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5.5.3 Population-Based Strategies on Production Scheduling

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Population-based metaheuristics are optimization methods that work with a set of candidate solutions, rather than just one. These algorithms evolve the population over time by sharing information among solutions and using strategies inspired by nature or social behavior. They are especially useful in complex production scheduling problems, where multiple objectives or large solution spaces make exact methods impractical.

Genetic Algorithms (GA) represent the most widely adopted population-based approach in production scheduling. Each solution is represented as a chromosome, usually encoding the sequence or assignment of jobs. The algorithm improves solutions over generations using three main steps: selection, where better solutions are more likely to reproduce; crossover, where two parent solutions combine to create new ones; and mutation, which introduces small random changes to keep the population diverse and avoid getting stuck in poor local solutions. GA is flexible and effective across many types of scheduling problems.

Particle Swarm Optimization (PSO) offers an alternative population-based paradigm inspired by social behavior in bird flocks. In the scheduling context, each particle represents a potential schedule moving through the solution space guided by its personal best experience and the swarm's collective knowledge. This allows the swarm to explore new areas while gradually focusing on promising regions. PSO is particularly useful for problems where the search space can be represented continuously or as job sequences.

These methods are also well-suited for multi-objective problems, where several goals—such as minimizing total processing time, reducing delays, or balancing machine usage—must be optimized at once. Population-based strategies can generate a variety of trade-off solutions, helping decision-makers choose the one that best fits their current needs. Because of their flexibility and ability to handle large and complex problems, population-based metaheuristics have become essential tools in modern production

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