Multi-objective optimization

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과제명: IoT 환경을 위한 고성능 플래시 메모리 스토리지 기반 인메모리 분산 DBMS 연구개발

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Single-objective optimization

- An optimization problem involves only one objective function, the task of finding the optimal solution.
- Global optimum / Local optimum
- Ex) Find out a CAR with minimum cost

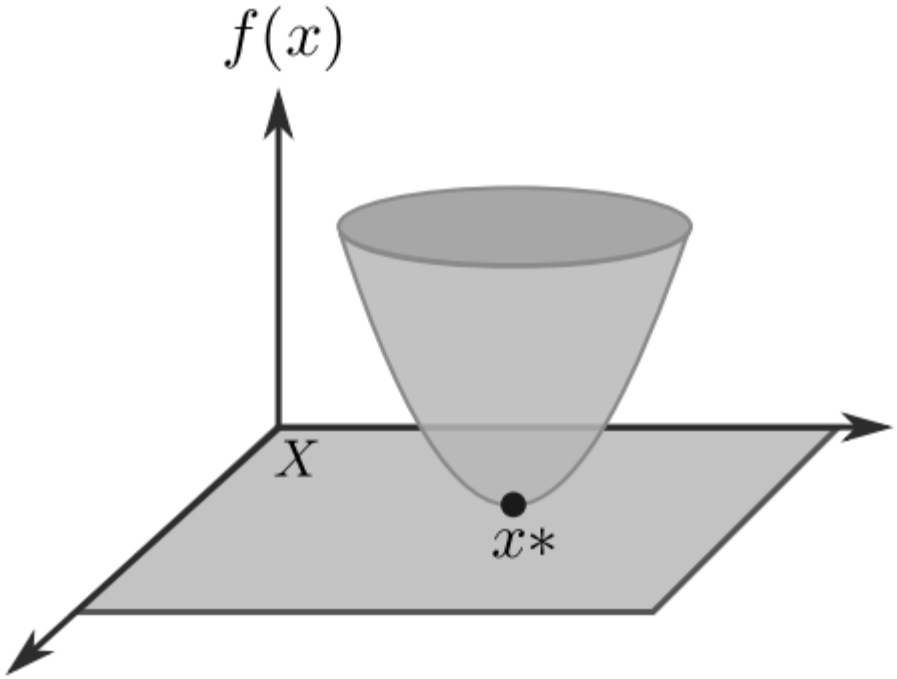
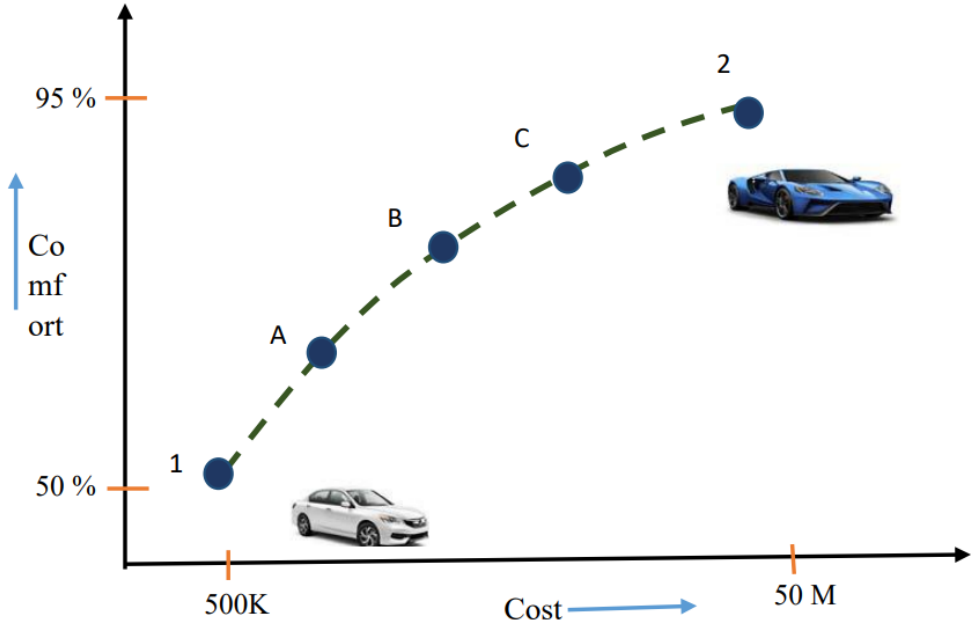


Figure 1: Single-objective optimization problem.

Catalog

Multi-objective optimization(Pareto optimization)

- Multiple criteria decision making involving more than one objective function to be optimized simultaneously
- optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives
- Does not typically exist one feasible solution that minimizes all objective functions simultaneously
- Ex) Find out a CAR with minimum cost AND maximum comfort



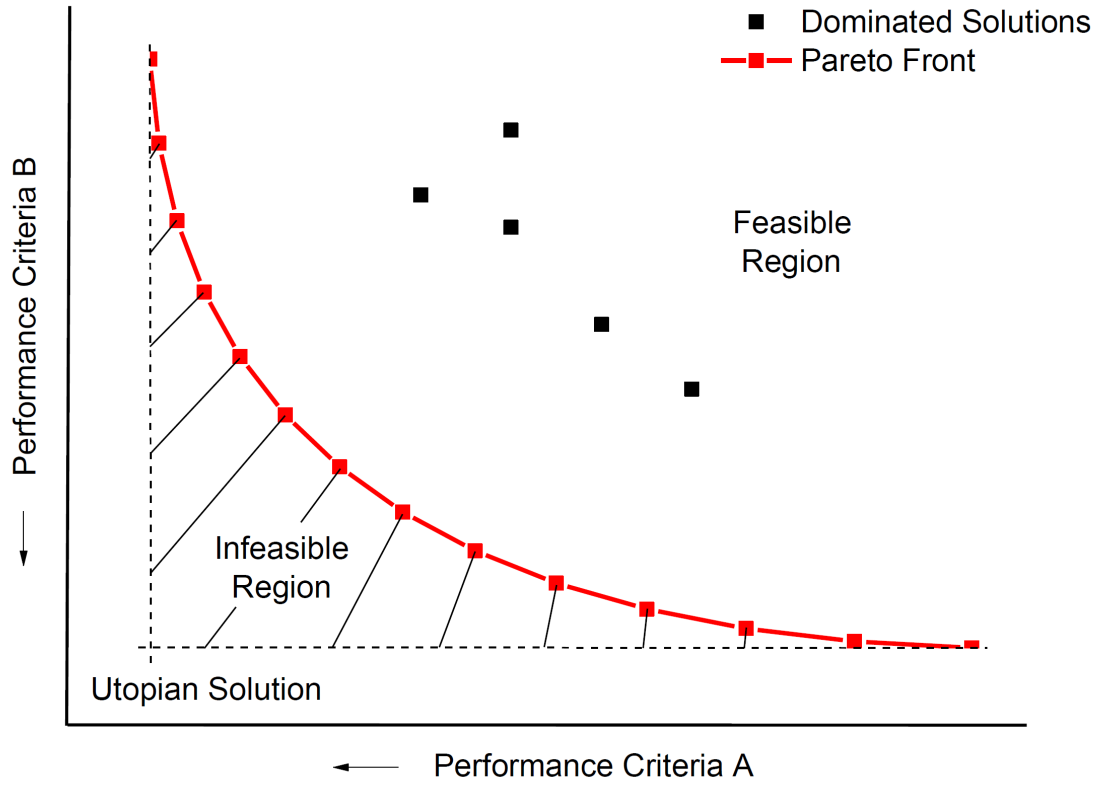
Multi-objective optimization(Pareto optimization)

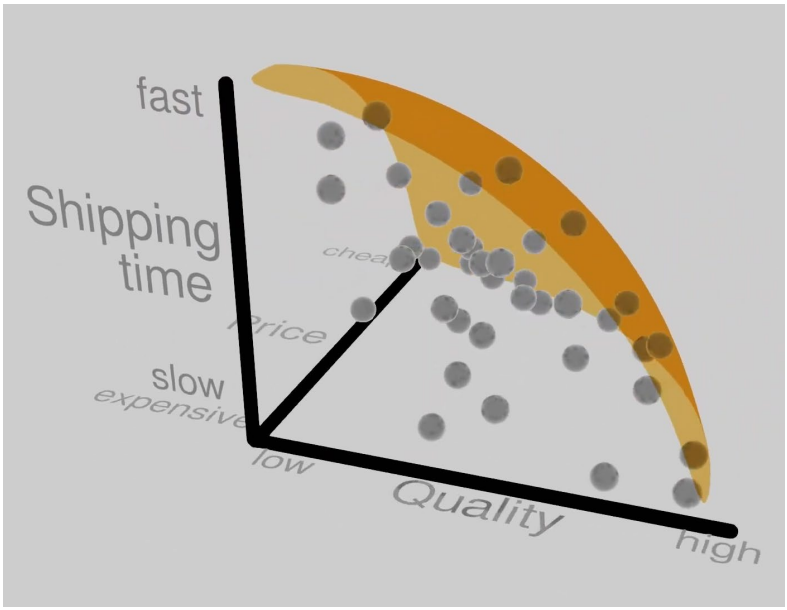
- Pareto optimal / Pareto frontier:

  Solutions that cannot be improved in any of the objectives

  without degrading at least one of the other objectives

- Feasible / Infeasible region



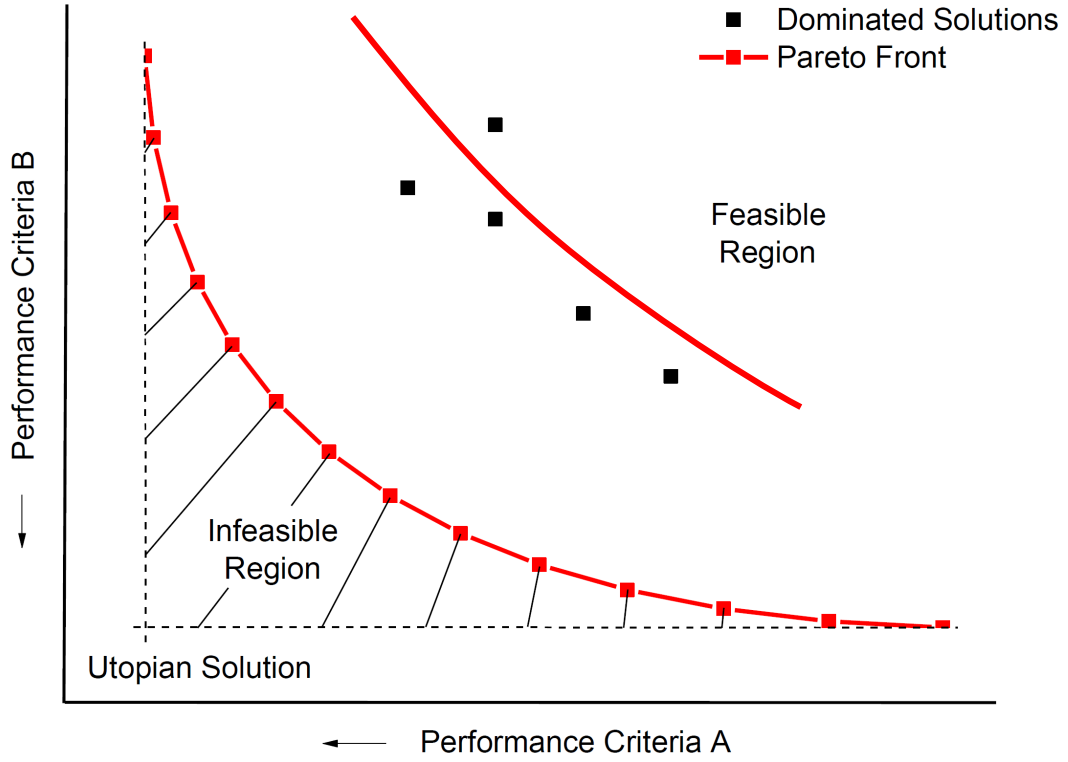


Multi-objective optimization(Pareto optimization)

- Pareto optimal / Pareto frontier
- Dominate / Non-dominate
- x_1 is said to dominate x_2 if,

1. $\forall i \in \{1, \ldots, k\}, f_i(x_1) \leq f_i(x_2)$, and
2. $\exists i \in \{1, \ldots, k\}, f_i(x_1) < f_i(x_2)$.

- Pareto frontier is composed of non-dominated points (frontier 0)
- Complexity is $O(N^3M)$ in Genetic Algorithm (M is the number of objective)



Multi-objective optimization(Pareto optimization)

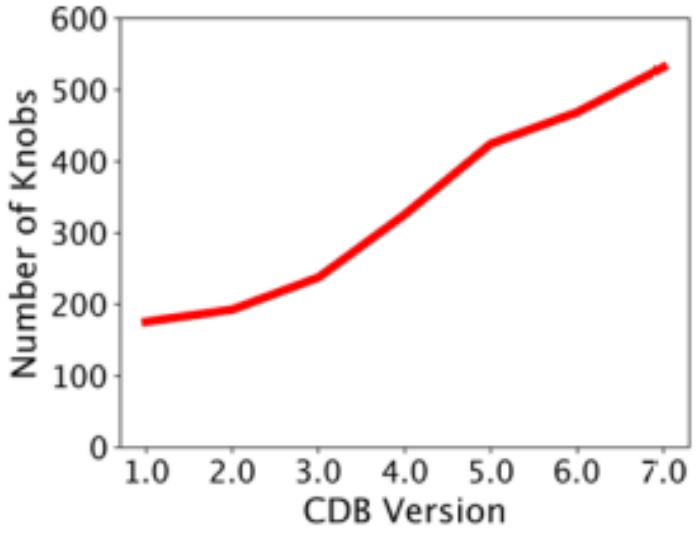
- Simple Example: Divide the Pareto frontier using the table below. (The smaller the Criteria, the better)

1. $\forall i \in \{1, \ldots, k\}, f_i(x_1) \leq f_i(x_2)$, and
2. $\exists i \in \{1, \ldots, k\}, f_i(x_1) < f_i(x_2)$.

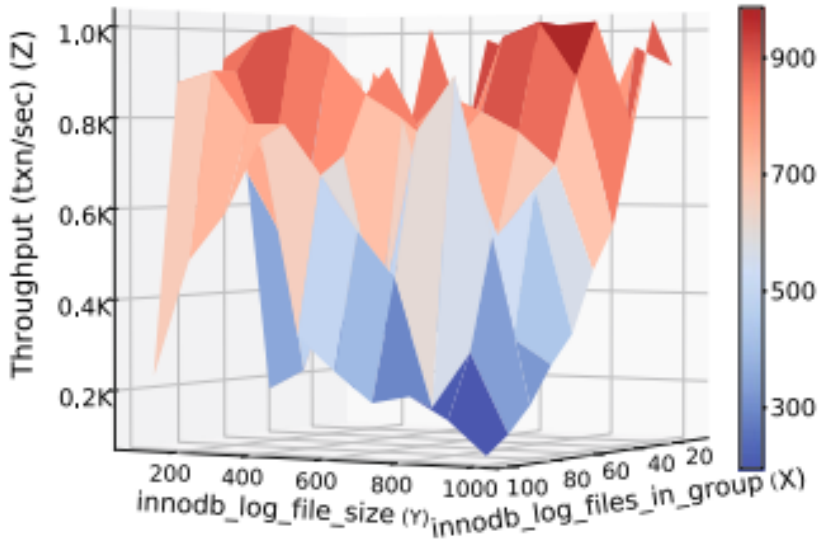
Product	Criteria 1	Criteria 2
A	3	7
B	6	5
C	8	7
D	10	11

Multi-objective optimization in Database Optimization

- Trade-offs in performance indicators
- More than one indicators to tune in database
- Ex) Throughput / latency, "WAF, SA, RATE, TIME" in RocksDB



(c) Knobs Increase

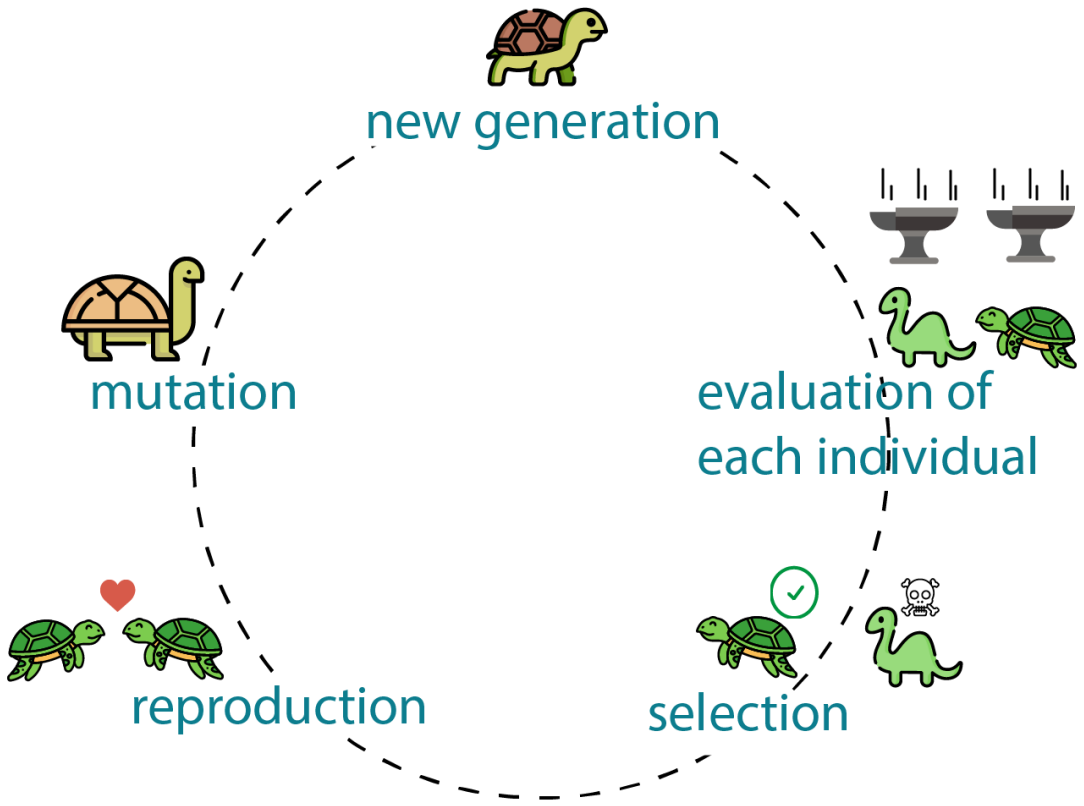


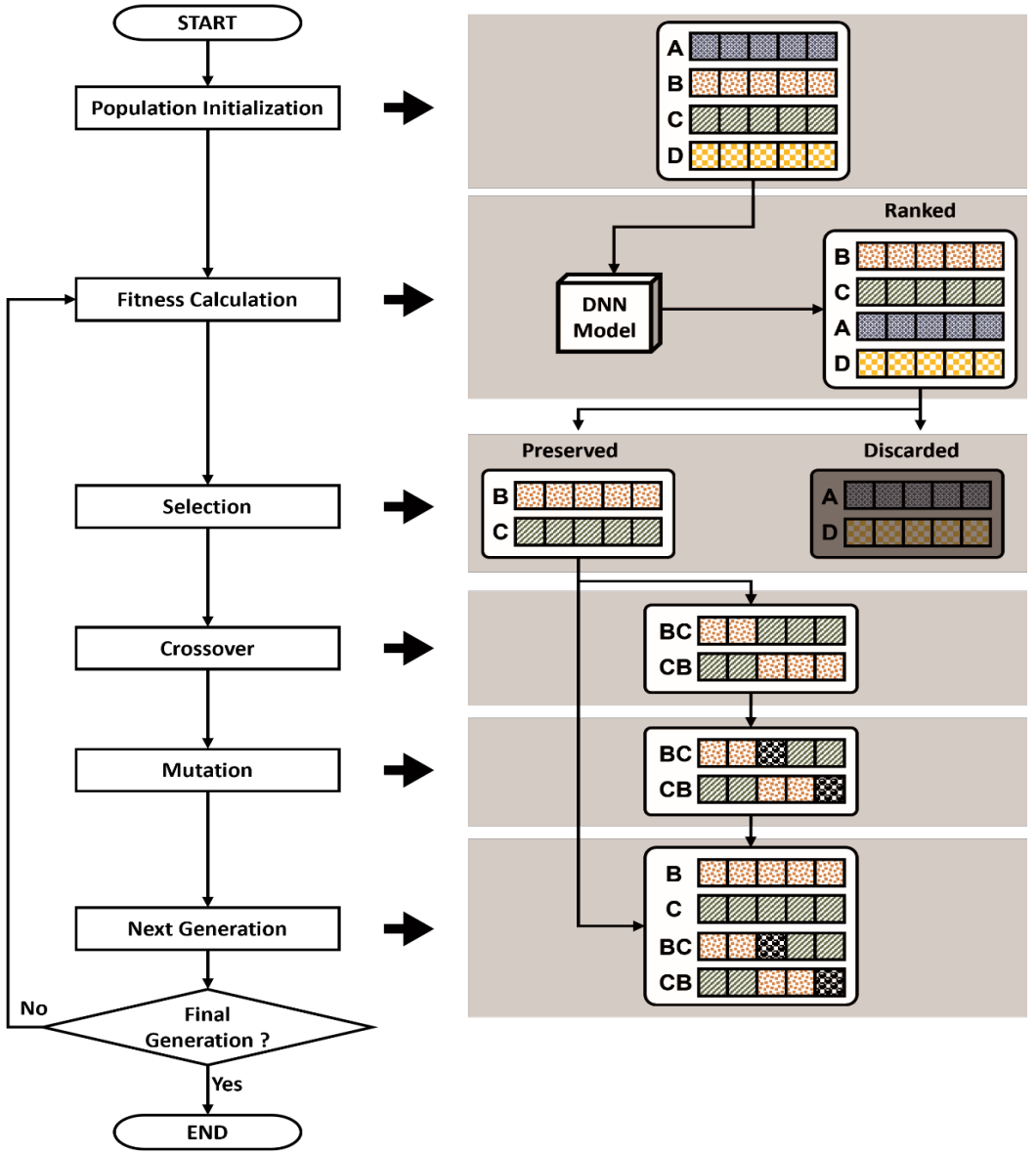
(d) Performance surface

Catalog

Genetic Algorithm

- Use a DNN model for performance prediction
- Use a score function to find an integrated indicator for 4 performance indicators(WAF, SA, RATE, TIME).





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- [2002] A Fast and Elitist Multiobjective Genetic Algorithm: NSGA-II
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- https://www.youtube.com/watch?v=9sXEBzI1R5Q (What's the Pareto frontier?)
- https://en.wikipedia.org/wiki/Multi-objective_optimization

Q & A

Thanks!