

# PA184 - Heuristic Search Methods

## Lecture 8 – Hybrid Heuristics

- Hybrids of SA, TS and GA
- Types of Hybrid Heuristics
- Examples of Hybrid Heuristics

### Learning outcomes:

- Understand the principles and motivations for hybrid heuristics.
- Recognise the different ways in which hybrid heuristics have been designed and classified.
- Describe the architecture and rationale for some examples of hybrid heuristic methods.

# Hybrids of SA, TS and GA

Three classic and very [representative examples of heuristic and evolutionary search](#) procedures are:

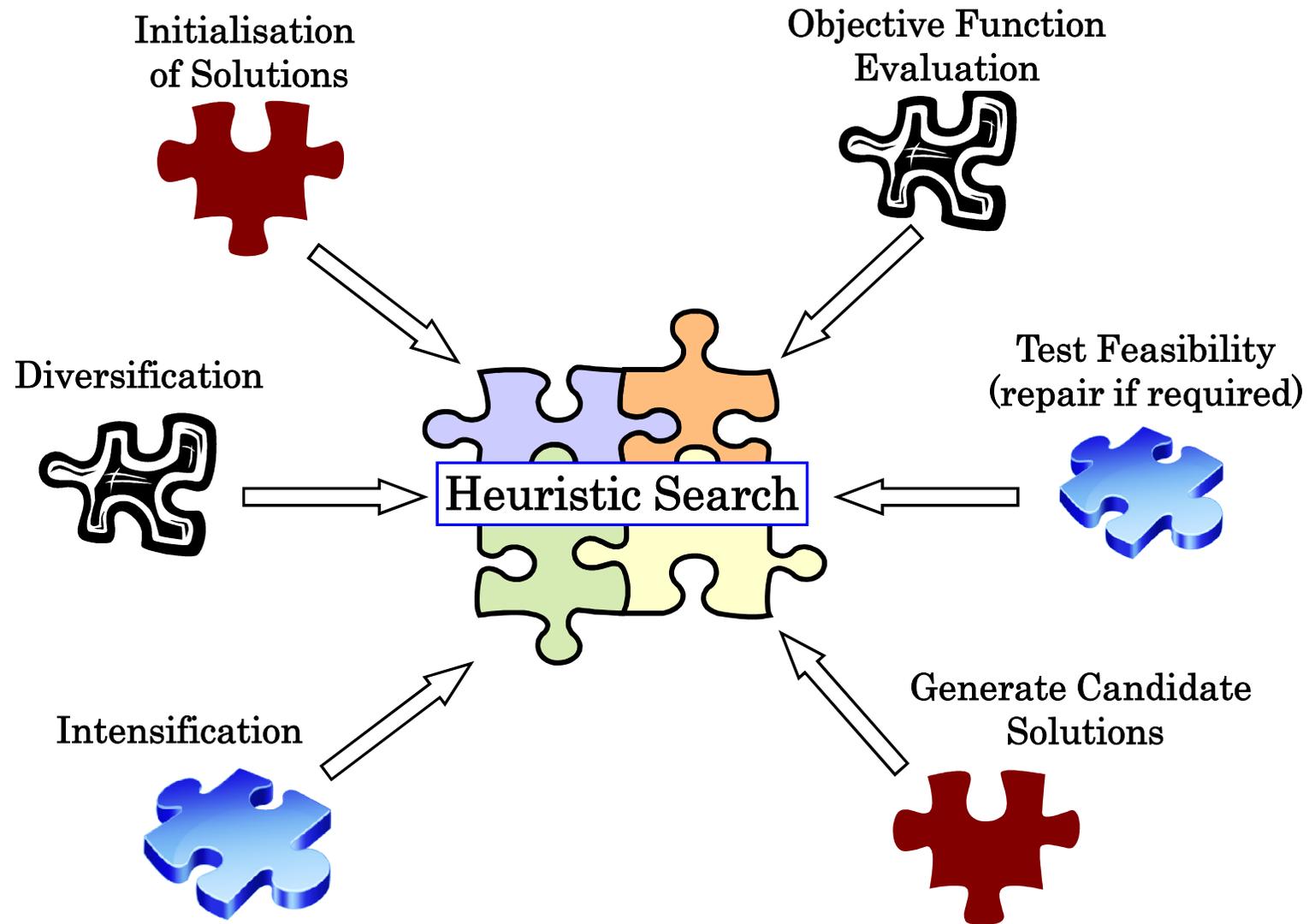
- Simulated Annealing (SA)
- Tabu Search (TS)
- Genetic Algorithms (GA)

Combinations of the above techniques were among the first hybrid heuristic algorithms proposed in the literature. A good example is the hybrid approach proposed in:

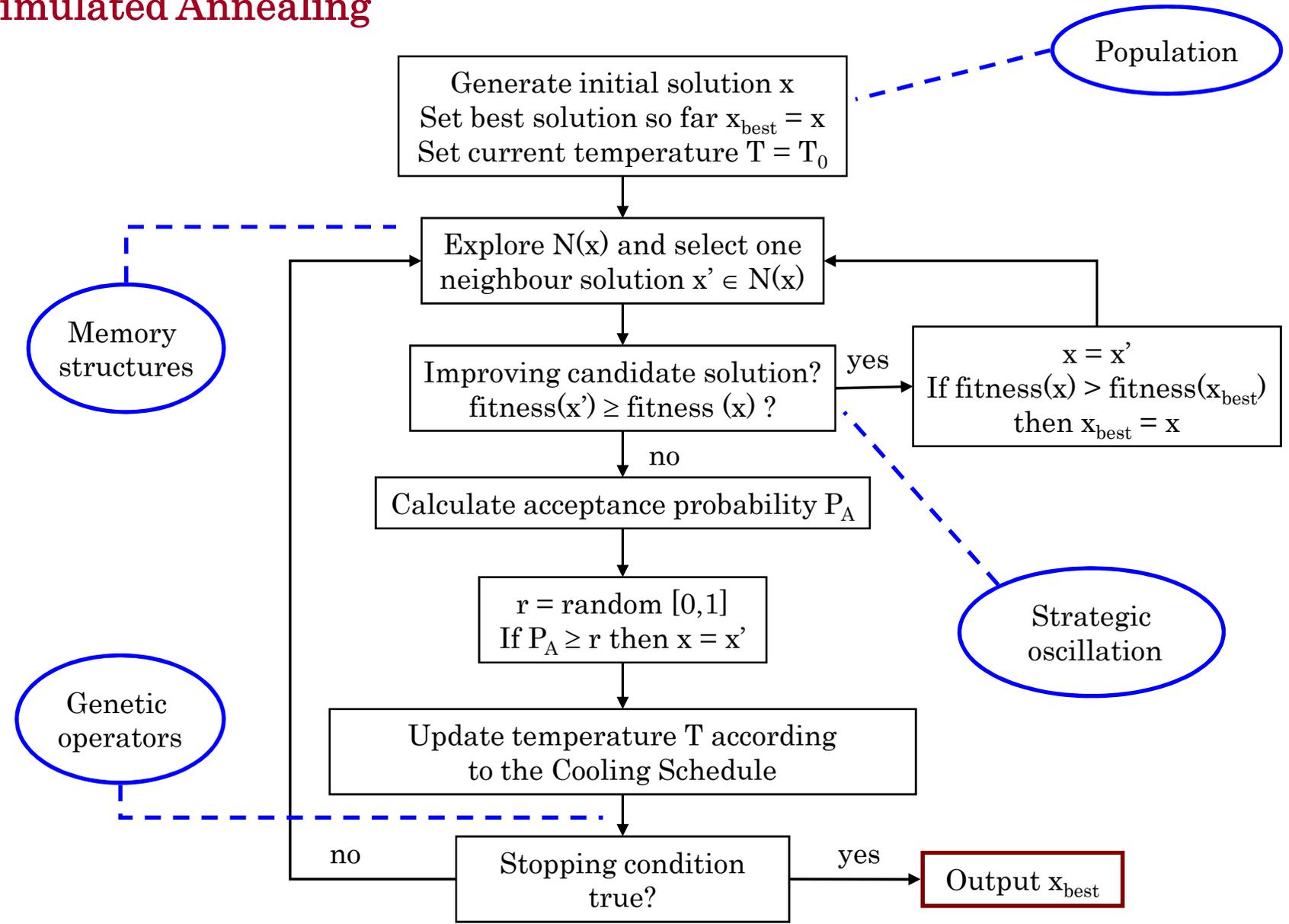
Bennett L. Fox. Integrating and accelerating tabu search, simulated annealing and genetic algorithms. *Annals of operations research*, Vol. 41, pp. 47-67, 1993.

Typically, hybrid algorithms seeks to [combine the strengths form different methods](#) while counteracting their weaknesses and produce a method that has the [key strategies needed in heuristic search](#).

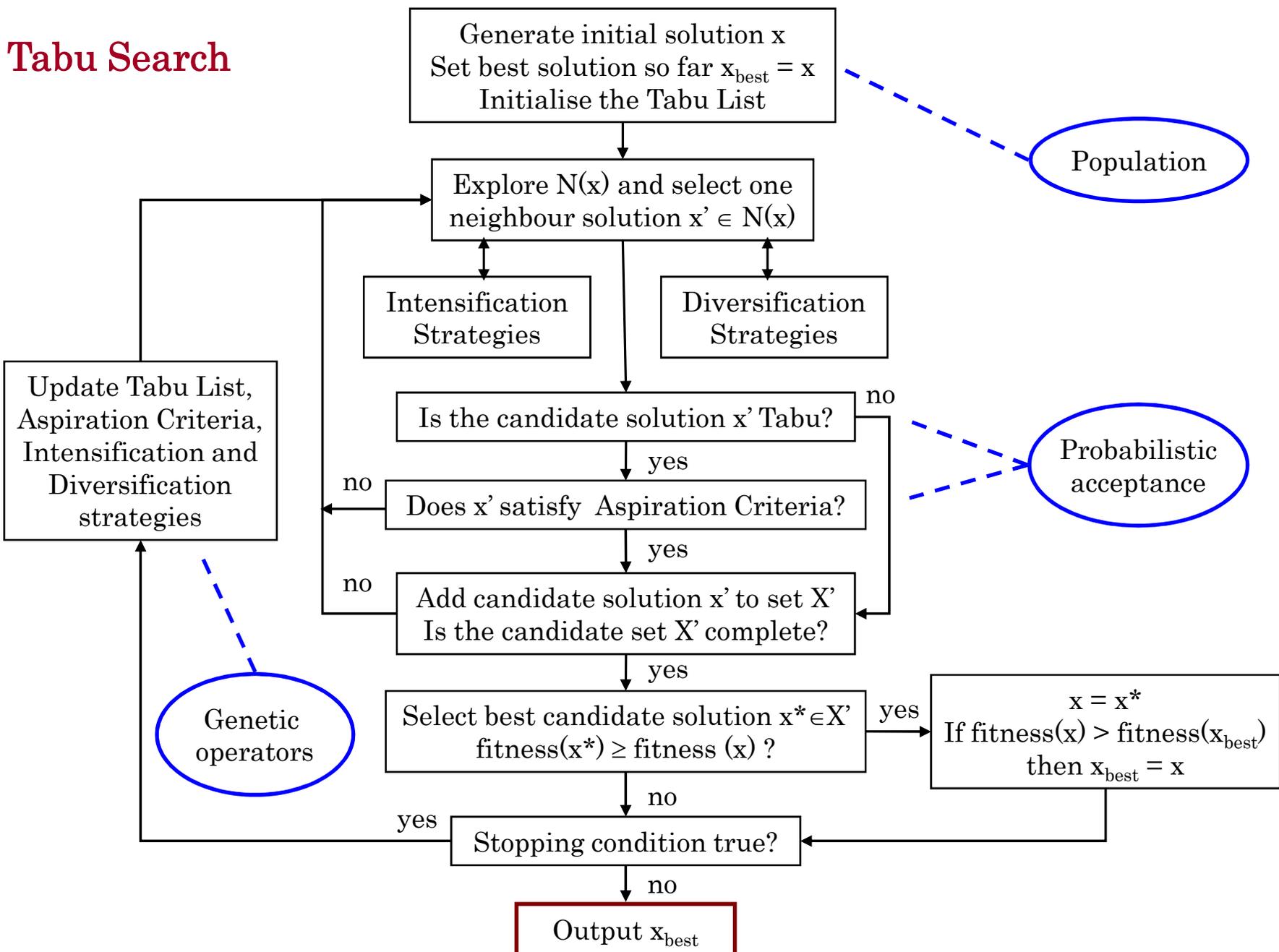
## Key strategies needed in heuristic search



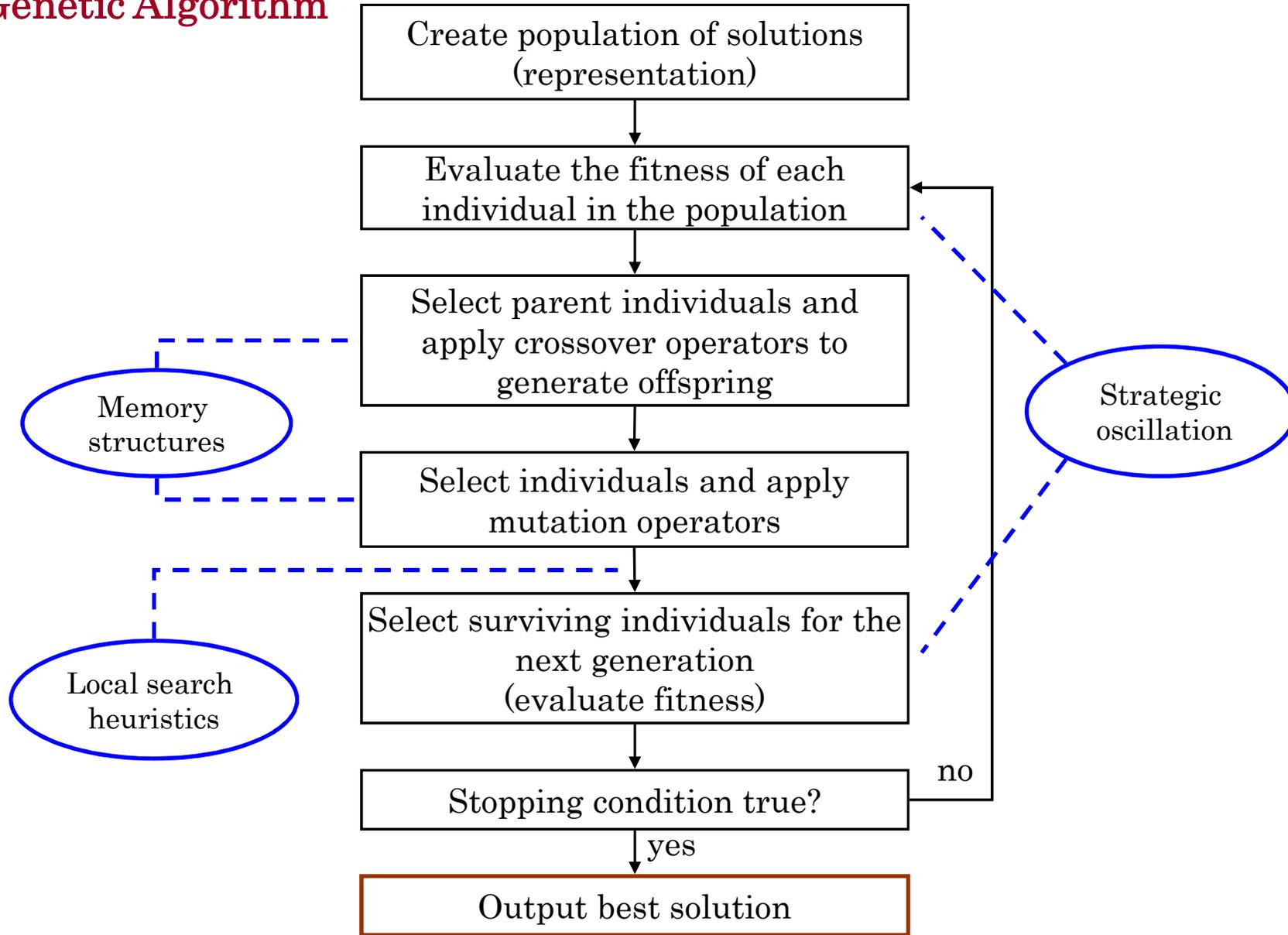
# Simulated Annealing



# Tabu Search

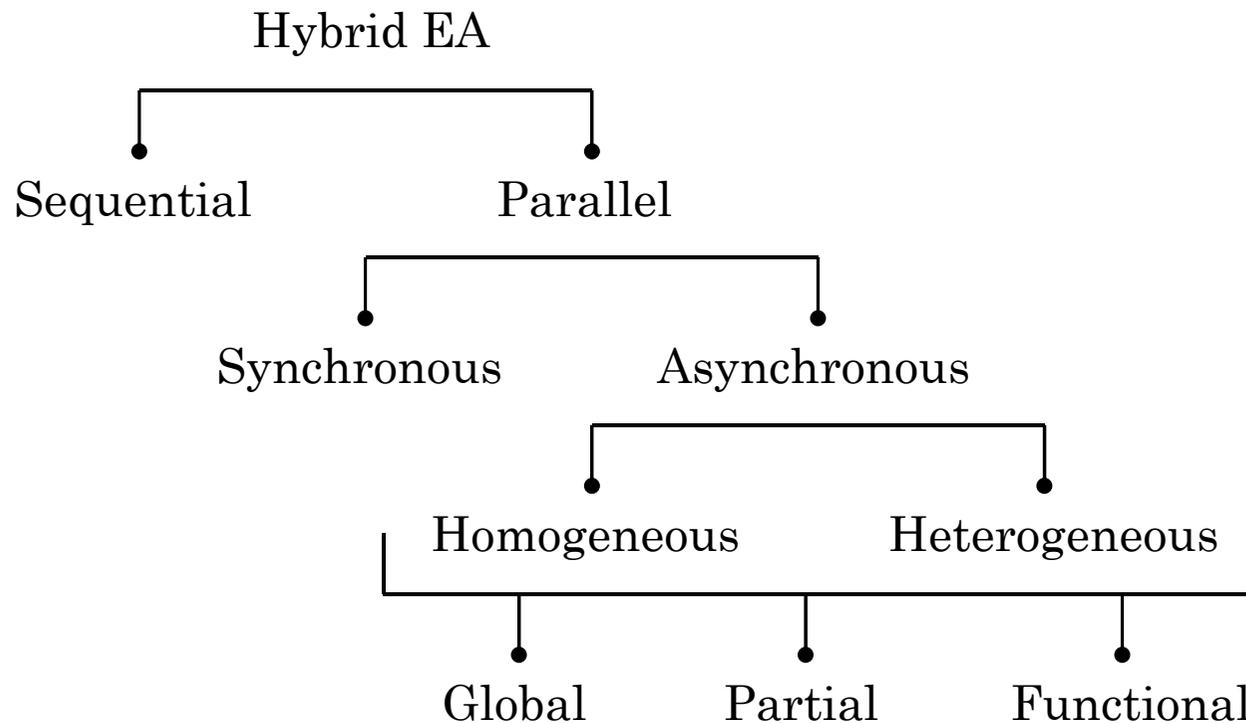


# Genetic Algorithm

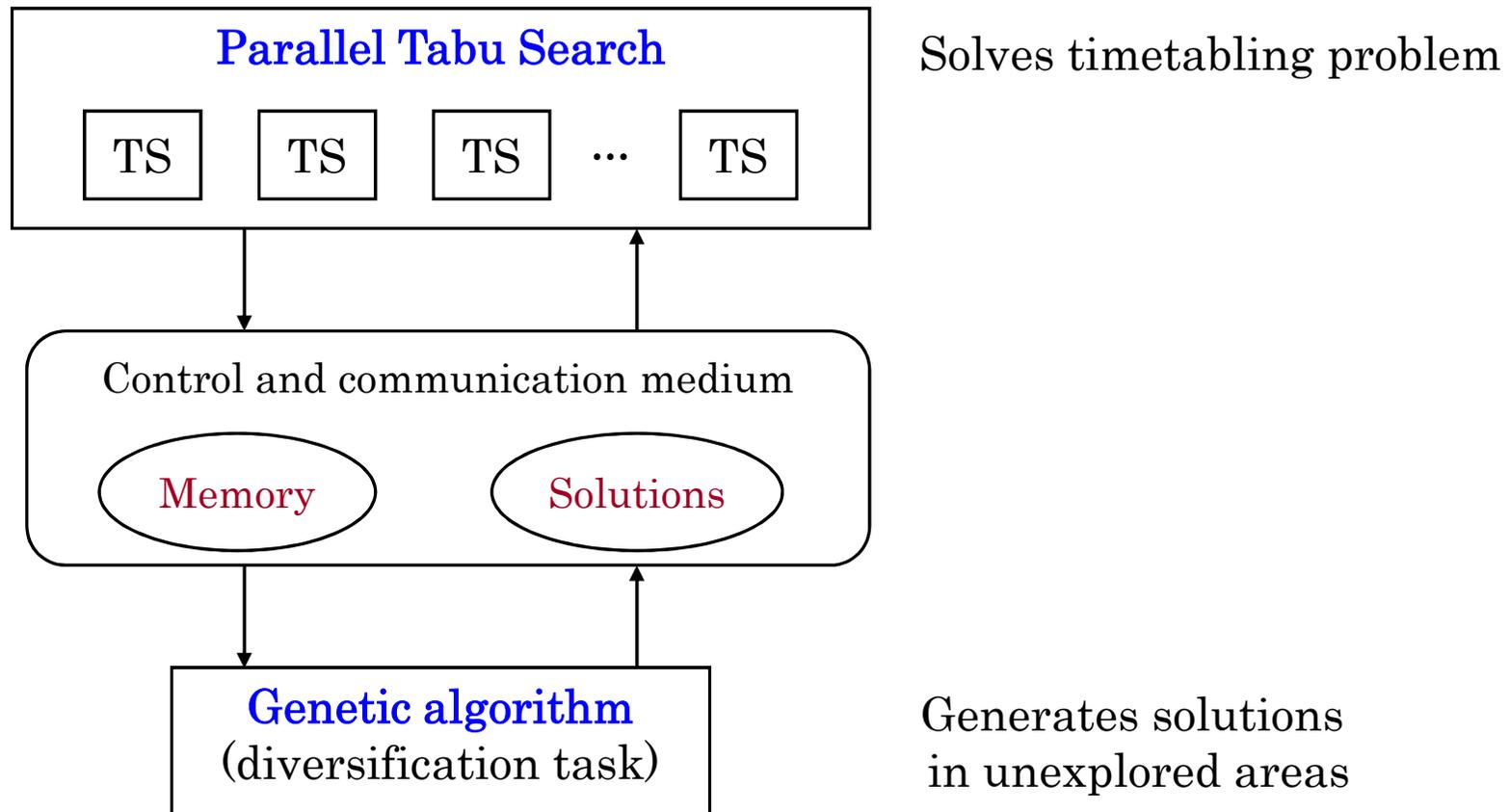


# Types of Hybrid Heuristics

Preux and Talbi (1999) proposed the following [classification of hybrid evolutionary algorithms](#).

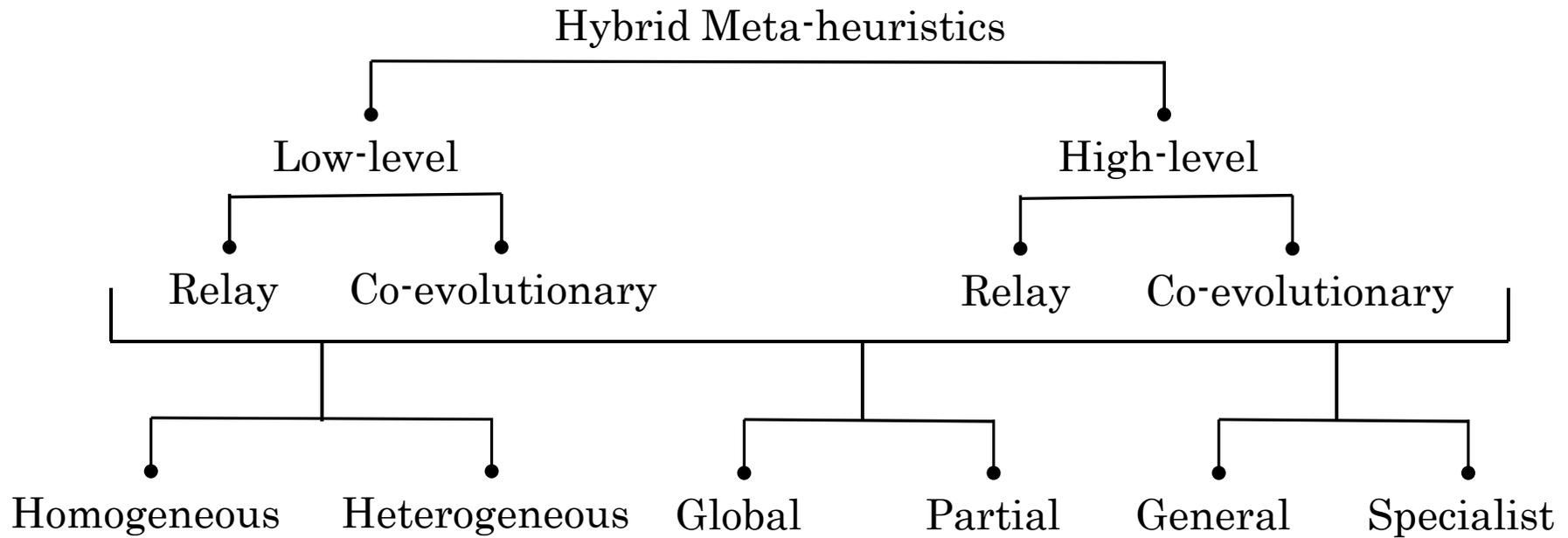


Example 8.1 A parallel asynchronous heterogeneous functional hybrid algorithm in the classification of Preux and Talbi (1999) can be illustrated as follows.

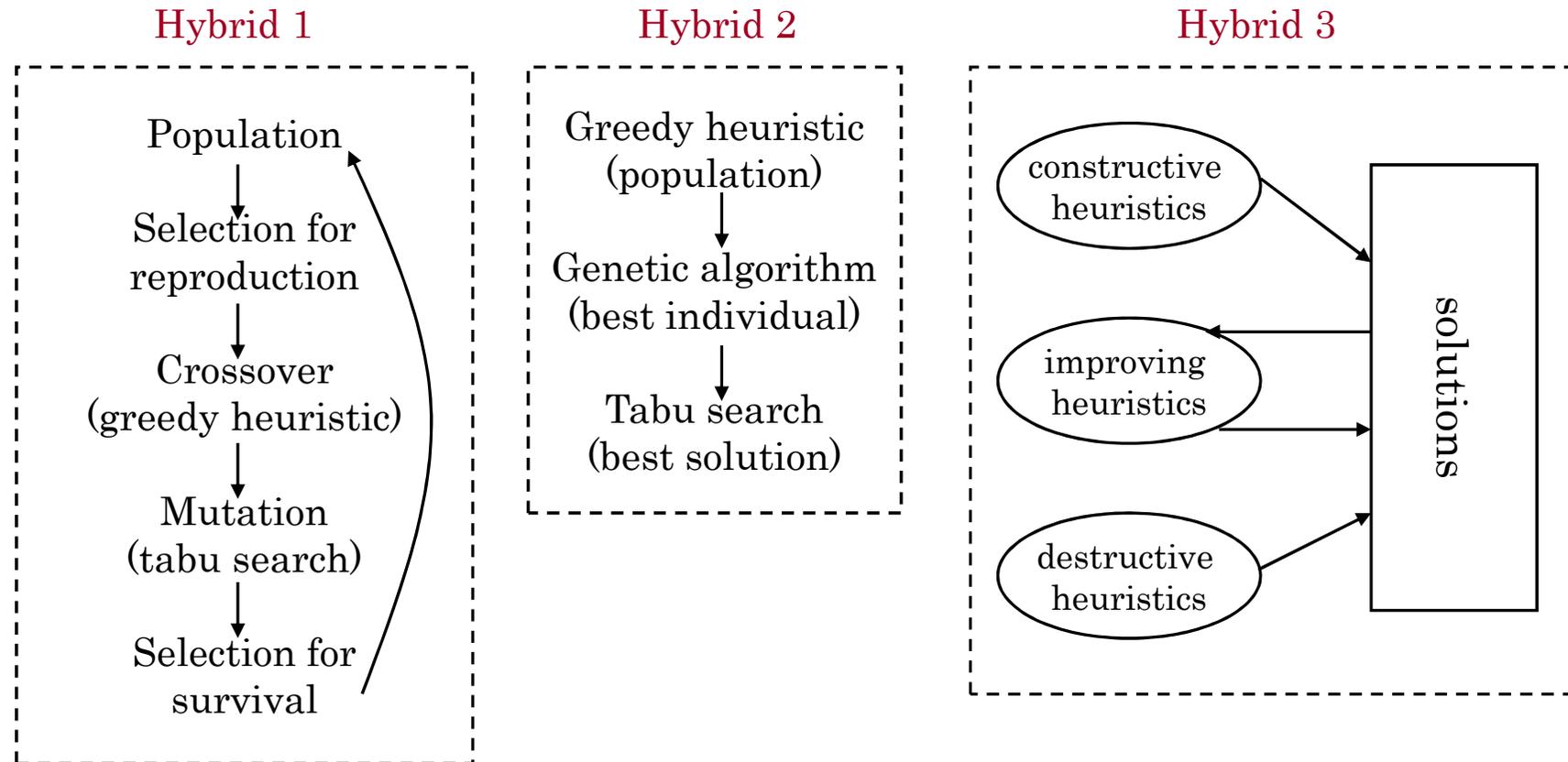


**Note:** these algorithms are also called cooperative meta-heuristics in recent literature.

Later, Talbi (2002) proposed a similar [classification of hybrid meta-heuristics](#).



Example 8.2 The following are some hybrid heuristics that have been proposed in the literature and can be classified according to the above taxonomies.



# Examples of Hybrid Heuristics

The number of articles and books describing some sort of hybrid algorithm involving heuristic methods is very large.

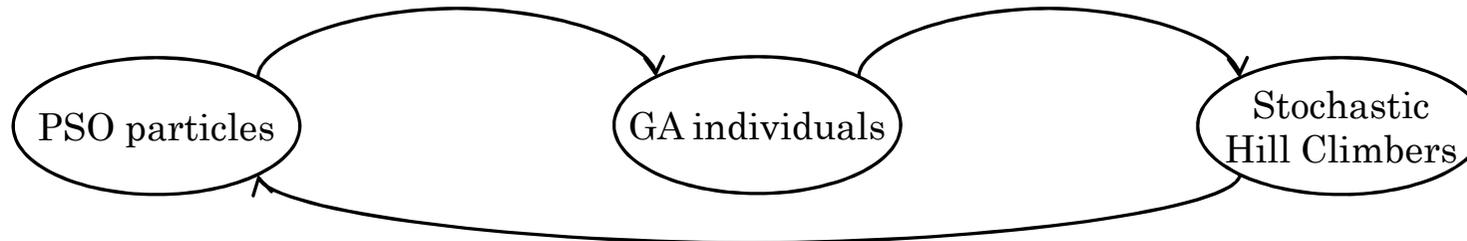
Because heuristic methods are ‘general’ search approaches, they are almost no limits in the way hybrid algorithms can be conceived, depending almost entirely on the designer’s ability.

These are just two examples of simple hybrid meta-heuristic methods:

Thiemo Krink, Morten, Lovbjerg. The lifecycle model: combining particle swarm optimisation, genetic algorithms and hill climbers. In: Proceedings of the 7th International Conference on Parallel Problem Solving from Nature (PPSN VII), LNCS, Vol. 2439, pp. 621-630, Springer-Verlag, 2002.

Dario Landa-Silva, Joe Henry Obit. Evolutionary Non-Linear Great Deluge for University Course Timetabling. In: Proceedings of the 2009 International Conference on Hybrid Artificial Intelligence Systems (HAIS 2009). LNAI, Vol. 5572, pp. 269-276, Springer-Verlag, 2009.

Example 8.3 The lifecycle model: combining particle swarm optimisation, genetic algorithms and hill climbers



### PSO Stage

$X_i$  is the particle's position  
 $V_i$  is the particle's velocity  
 $P_i$  is the particle's best  
 $P_g$  is the global best position  
 $X_i = X_i + V_i$   
 $V_i$  = calculated based on  
Inertia, current position,  
particle's best, global best  
position and random factors.

### GA Stage

Binary tournaments  
Arithmetic crossover  
Non-uniform mutation  
Elitism

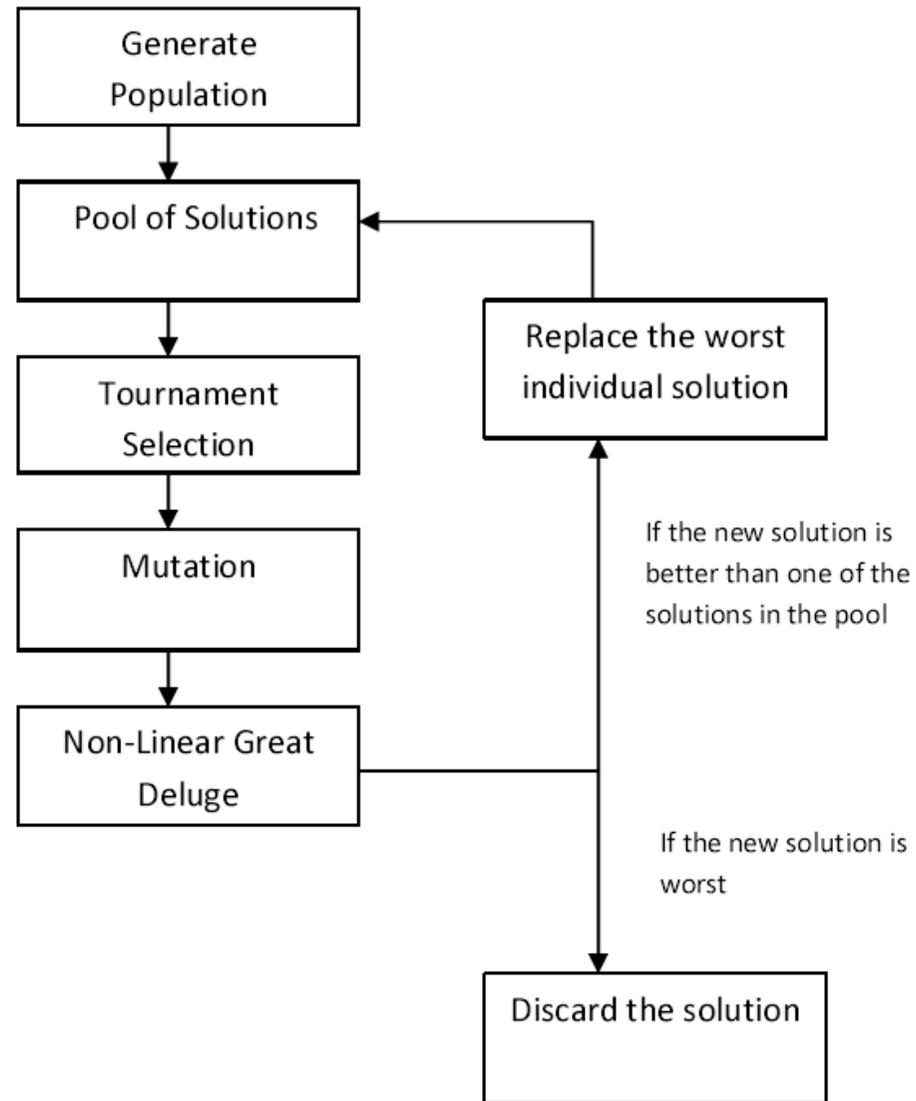
### Stochastic HC Stage

Neighbour  $X_n$  replaces  $X_c$   
with some probability given  
by:

$$p = 1/(1+\exp((f(X_n)-f(X_c))/T))$$

where  $T$  is a constant  $\approx 10$

Example 8.4 An evolutionary non-linear great deluge.



## Example 8.5 Squeaky wheel optimisation (SWO) approach

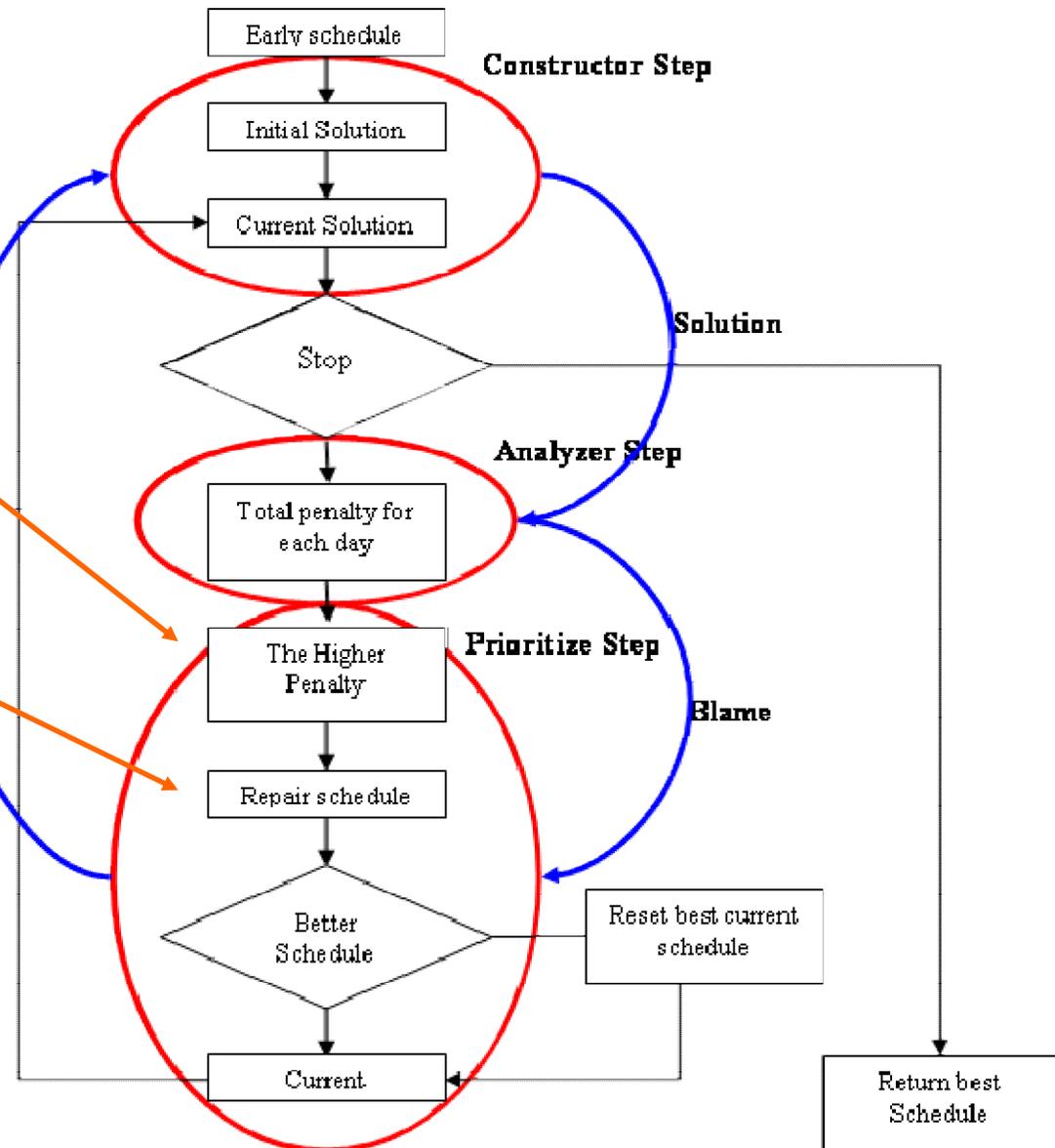
Prioritise penalised  
schedule days

- badly scheduled days will  
be repaired first

Neighbourhood moves to  
repair schedule

Strategies implemented:

- best of x swaps in an individual schedule
- multi-neighbourhood search to select best move according to violations
- accept non-improving moves as in Great Deluge



## Additional Reading

Bennett L. Fox. *Integrating and accelerating tabu search, simulated annealing and genetic algorithms*. Annals of operations research. 41, 47-67, 1993.

Fred Glover, LJames P. Kelly, Manuel Laguna. *Genetic algorithms and tabu search: hybrids for optimization*. Computers and operations research, 22(1), 111-134, 1995.

Ph. Preux, E.-G. Talbi. *Towards hybrid evolutionary algorithms*. International Transactions in Operational Research, 6, 557-570 , 1999.

E.-G. Talbi. *A taxonomy of hybrid metaheuristics*. Journal of heuristics, 8, 541-564, 2002.

Günther R. Raidl. *A unified view of hybrid metaheuristics*. In; Proceedings of the 3<sup>rd</sup> International Workshop on Hybrid Metaheuristics (HM 2006), LNCS, Vol. 40-30, pp. 1-12, 2006.