A Generic Framework for Local Search : Application to the Sudoku Problem

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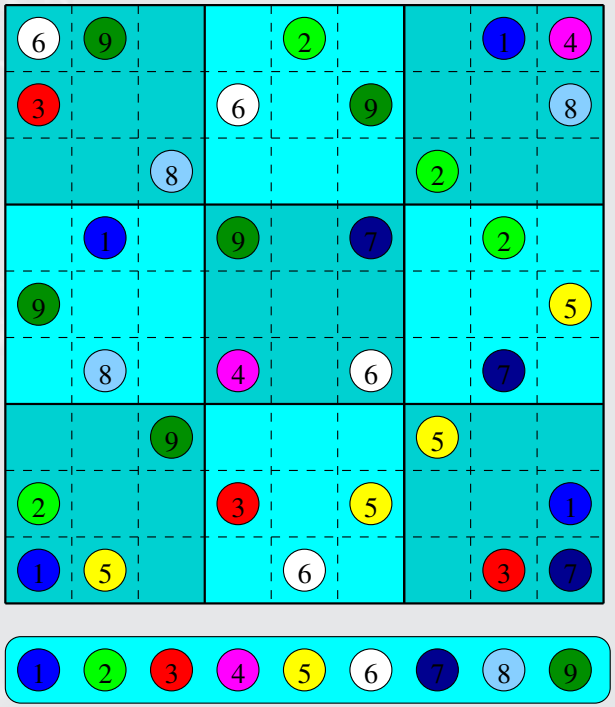
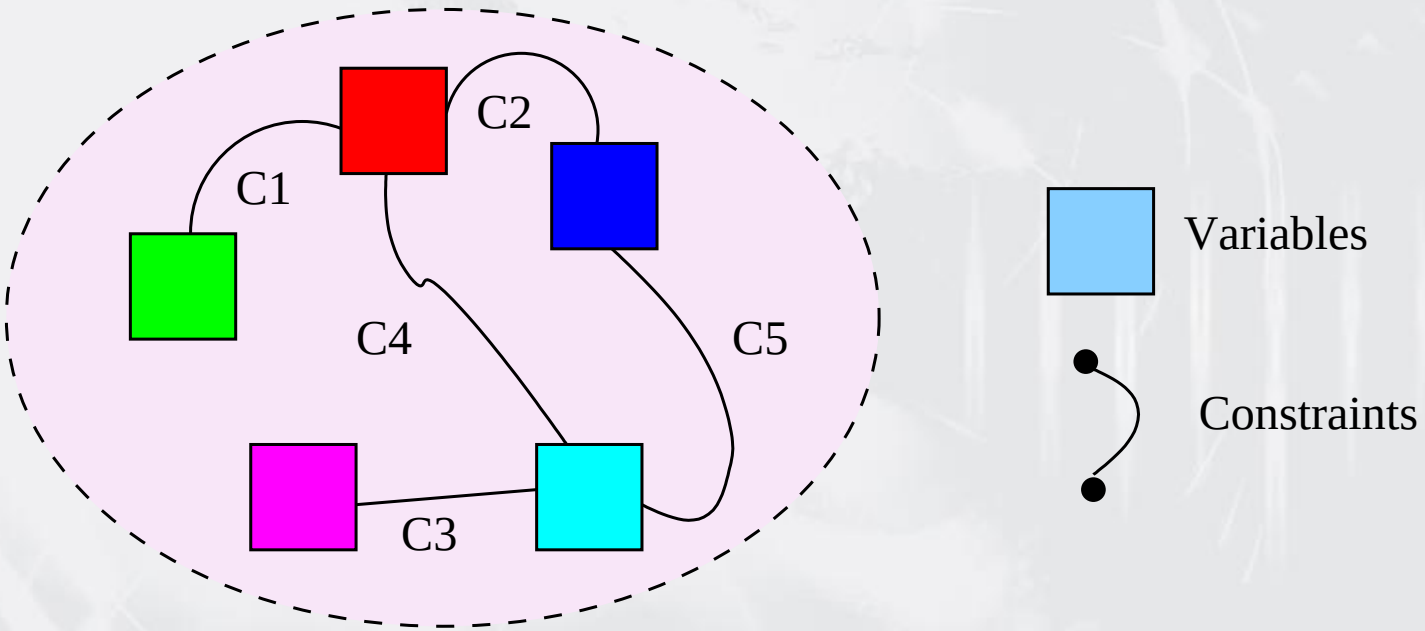
Outline

- Local search for solving CSP
- A framework for local search techniques
- Generic Iteration Algorithm with reduction functions
- Some results for the sudoku problem
- Conclusion



Constraint satisfaction Problem (CSP)



Local search (1)

Definition :

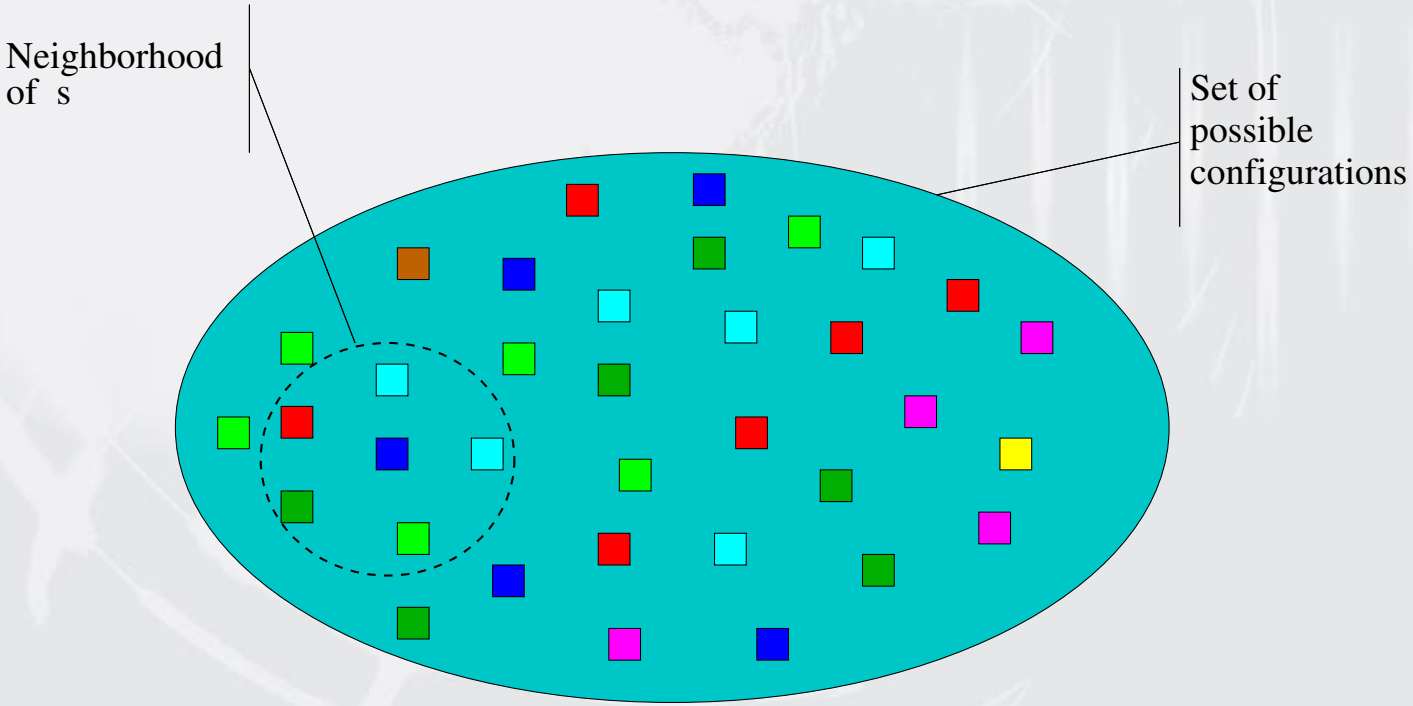
- Explore a $D_1 \times D_2 \times \cdots \times D_n$ search space
- Move from neighbor to neighbor thanks to an evaluation function
  - Intensification
  - Diversification

Properties :

- focus on some “promising” parts of the search space
- does not answer to unsat. problems
- no guaranteed
- “fast” to find a “good” solution

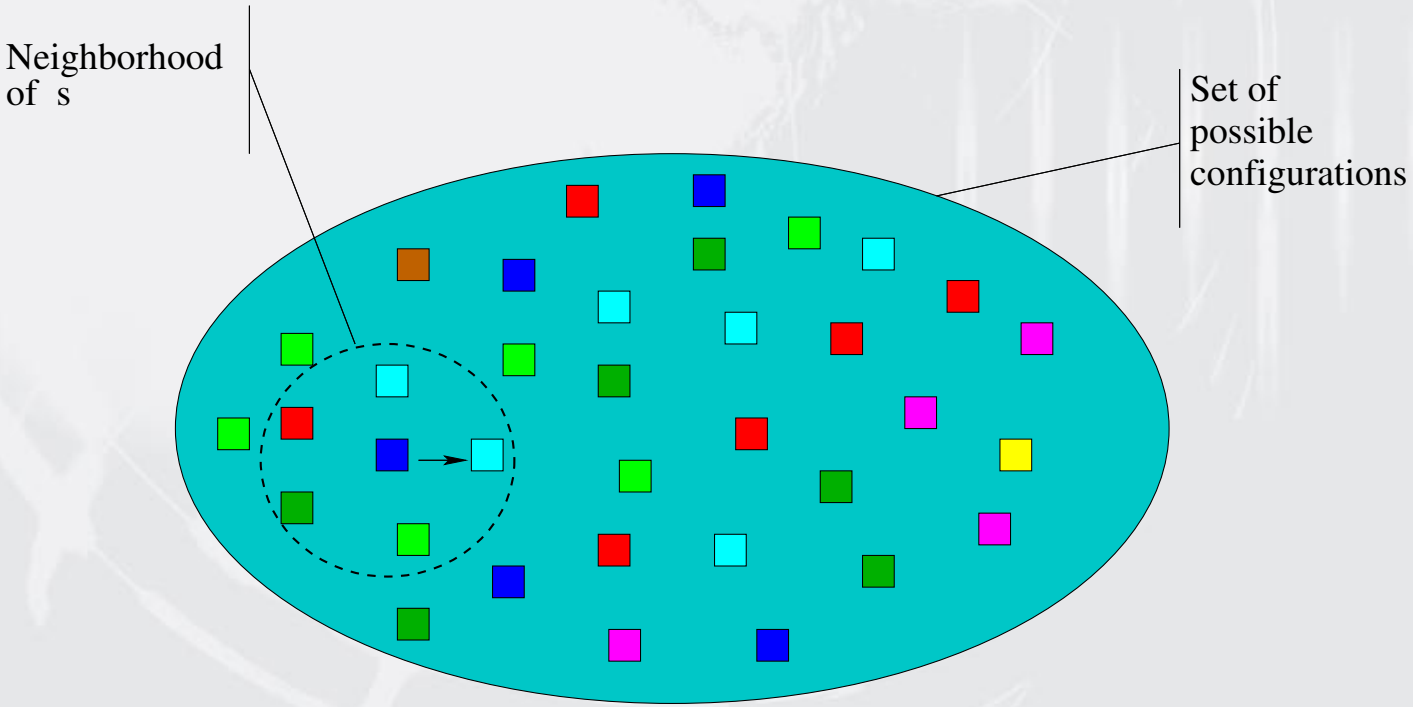
Local search (2)

- Search space : set of possible configurations
- Tools : neighborhood and evaluation function



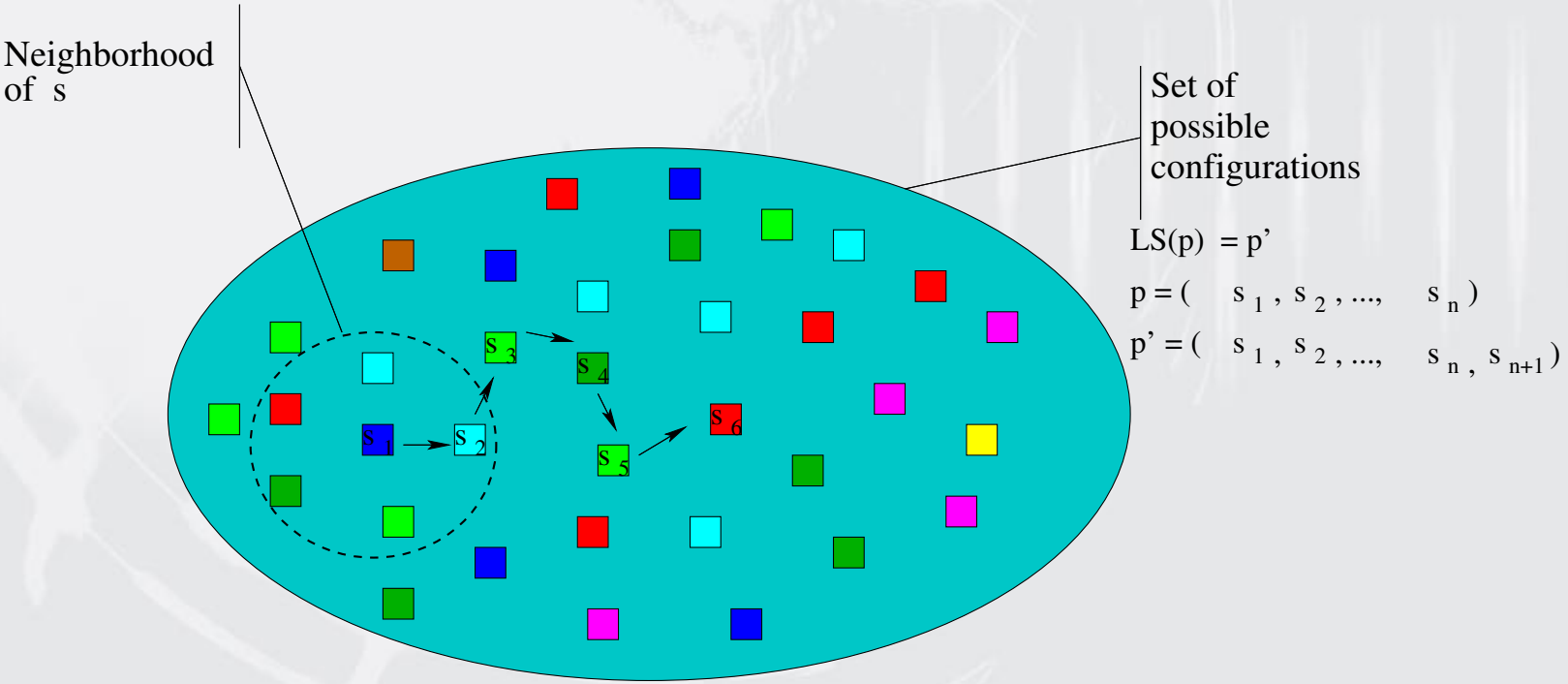
Local search (3)

- Search space : set of possible configurations
- Tools : neighborhood and evaluation function



Local search (4)

- Search space : set of possible configurations
- Tools : neighborhood and evaluation function



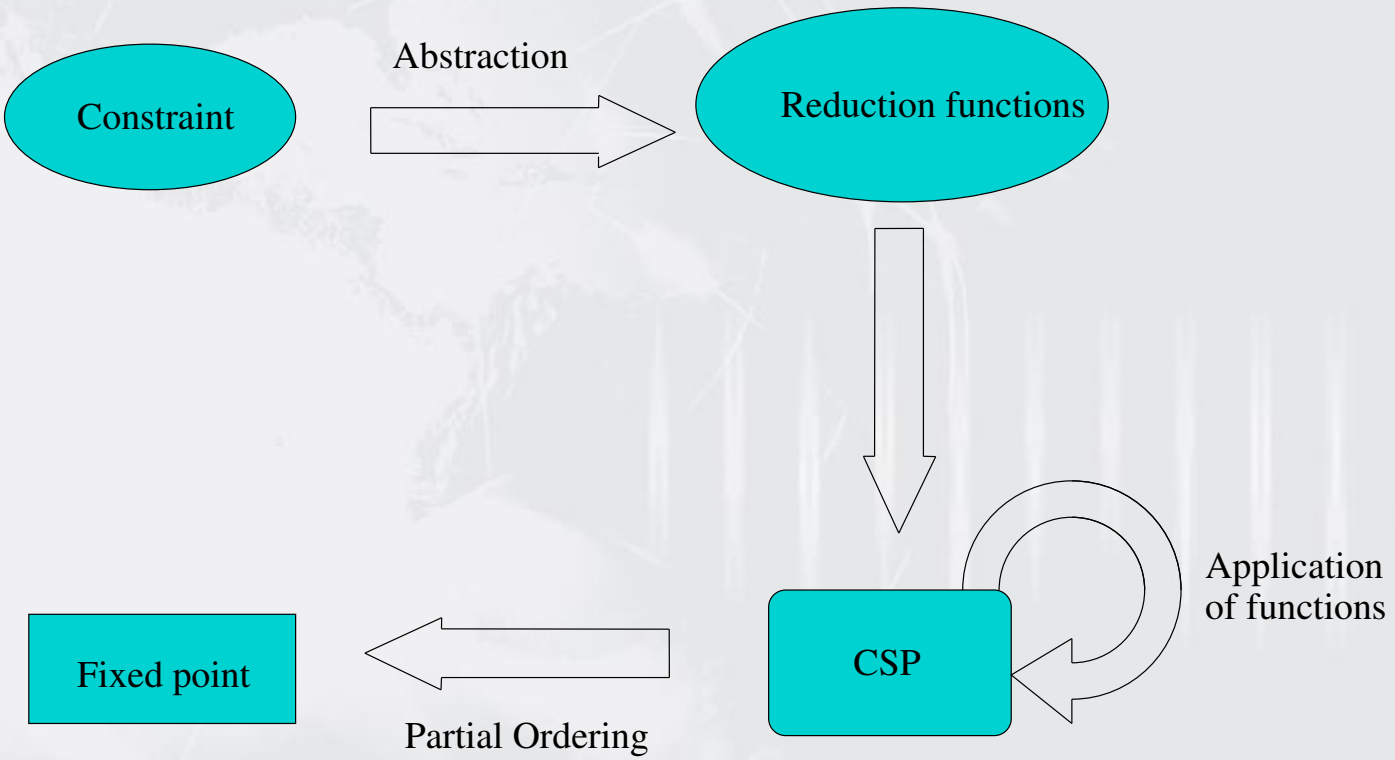
A framework for local search techniques

- Idea :
  - Fine grain control
  - More strategies
- Technique :
  - Decomposing local search resolution into basic functions
  - Adapting chaotic iterations

Our Purpose :

- Use of an existing theoretical model for CSP solving
- Definition of the solving process

Abstract Model K.R. Apt [CP99]

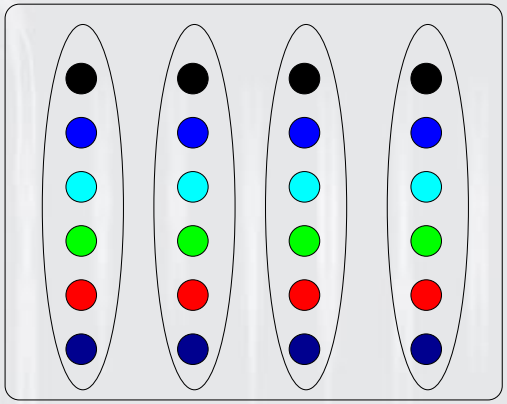


A Generic Algorithm

$F = \{$ set reduction functions$\}$

$X =$ initial *CSP*
$G = F$
While $G \neq \emptyset$
choose $g \in G$
$G = G - \{g\}$
$G = G \cup update(G, g, X)$
$X = g(X)$
EndWhile

X =

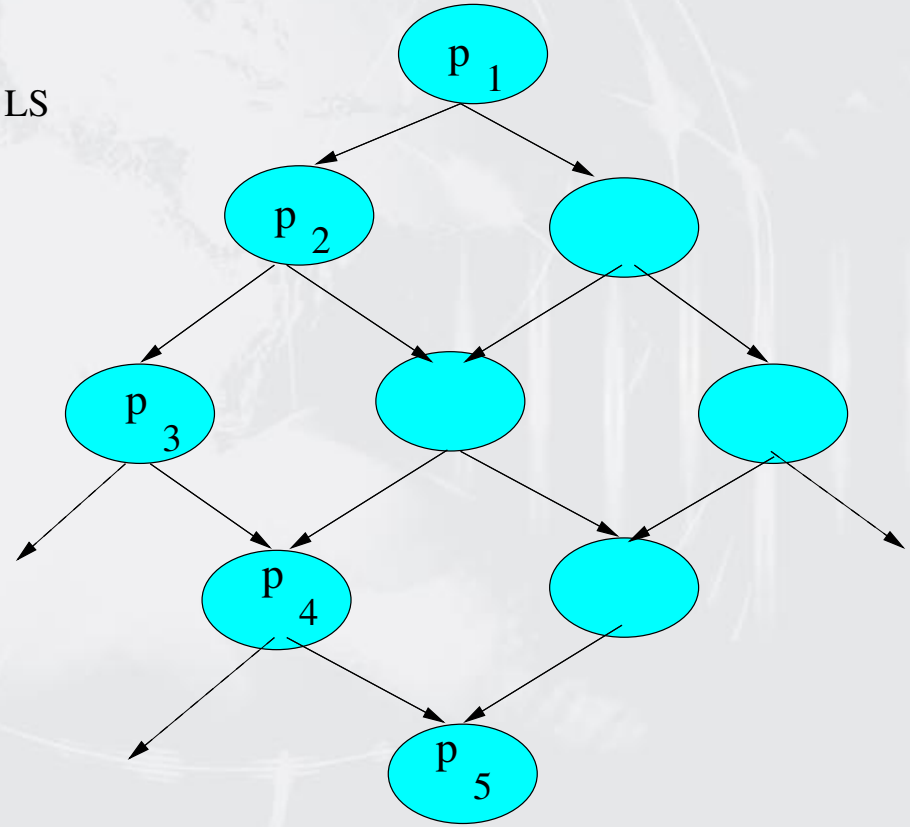


The theoretical model for CSP solving

Partial ordering :

Function to pass from one LS state to another

State of LS



Terminates with a fixed point : local minimum, maximum number of iteration

Ls Ordering

Characteristics of a LS path

- notion of solution
- maximum length

Operational (computational) point of view : path = samples
A sample :

- Depends on a CSP
- Corresponds to a local search state

Neighborhood and Move functions

Neighborhood :

- FullNeighbor : $V' = \{s \in D | s \notin V\}$
- TabuNeighbor : $V' = \{s \in D | \ \nexists k,\ n - l \leq k \leq n, s_k = s\}$
- DescentNeighbor : $p = (s_1, \ldots, s_n)$ and $V' = s \subset D$ s.t. / $\exists s' \in V$ s.t $eval(s') < eval(s_n)$

Move :

- BestMove : $p' = p \oplus s'$ and $eval(s') = min_{s'' \in V} eval(s'')$
- ImproveMove : $p = p'' \oplus s_n$ and $p' = p \oplus s$ s.t. $eval(s') < eval(s_n)$
- RandomMove : $p' = p \oplus s'$ and $s' \in V$

Instantiate the GI algorithm

We can precise here the input set of function F.

Tabu search :

- TabuNeighbor
- BestNeighBor

Random walk + Descent :

- FullNeighbor
- BestNeighBor
- RandomNeighbor
- DescentNeighbor
- ImproveNeighBor

Random walk :

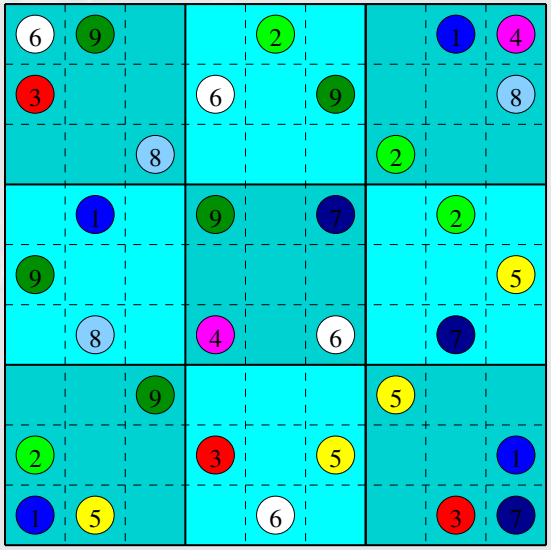
- FullNeighbor
- BestNeighBor
- RandomNeighbor

TabuSearch + Descent :

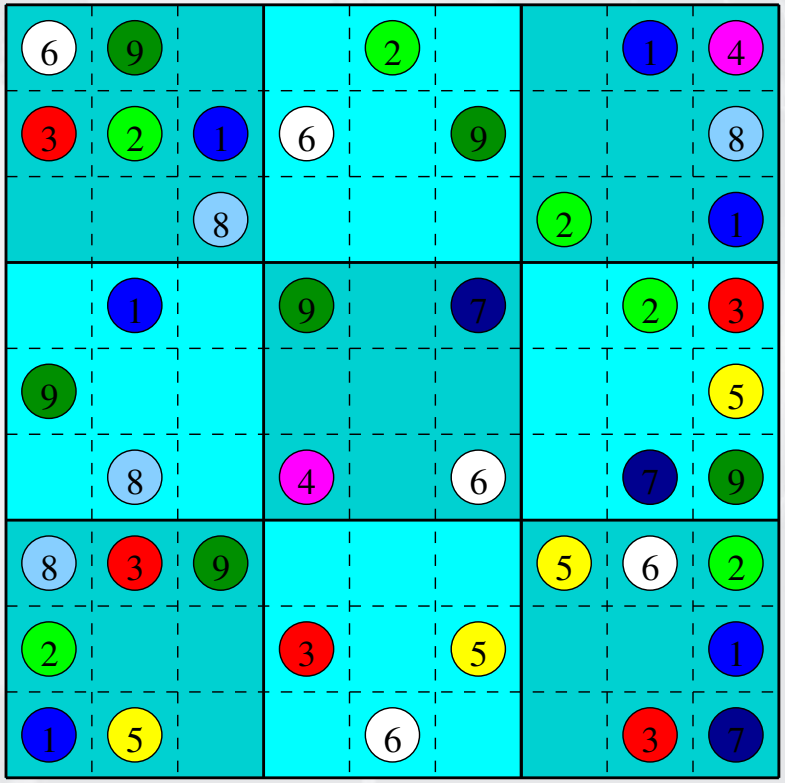
- TabuNeighbor
- DescentNeighbor
- ImproveNeighBor
- BestNeighBor

Sudoku problem

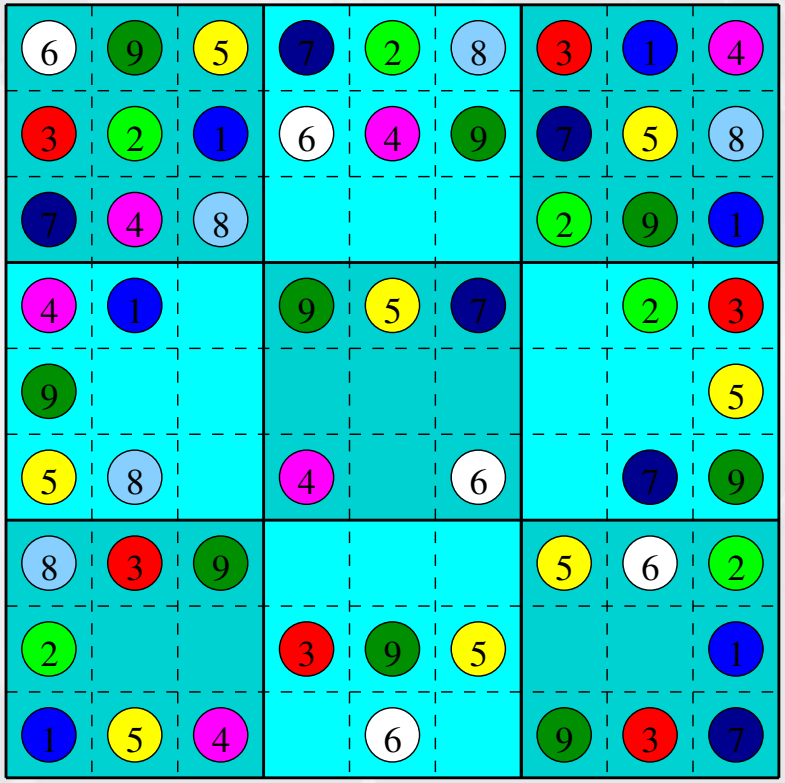
- $n^2 \times n^2$ problem
- n^4 variables
- *AllDiff* constraints



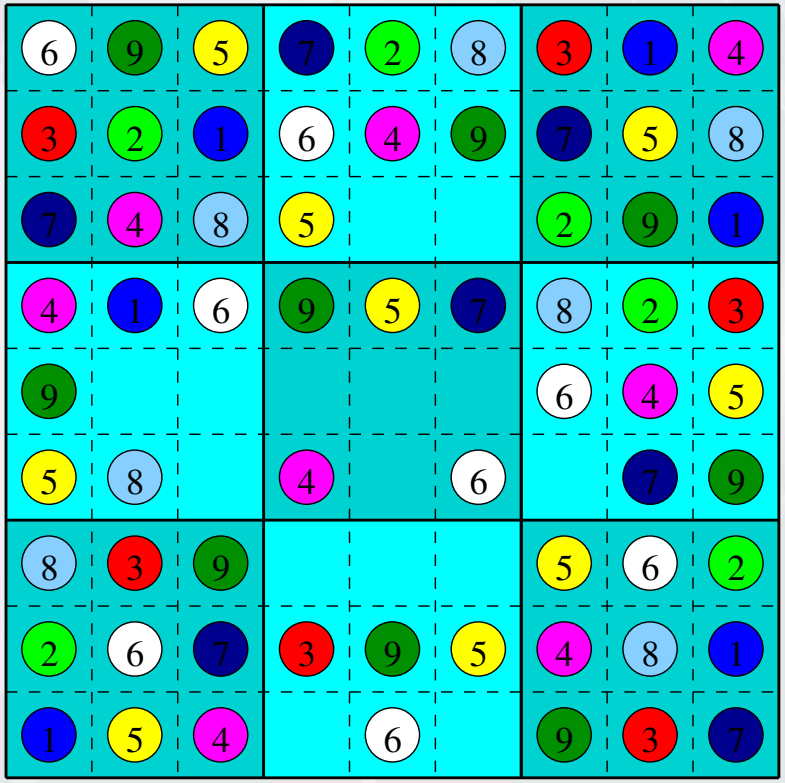
Sudoku problem



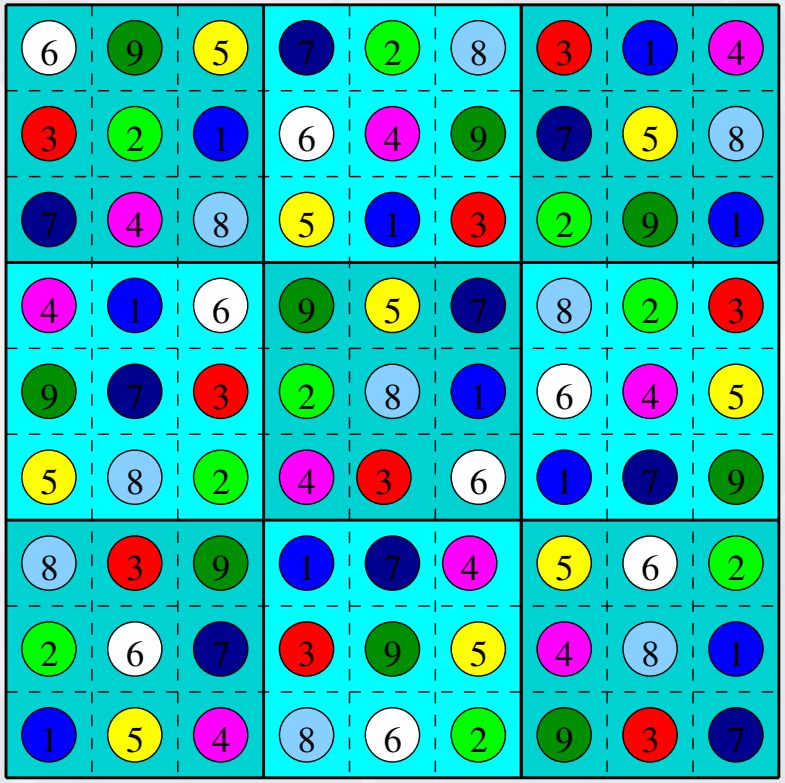
Sudoku problem



Sudoku problem



Sudoku problem



	TabuSearch			RandomWalk		
n^2 x n^2	16x16	25x25	36x36	16x16	25x25	36x36
cpu time	3,14	115,08	3289,8	3,92	105,22	2495
deviations	1,28	52,3	1347,4	1,47	49,3	1099
mvts	405	3240	22333	443	2318	13975
	Descent + TabuSearch			Descent +RandomWalk		
n^2 x n^2	16x16	25x25	36x36	16x16	25x25	36x36
cpu time	2,34	111,81	2948	2,41	82,94	2455
deviations	1,42	55,04	1476	1,11	36,99	1092
mvts Avg	534	3666	20878	544	2581	14908

Conclusion and Future works

- A generic model local search methods
- Design of strategies

- Dynamic strategies learning
- Providing more tools in a generic environment
- A generic implementation

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