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ANT COLONY OPTIMIZATION FOR SOLVING SUDOKU PUZZLES

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- I. Sabuncu. Solving sudoku puzzles using hybrid ant colony optimization algorithm. Proceedings of the 1st International Conference on Industrial Networks and Intelligent Systems, 2015.
- K. Schiff. An ant algorithm for the sudoku problem. Journal of Automation, Mobile Robotics and Intelligent Systems JAMRIS, pages 24–27, 2015.

WHAT IS SUDOKU

- Number Placement Game.
- Digits from 1-9 can exist just once in:
  - Each column,
  - Each row,
  - Each sub-grid.

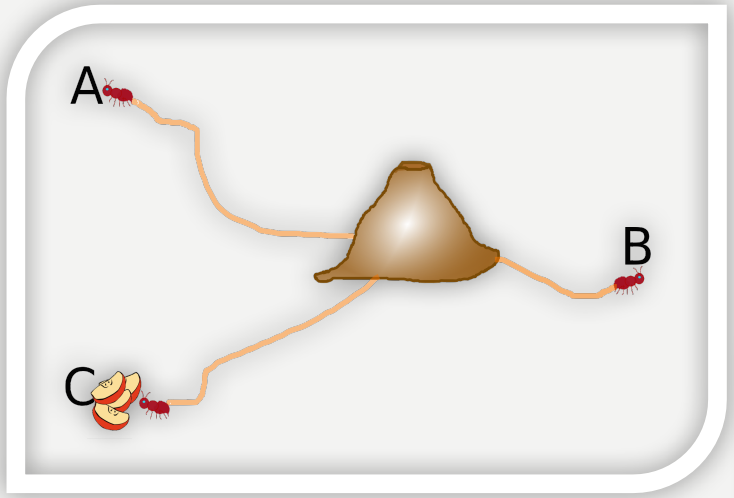
8	-	-	-	-	-	-	-	-
-	-	3	6	-	-	-	-	-
-	7	-	-	9	-	2	-	-
-	5	-	-	-	7	-	-	-
-	-	-	-	4	5	7	-	-
-	-	-	1	-	-	-	3	-
-	-	1	-	-	-	-	6	8
-	-	8	5	-	-	-	1	-
-	9	-	-	-	-	4	-	-

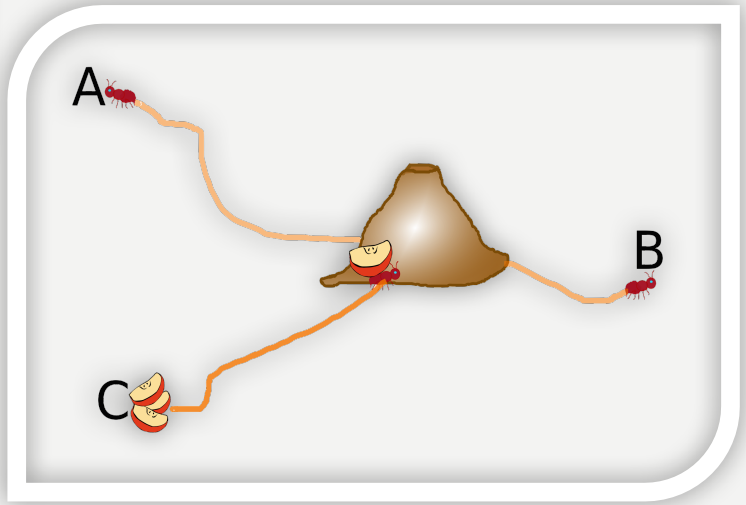
* Telegraph. World's hardest sudoku: Can you crack it? http: //www.telegraph.co.uk/news/science/science-news/9359579/Worlds-hardest-sudoku-can-you-crack-it.html, November 2015.

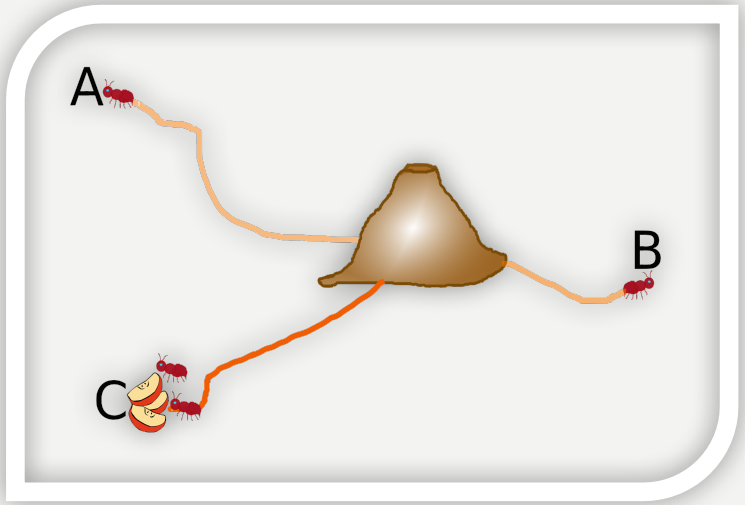
HISTORY OF SUDOKU

- Sudoku invented by Howard Garns in 1979 and published in Dell Magazines named as "**Number Place**".
- In 1986, the "Number Place" game is named as "Sudoku"
- It is a Japanese word which means "the digits are limited to one occurrence".
- Became popular in late 2004s by being a regular daily feature in most of the newspapers and magazines all around the world,
- Nowadays there are many international Sudoku competitions.

HOW ANTS FINDS PATH BETWEEN FOOD-NEST? PHEROMONE







WHAT IS ANT COLONY OPTIMIZATION

- Ant Colony Optimization is searching based on food-searching behavior of ants.
- Probabilistic search among alternatives using pheromone accumulation.
- Provide near-optimal solution to Traveling Salesman Problem.

ANT COLONY OPTIMIZATION FOR SOLVING SUDOKU PUZZLES

- Simplification Step:
  - Data Structure
    - 9-bit of short is used
    - Bitwise operations are applied to compute candidate values.

8	1, 2, 4, 6	2,4,5, 6,9	-	-	-	-	-	-
1,2, 4,5,9	1,2,4	3	6	-	-	-	-	-
1,4,5, 6	7	4,5,6	-	9	-	2	-	-
-	5	-	-	-	7	-	-	-
-	-	-	-	4	5	7	-	-
-	-	-	1	-	-	-	3	-
-	-	1	-	-	-	-	6	8
-	-	8	5	-	-	-	1	-
-	9	-	-	-	-	4	-	-

ANT COLONY OPTIMIZATION FOR SOLVING SUDOKU PUZZLES

- Ant Colony Step:
  - Randomly select an unassigned cell.
  - Assign cell to the candidate with highest pheromone accumulation.
  - Apply simplification
  - Check for validity – Assigning a valid candidate may cause some unassigned cells to have zero candidates.
    - If valid – increment pheromone accumulation of initial selection.
    - If not valid – decrement pheromone accumulation of initial selection.

8	1, 2, 4, 6	2,4,5, 6,9	-	-	-	-	-	-
1,2, 4,5,9	1,2,4	3	6	-	-	-	-	-
1,4,5, 6	7	4,5,6	-	9	-	2	-	-
-	5	-	-	-	7	-	-	-
-	-	-	-	4	5	7	-	-
-	-	-	1	-	-	-	3	-
-	-	1	-	-	-	-	6	8
-	-	8	5	-	-	-	1	-
-	9	-	-	-	-	4	-	-

EXPERIMENTAL RESULTS

Puzzle Name	Duration (sec.)
Puzzle 1	0
Puzzle 2	0.25
Puzzle 3	7.45
Puzzle 4	0.77
Puzzle 5	0
Puzzle 6	4.03
Puzzle 7	1.1
Puzzle 8	6.8
Puzzle 9	1.72
Puzzle 10	0
Puzzle 11	1092.11

CONCLUSION

- Basic implementation of Ant Colony Optimization Algorithm solved even very-difficult Sudoku Puzzle.
- Pheromone evaporation can also be added to the system.
- Types of puzzles which algorithm solves faster and which algorithm fails may be classified,
- Algorithm may be improved according to this classification.

QUESTIONS