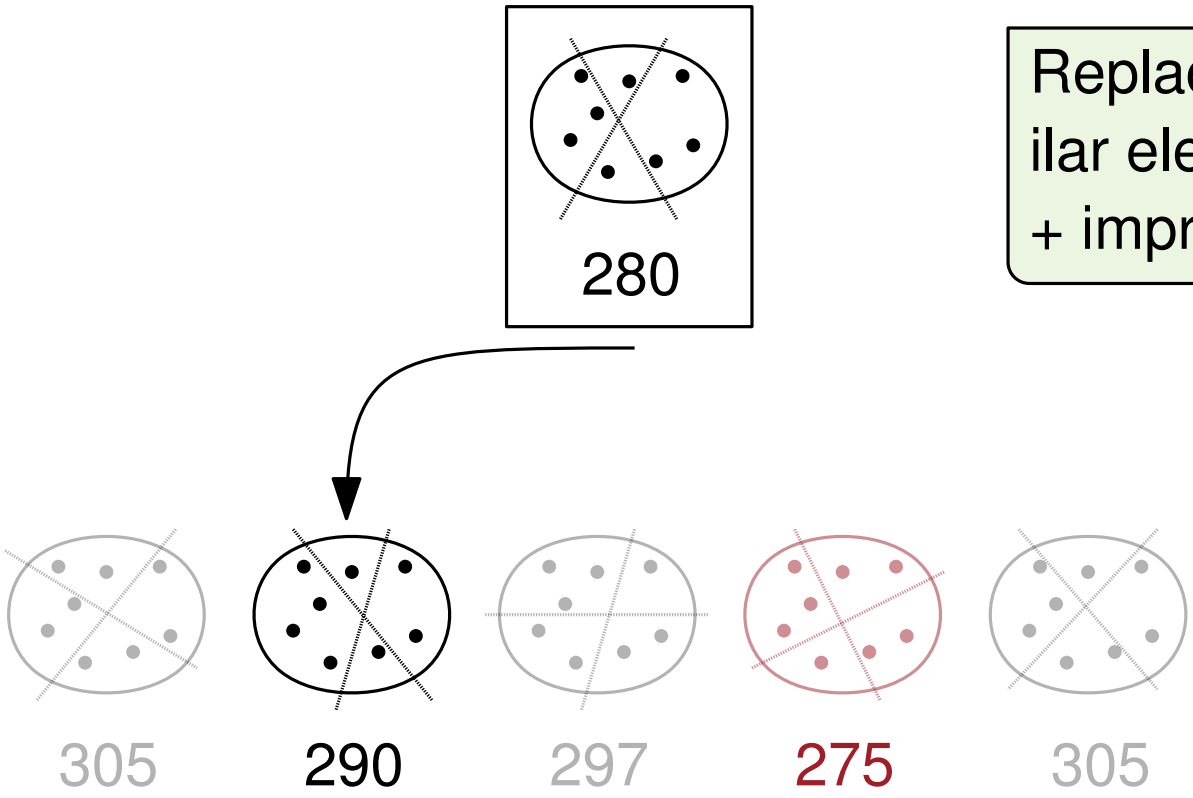


Replace the worst element in P

Population P

$\lambda - 1$

Replacement Strategy

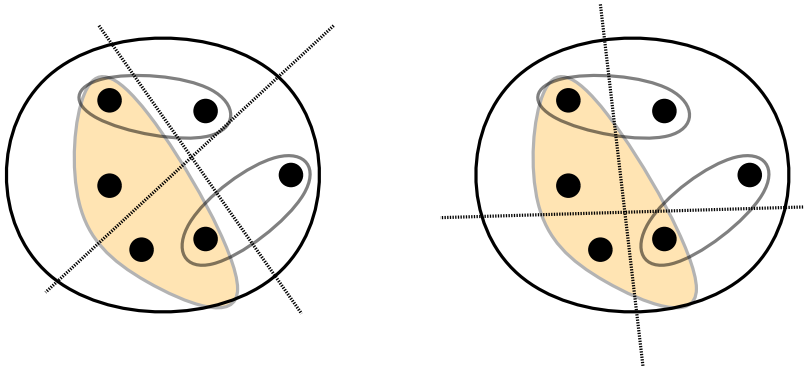


Replace the most similar element in P
+ improving quality

Population P

$\lambda - 1$

Diversity

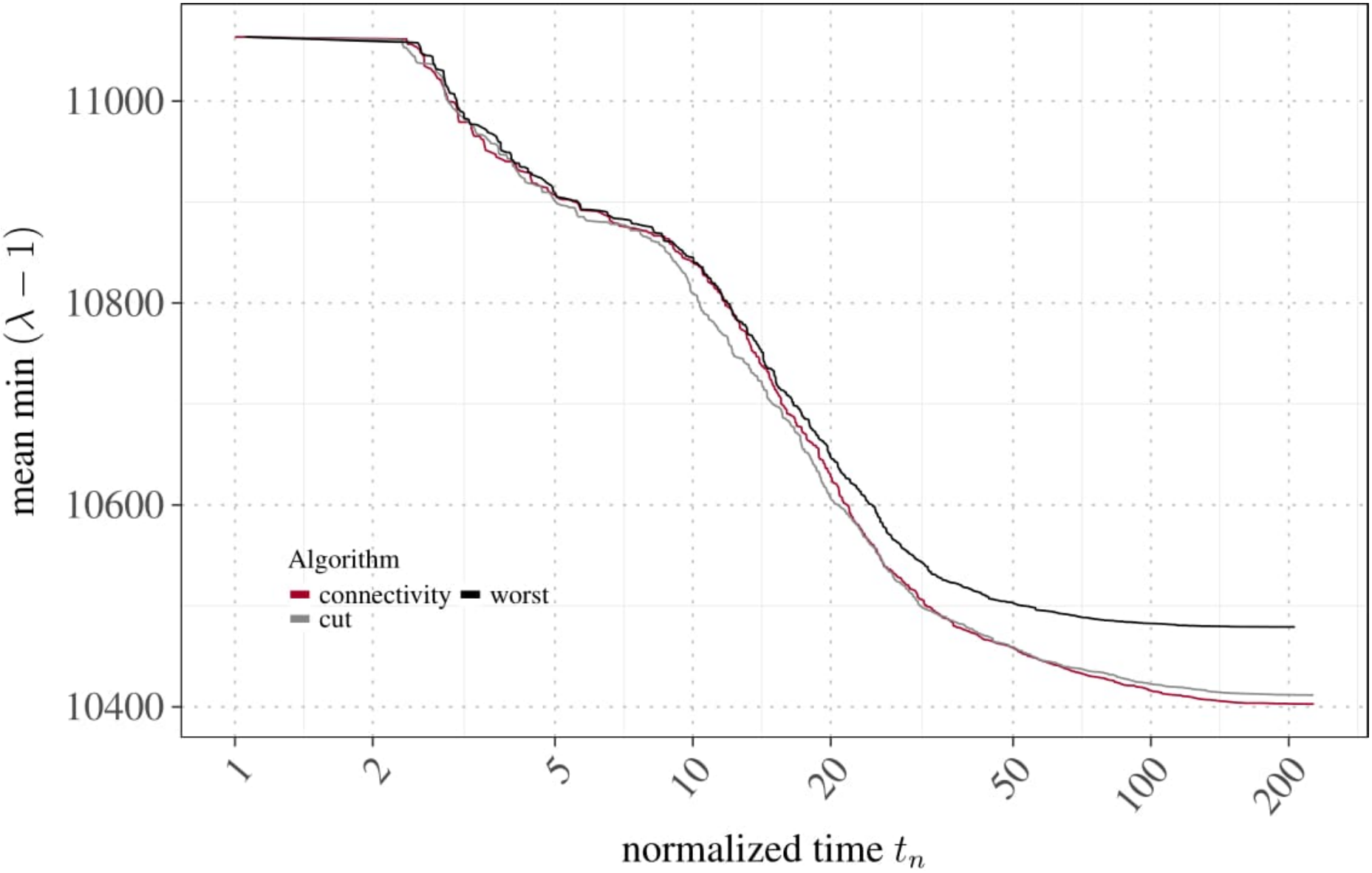


			difference
cut	1, 1, 1	1, 1, 1	0,0,0 = 0
connectivity	2,2,2	2,3,2	0,1,0 = 1

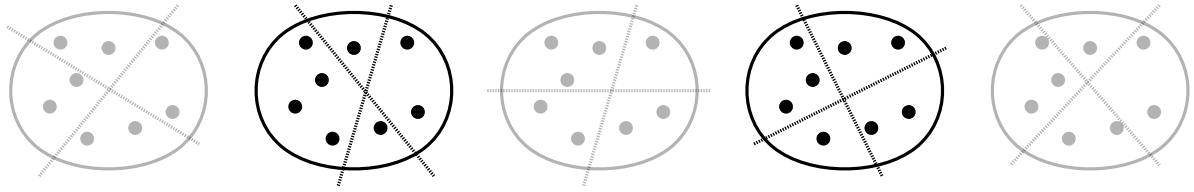
There are two approaches for difference :

- count the different cut edges
- count the different blocks of cut edges

Test Results

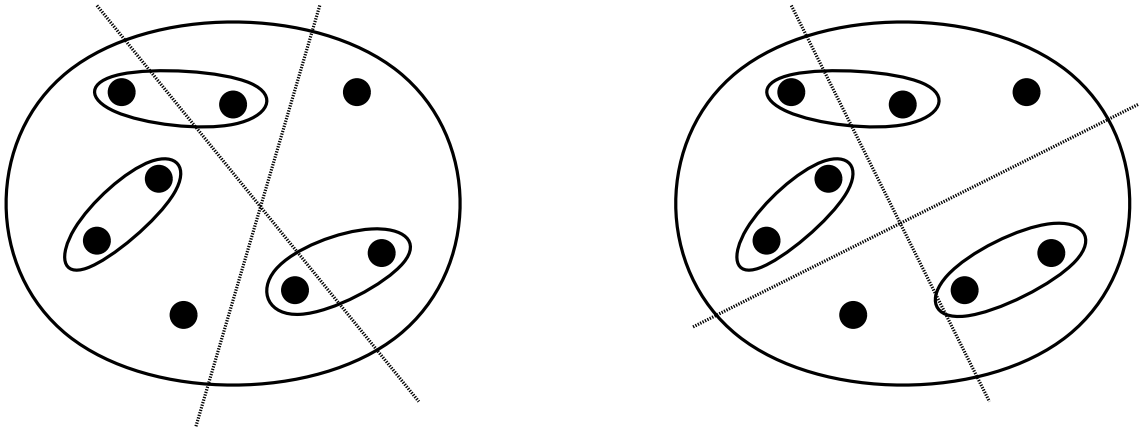


Edge Frequency Multicombine



We inspect the $\sqrt{|P|}$ best individuals of P

Edge Frequency Multicombine



The frequency of each hyperedge is analyzed

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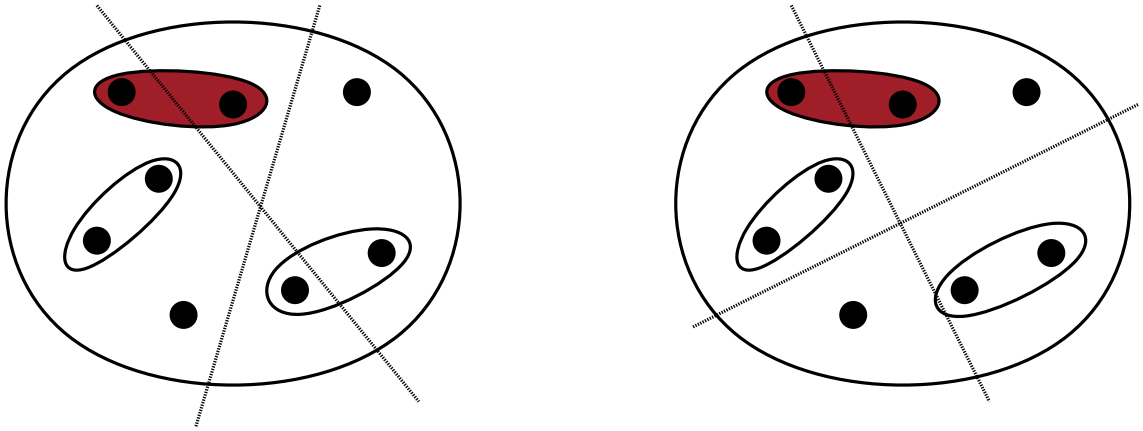

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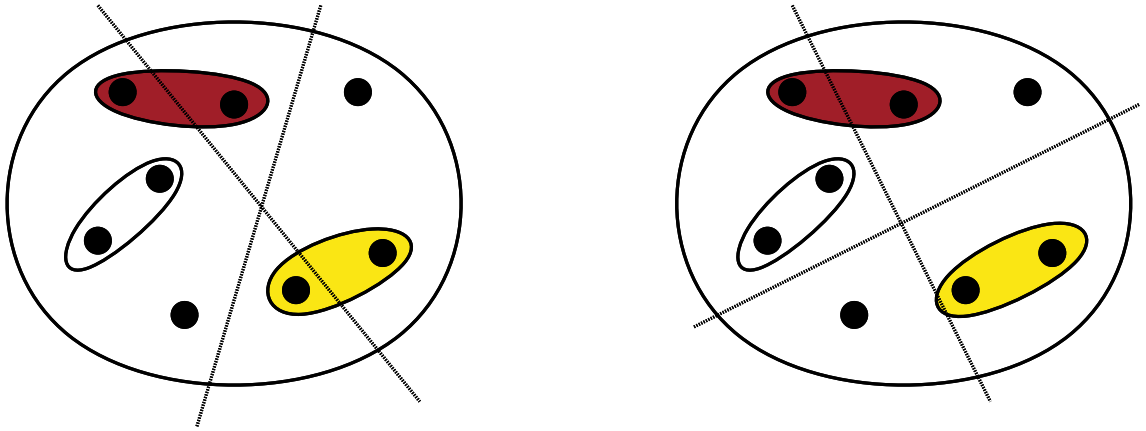

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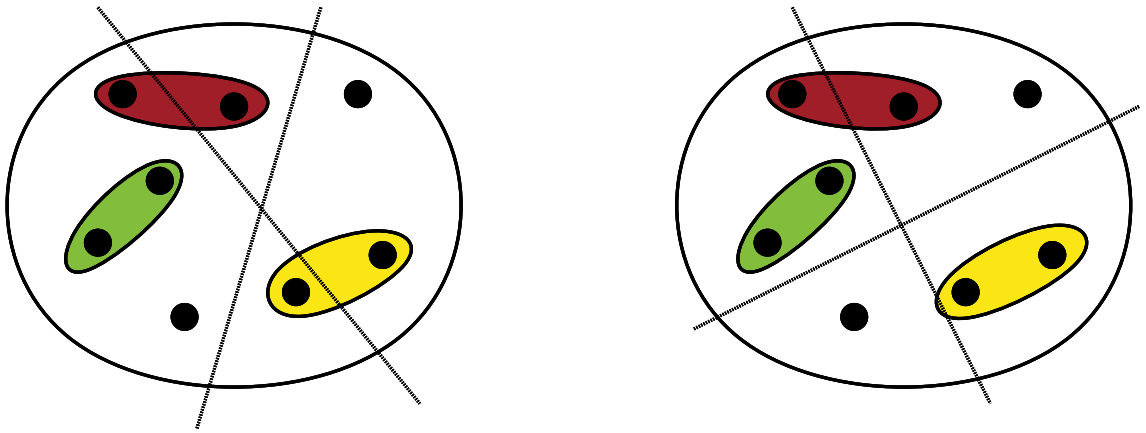

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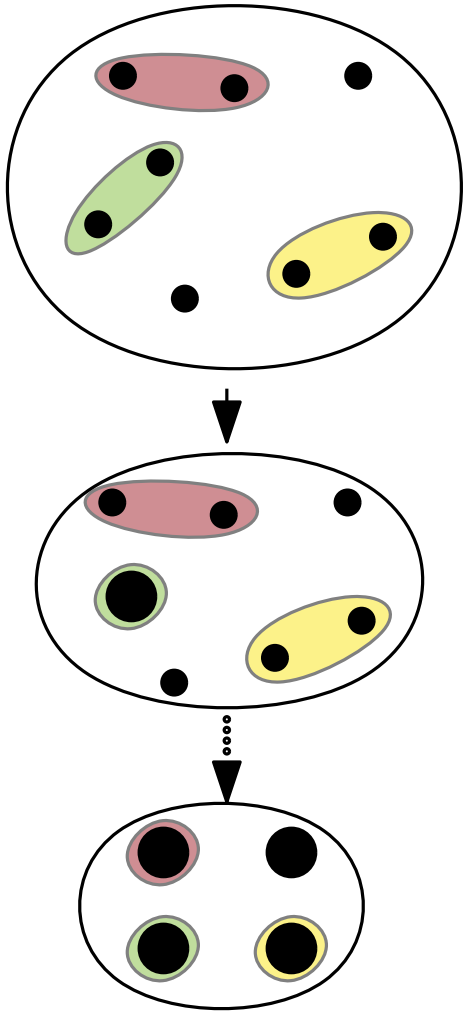

Coarsening:

- the frequency of e discourages contracting e
- low frequency edges are contracted first

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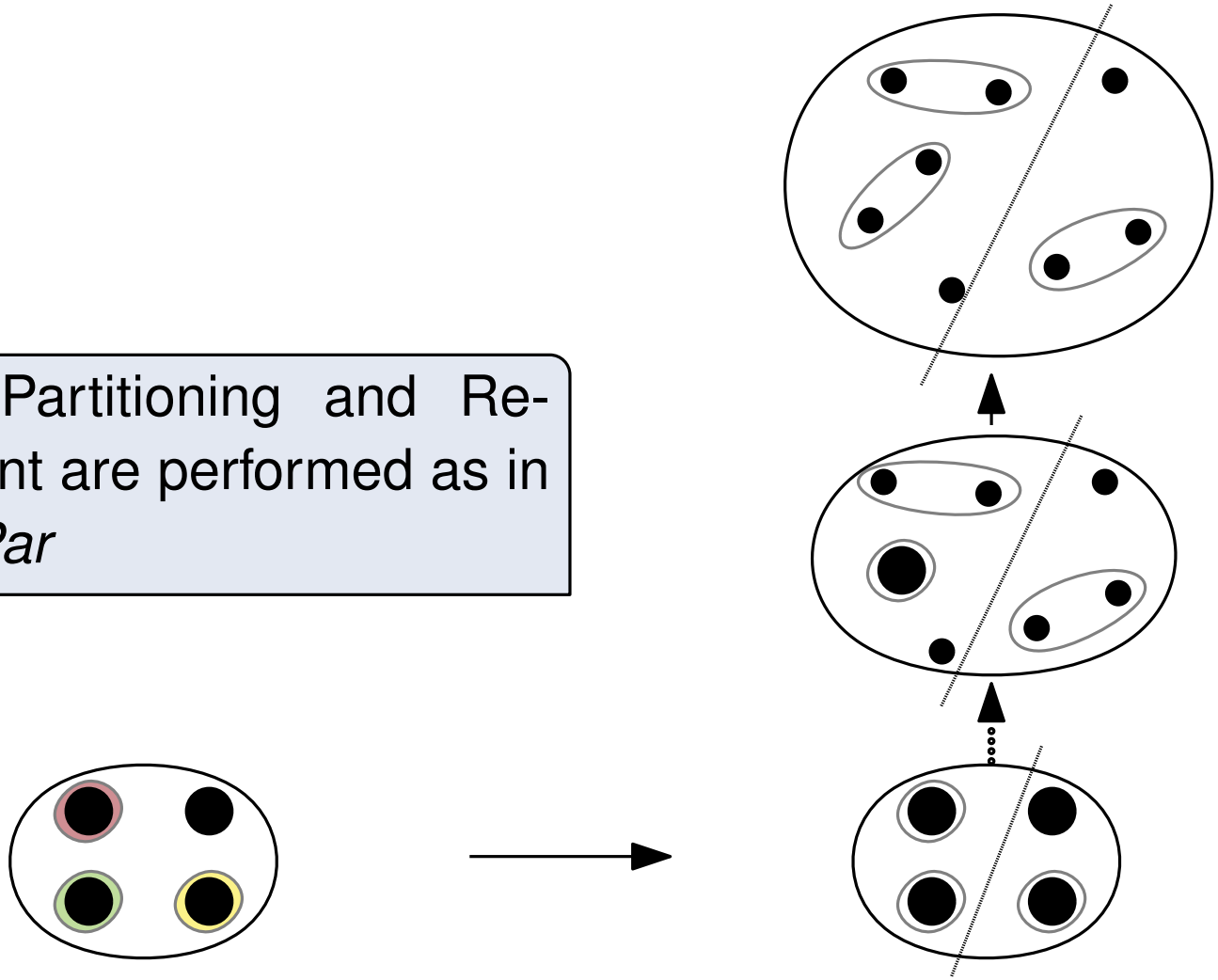
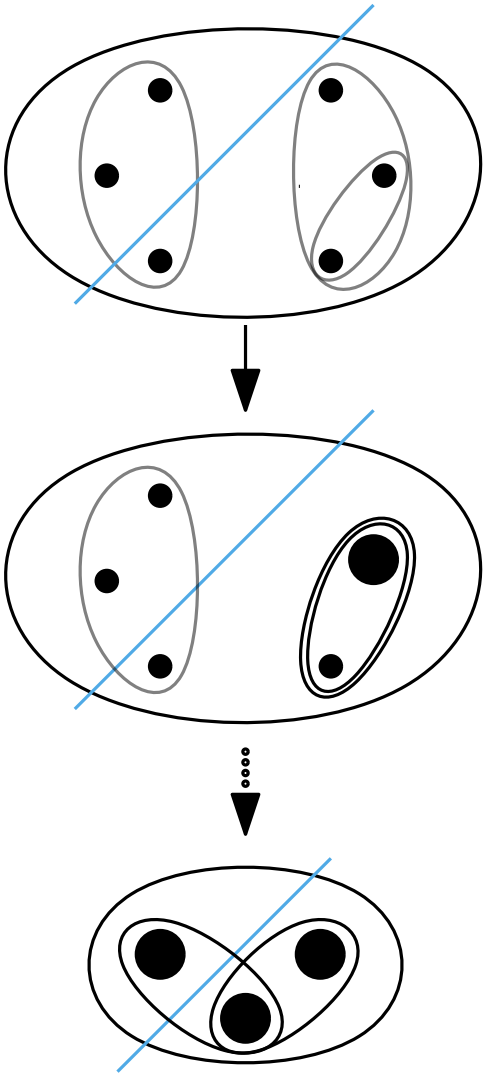
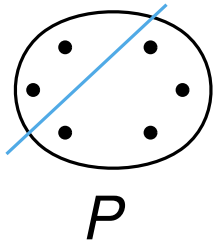
Edge Frequency Multicombine

Initial Partitioning and Refinement are performed as in *KaHyPar*



V-Cycle (+ New Initial Partitioning)

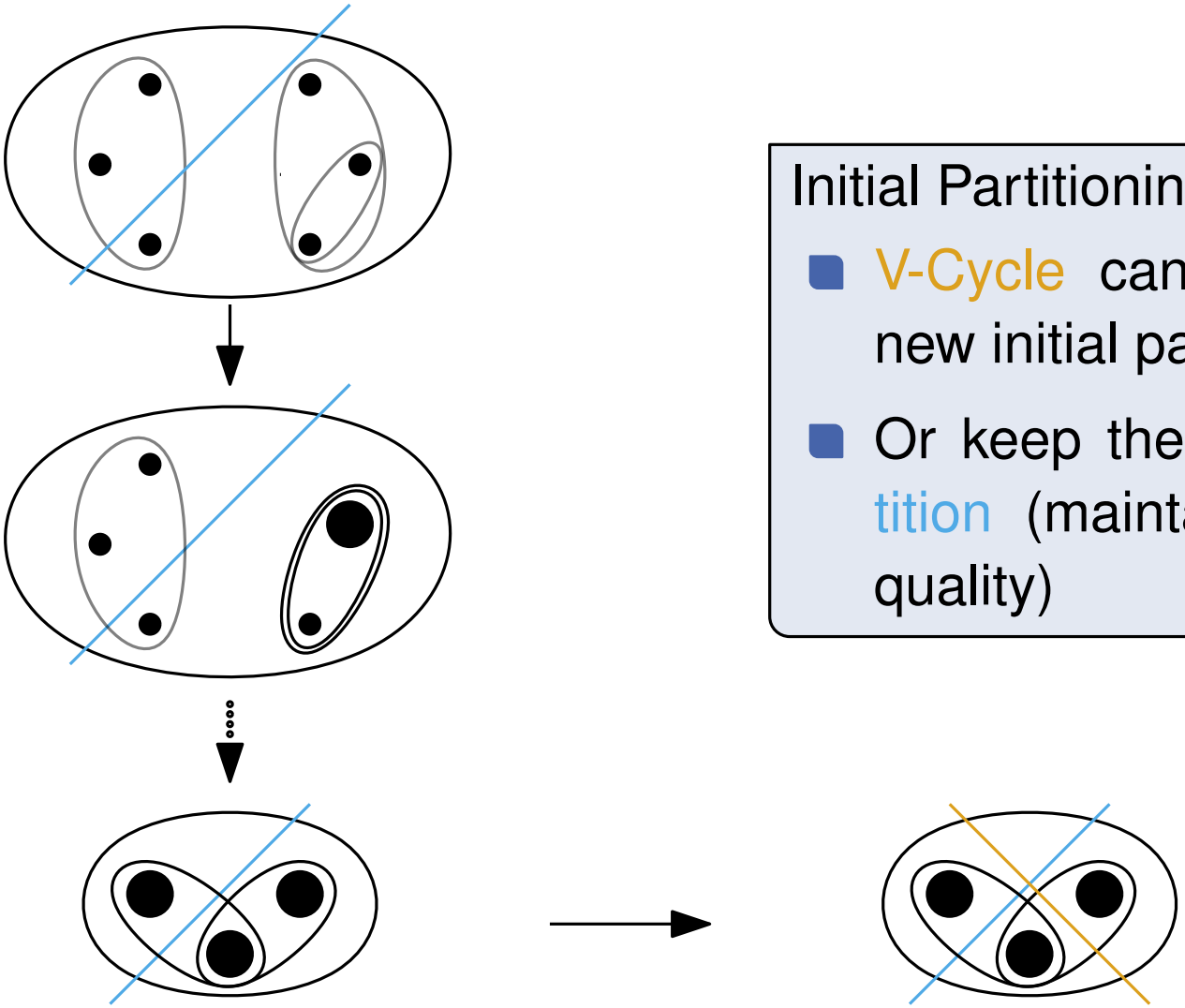




Coarsening:

- contractions must respect P
- does not change solution quality

V-Cycle (+ New Initial Partitioning)



Initial Partitioning:

- V-Cycle can generate a new initial partitioning
- Or keep the current partition (maintains solution quality)

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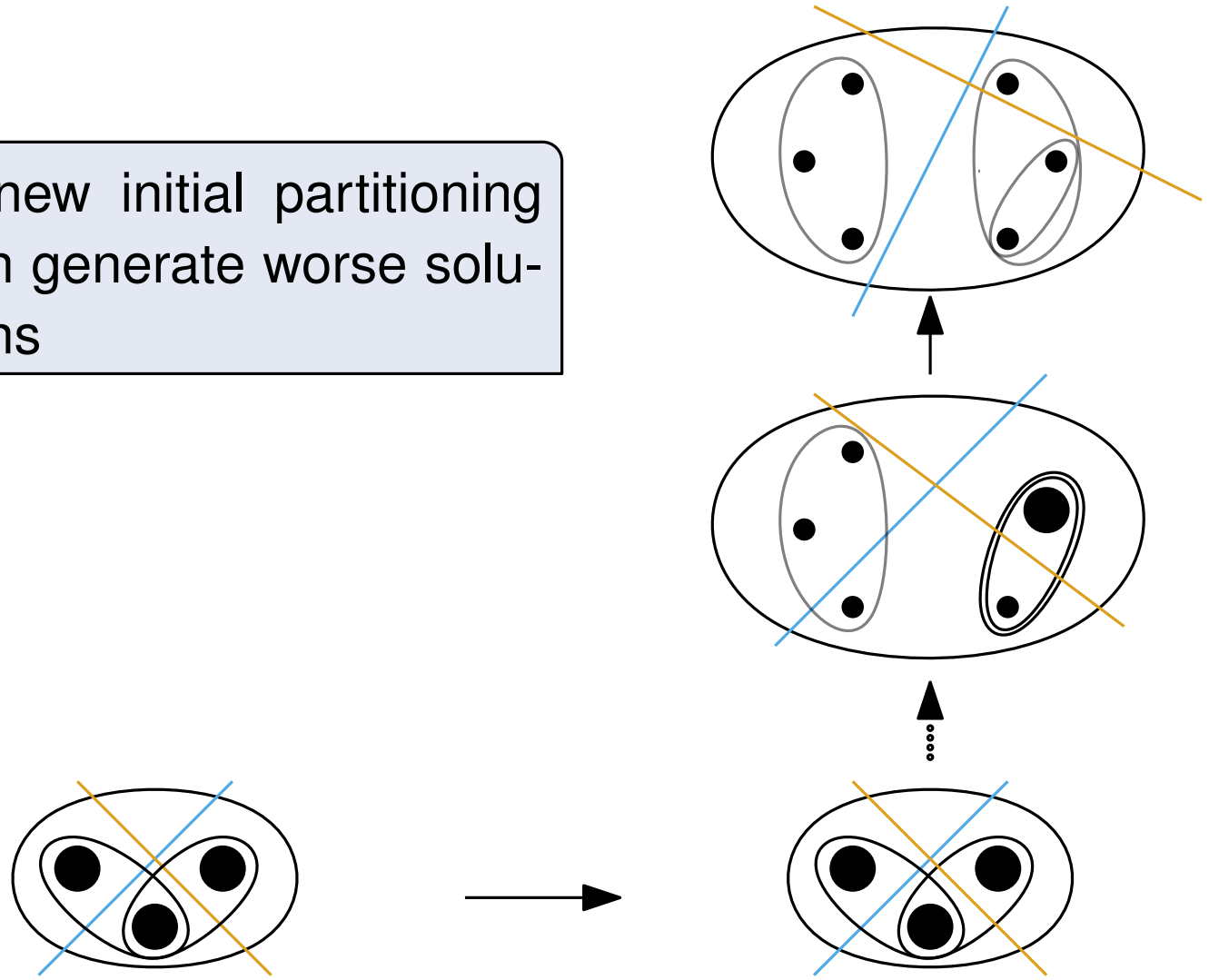
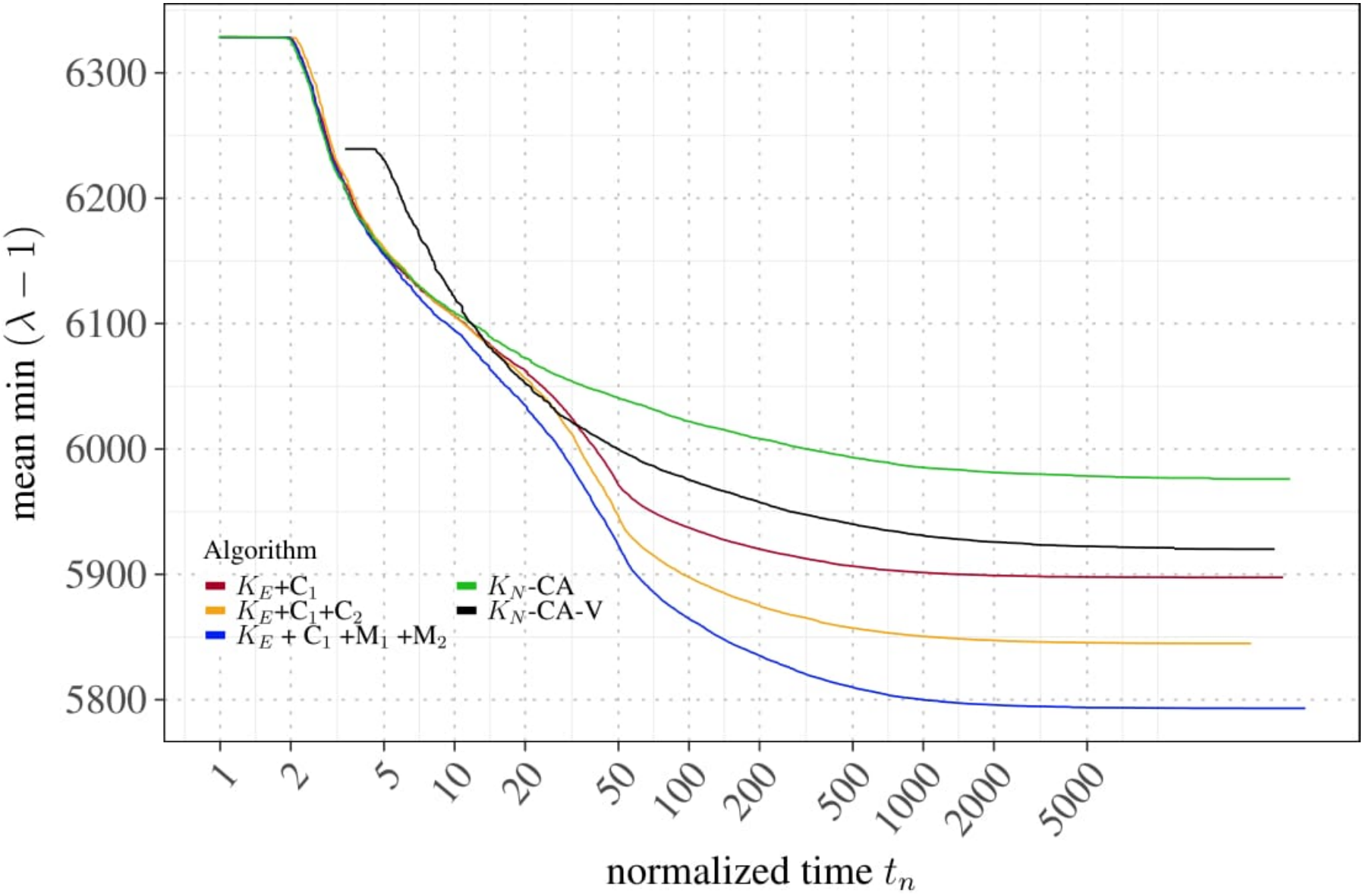
V-Cycle (+ New Initial Partitioning)

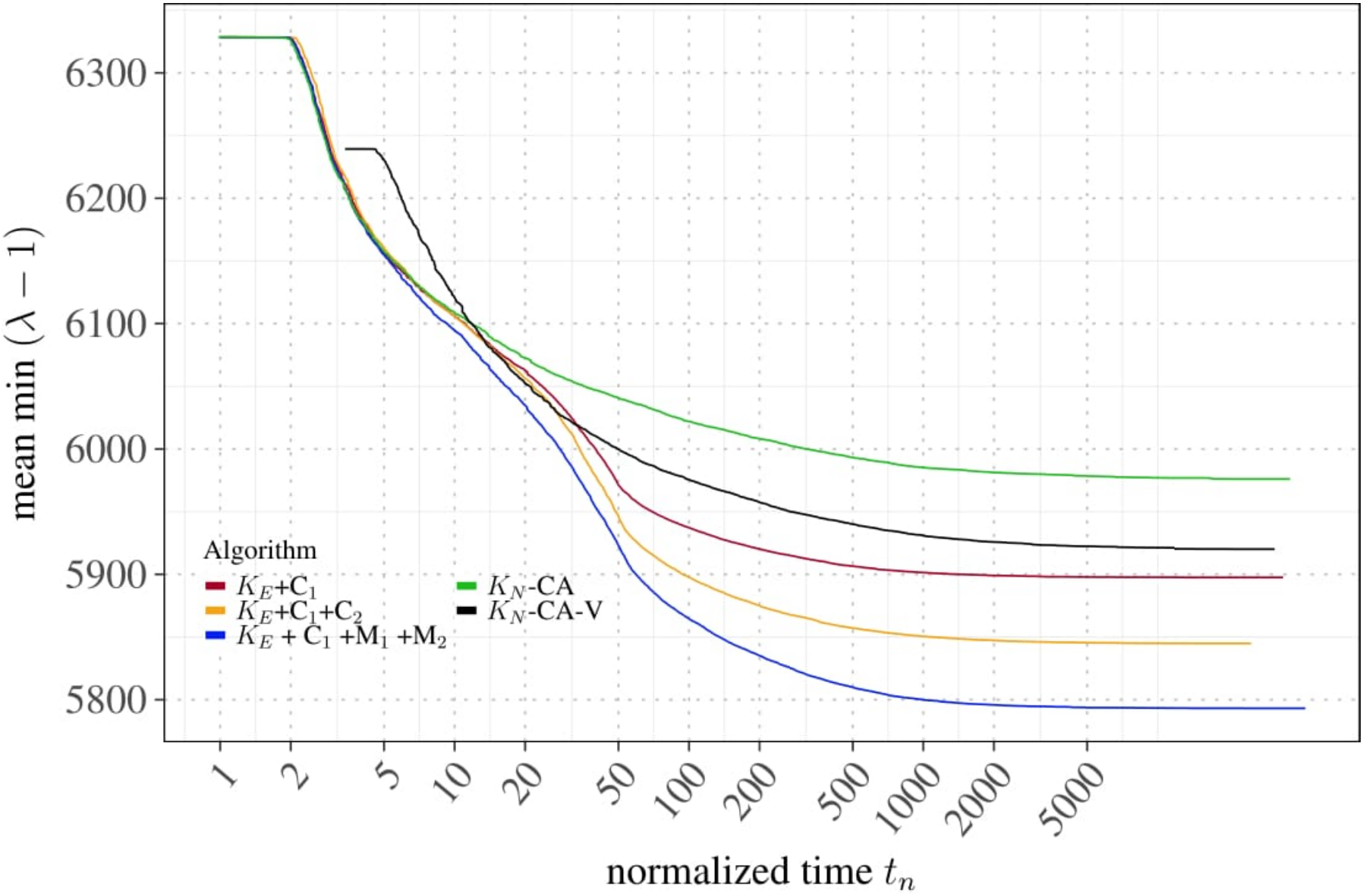
- A new initial partitioning can generate worse solutions



Results


mean min ($\lambda - 1$)
6300
6200
6100
6000
5900
5800
1
2
5
10
20
50
100
200
500
1000
2000
5000
normalized time t_n
Algorithm
K_E+C$_1$
K_E+C$_1$+C$_2$
K_E + C$_1$ +M$_1$ +M$_2$
K_N-CA
K_N-CA-V

Results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normalized time t_n
Algorithm
K_E+C$_1$
K_E+C$_1$+C$_2$
K_E + C$_1$ +M$_1$ +M$_2$
K_N-CA
K_N-CA-V