METAHEURISTICS

From Design to Implementation

Sections 5.4, 5.5 and 5.7

Section 5.4

Hybrid Metaheuristics with Machine Learning and Data Mining

Data Mining Techniques

Main Schemes of Hybridization

Data Mining Techniques

Data Mining Techniques

- Classification
  - Examining the attributes of a given instance to assign it to a predefined class
- Classification rule learners
  - Discovering a set of rules from the data that forms an accurate classifier
- Clustering
  - Partitioning the input data set into subsets (clusters), so that data in each subset share common aspects. The partitioning is often indicated by a similarity measure implemented by a distance
- Association rule learners
  - Discovering elements that occur in common within a given data set

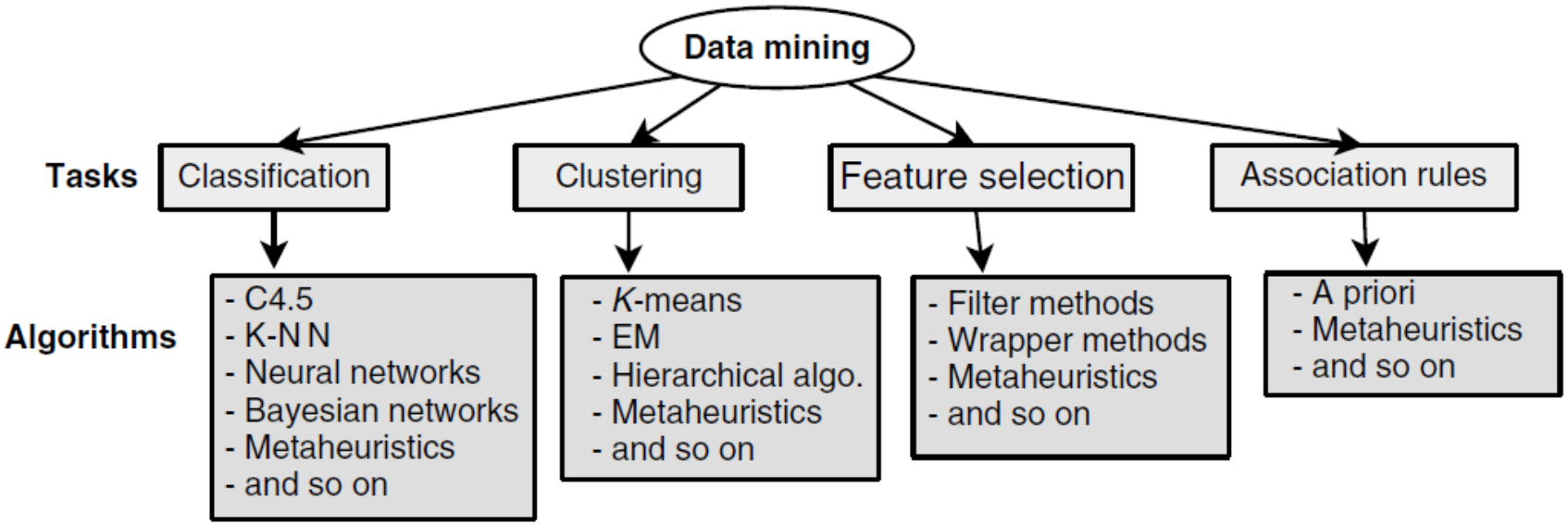

FIGURE 5.30 Some data mining tasks and associated algorithms.

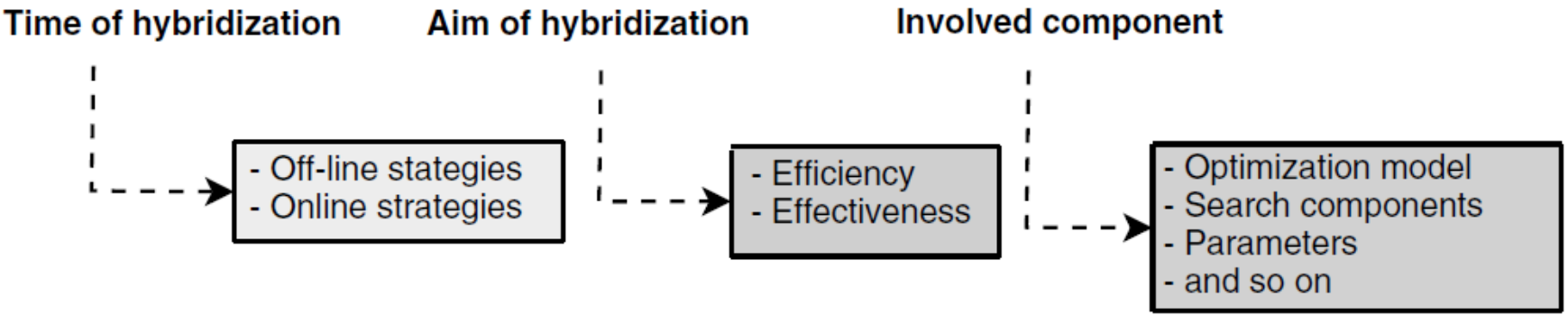

FIGURE 5.31 Some ways integrating knowledge into metaheuristics.

Main Schemes of Hybridization

Low-Level Relay Hybrid (LRH)

- Common in S-metaheuristics
- Optimization model
  - The extracted knowledge may be used to transform the target optimization model
- Parameter setting
  - Change the value of parameters dynamically during the search

Low-Level Teamwork Hybrids (LTH)

- Popular in P-metaheuristics
- Search components

FIGURE 5.32 Extracting knowledge from the history of the search and its use into search operators.

Low-Level Teamwork Hybrids (LTH)

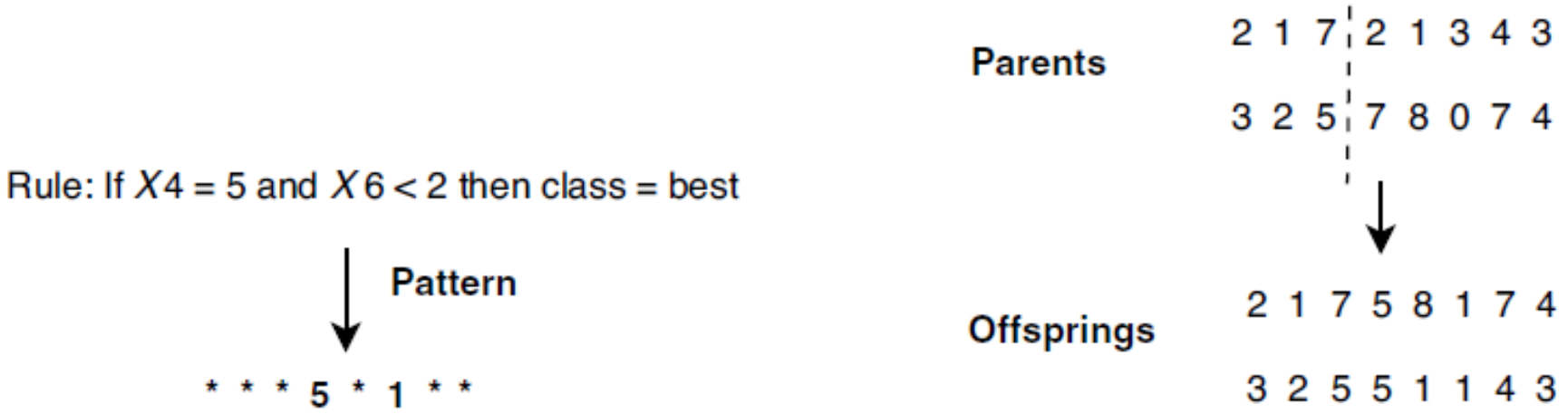

FIGURE 5.34 Crossover operator using the induced rule as a pattern. For instance, the extracted pattern (...5.1..) is included into the offsprings.

Low-Level Teamwork Hybrids (LTH)

- Parameter setting
  - Can be modified during the search
- Optimization model
  - Approximate with supervised classification algorithms
  - Reduce number of solutions to evaluate

Low-Level Teamwork Hybrids (LTH)

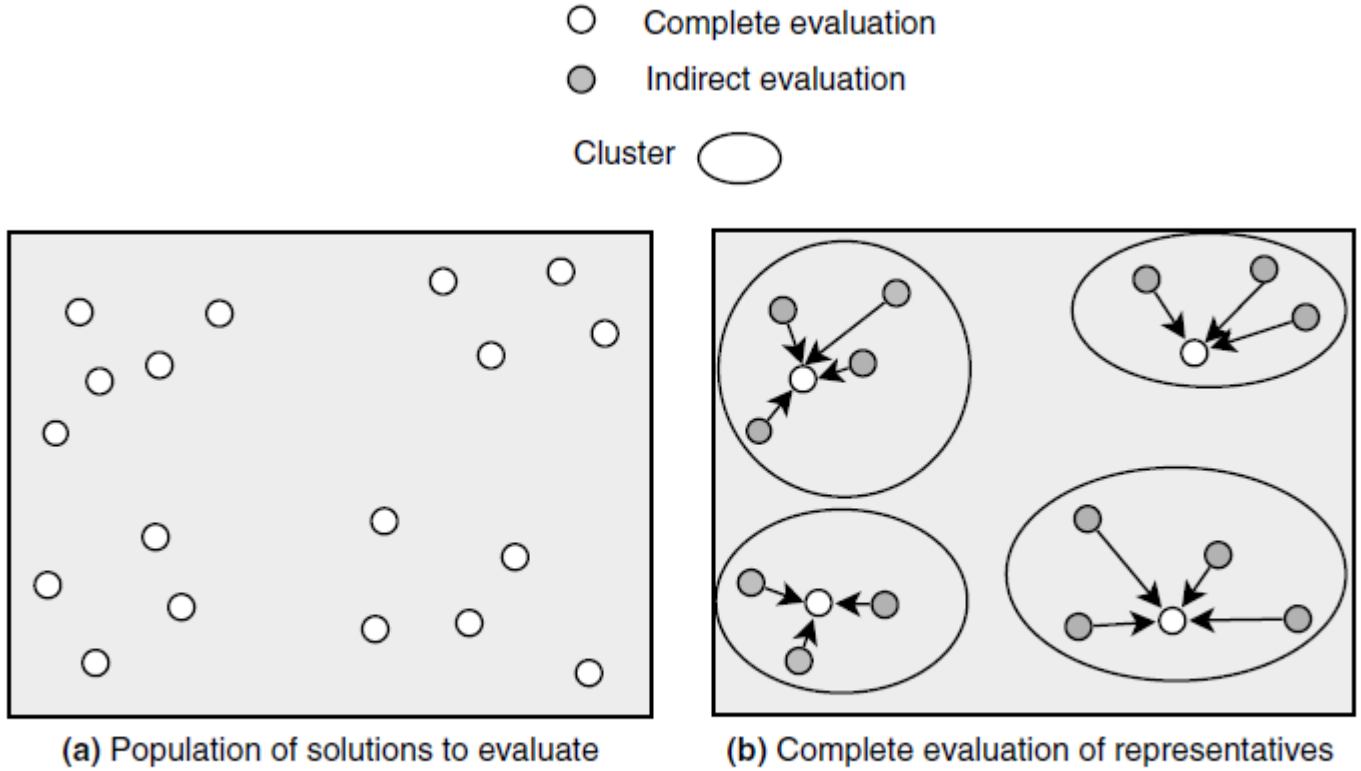

FIGURE 5.35 Evaluating a solution by using the representative of its cluster (fitness imitation).

High-Level Relay Hybrid (HRH)

- Search components
  - Data mining applied to the initialization of solutions
- Parameter setting
- Optimization model
  - Data mining to decompose the optimization problem handled by a metaheuristic

High-Level Relay Hybrid (HRH)

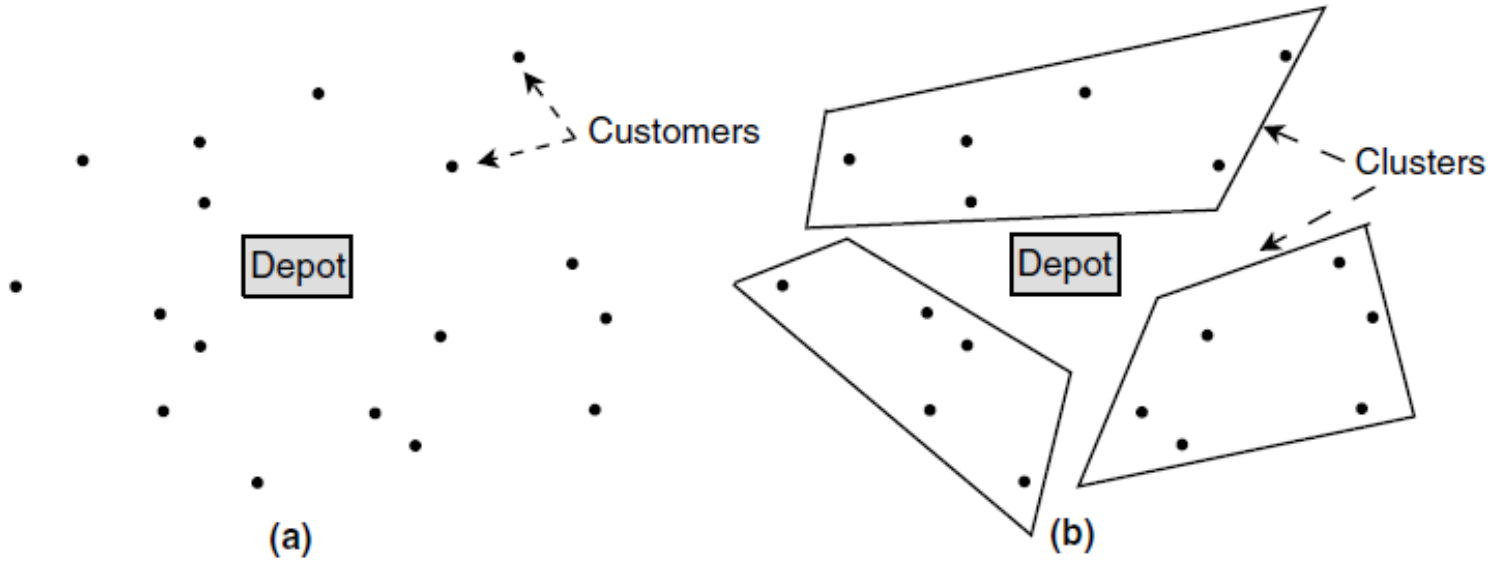

FIGURE 5.37 Decomposing an optimization problem using clustering algorithms. (a) Instance of the VRP problem. (b) Clustering the customers and then applying a TSP metaheuristic to the subproblems.

High-Level Teamwork Hybrid (HTH)

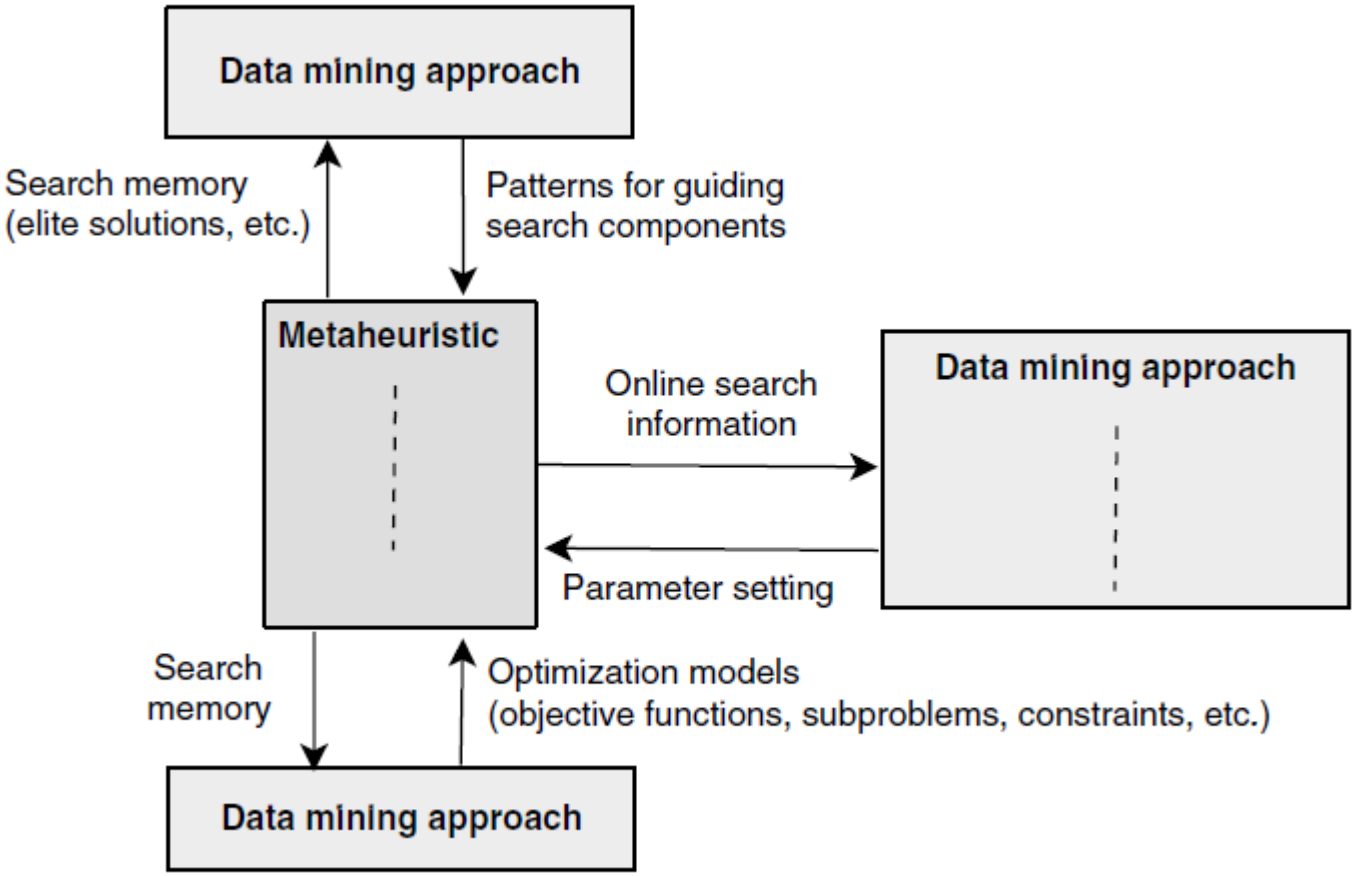

FIGURE 5.39 Online knowledge extraction and its use by a metaheuristic.

Section 5.5

Hybrid Metaheuristics for Multiobjective Optimization

- Combining Metaheuristics for MOPs
- Combining Metaheuristics with Exact Methods for MOPs
- Combining Metaheuristics with Data Mining for MOPs

Combining Metaheuristics for MOPs

Low-Level Relay Hybrids (LRH)

- Represents multiobjective hybrid metaheuristics in which a given metaheuristic is embedded into a S-metaheuristic
- Few examples belong to this class

Low-Level Teamwork Hybrids (LTH)

- S-metaheuristics embedded into P-metaheuristics

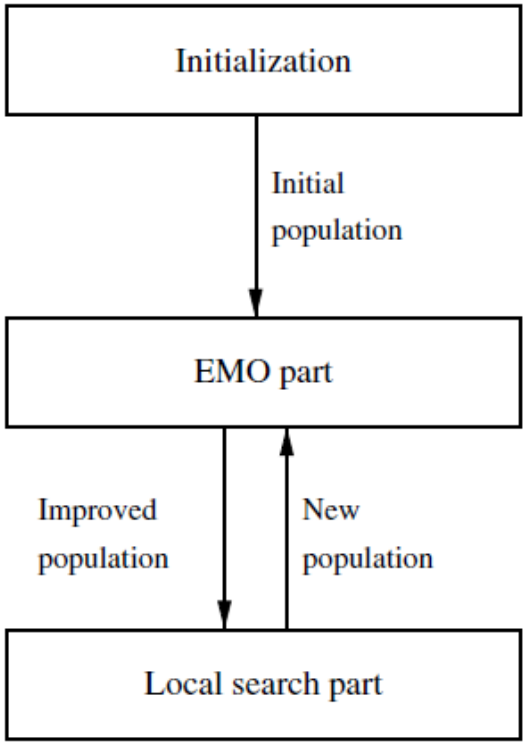

FIGURE 5.40 Generic form of multiobjective genetic local search algorithms (MOGLS).

High-Level Relay Hybrids (HRH)

- Multiobjective metaheuristics are executed in a sequence
  - Use a P-metaheuristic to approximate the Pareto set
  - Intensify it by using a S-meteheuristic

High-Level Teamwork Hybrids

- Several multiobjective metaheuristics performing a search in parallel and cooperating to find a Pareto set approximation

Combining Metaheuristics with Exact Methods for MOPs

Main Idea

The main interest is to adapt the classical monoobjective hybrids to multiobjective optimization

Combining Metaheuristics with Data Mining for MOPs

Metaheuristics + Data Mining = <3

- Search operators
  - Recombination operators in P-metaheuristics, neighborhoods in S-metaheuristics
- Parameter setting
  - Efficiency of an operator may change during the execution of the algorithm

Example of approach:

Applying clustering algorithms on the archive

Section 5.7

Conclusions and Perspectives

Conclusions and Perspectives

- Hybrid metaheuristics represent the most efficient algorithms for difficult problems
- Designing a metaheuristic can be reduced to selecting the most suited search components and combining them
- It is difficult to set the new parameters introduced by hybridization