Ant Colony Optimization

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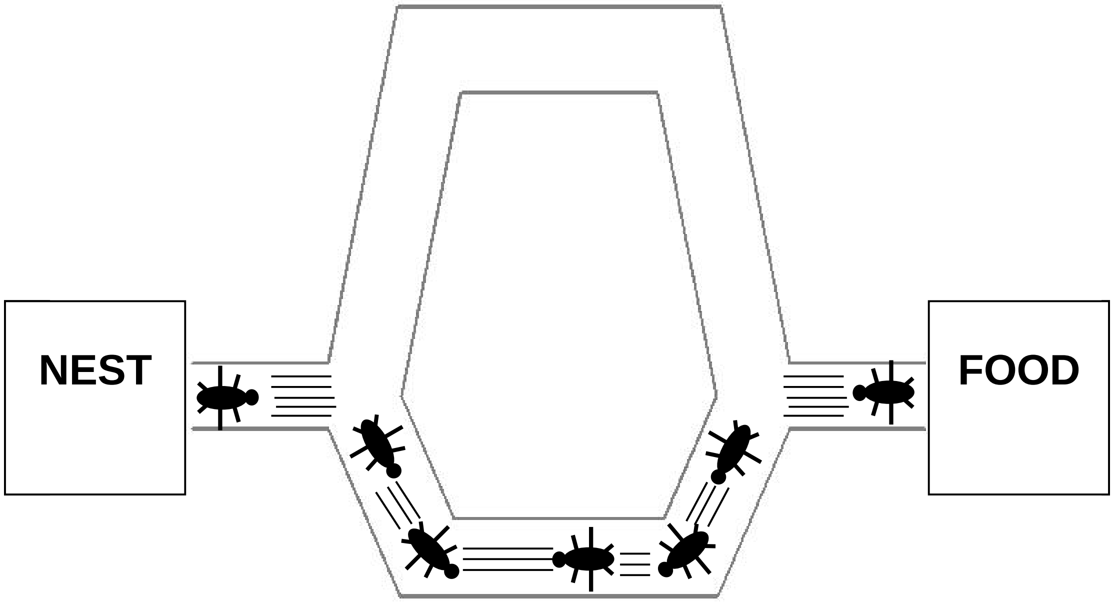
Introduction

- Ant colony optimization is a class of algorithm, which is classified under the branch of study swarms intelligence.
- Swarms Intelligence?
- Inspired by the behaviour of real ants.
- First algorithm that belong to this class was Ant system.

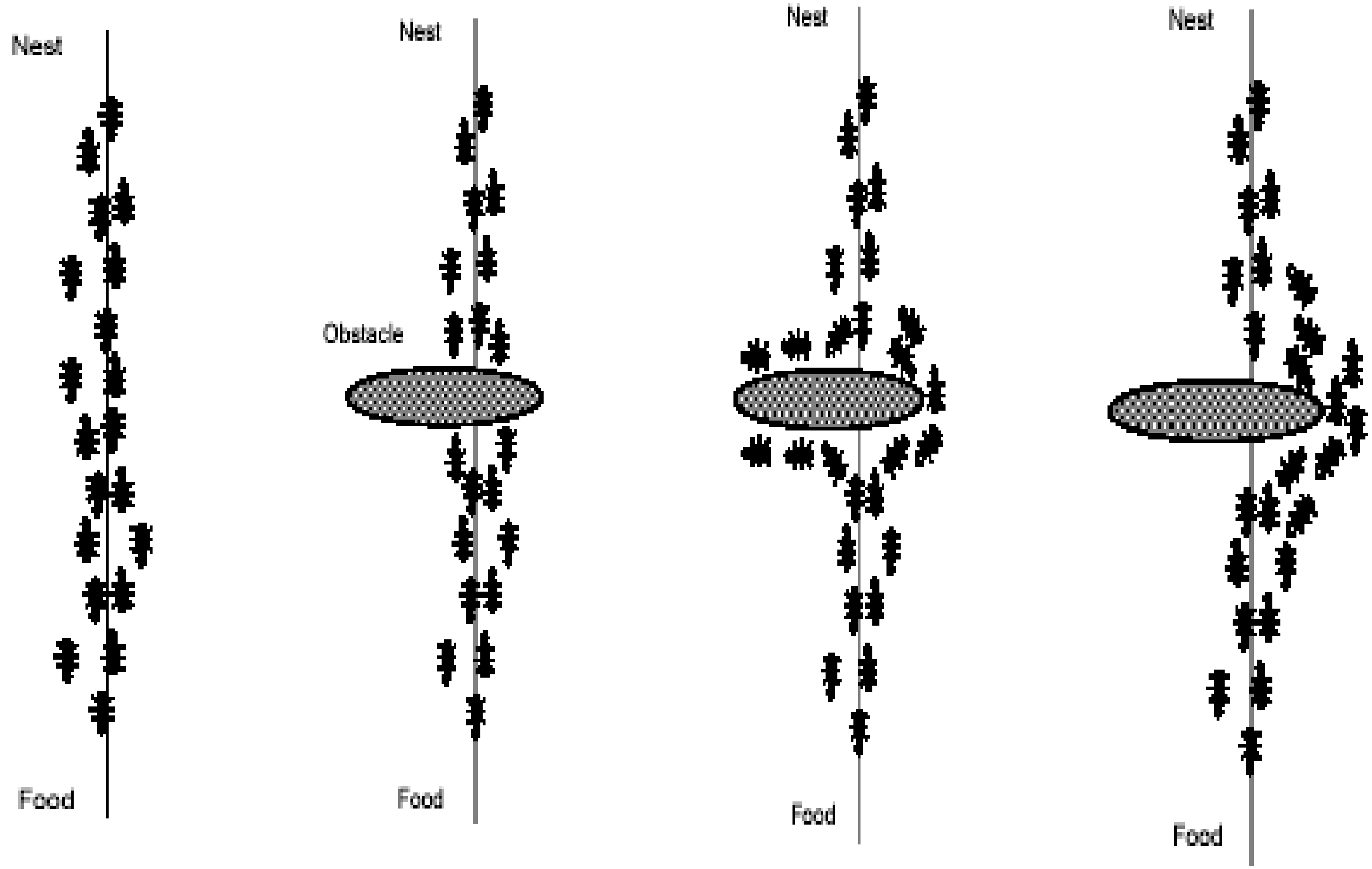
Natural behavior of ant

- By leaving pheromones behind them.
- Wherever they go, they let pheromones behind here, marking the area as explored and communicating to the other ants that the way is known.
- Double Bridge experiment

Study Of Ants :Double bridge exp.



How can they manage such tasks ?



ACO –Ant System in detail

- Artificial ants form a multi-agent system performing the functions as observed in the real ant system
- Exploit stigmergistic communication

The ACO meta-heuristic relies on the co-operation of a group of artificial ants to obtain a good solution to a optimization problem such as the TSP

- Artificial ants are mutants of a real ant system
- The resulting shortest route mapping determined by the agents can be applied to the optimization problem

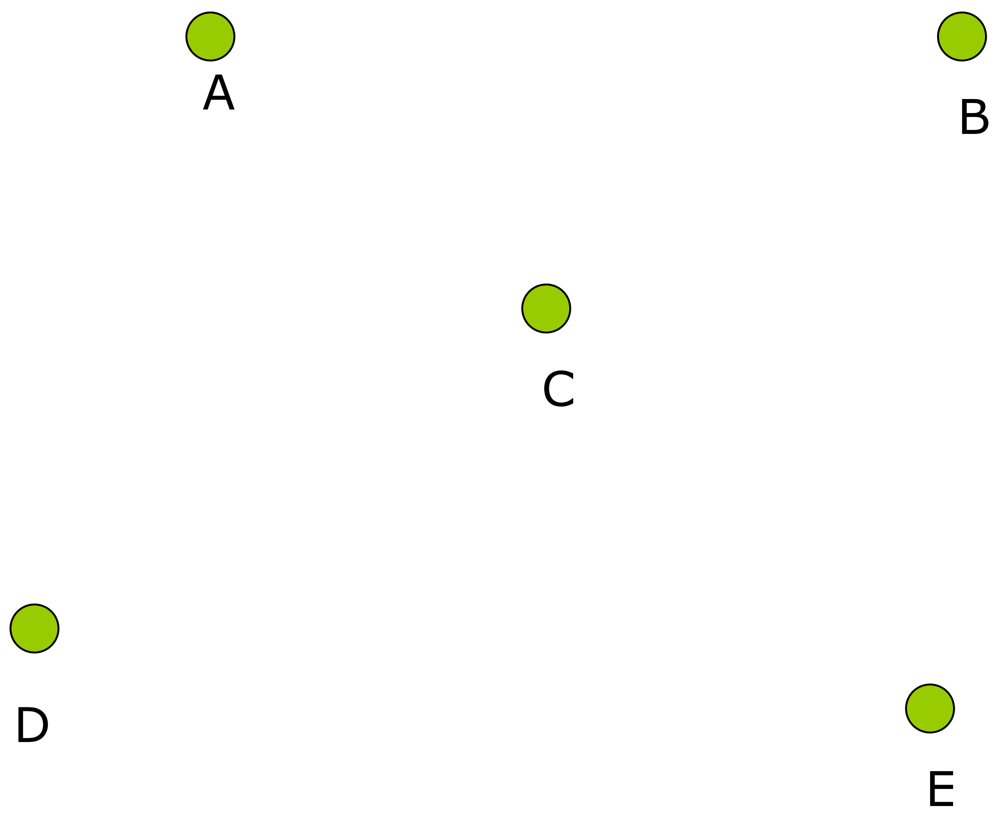
Real vs. Artificial ANTS

REAL ANT

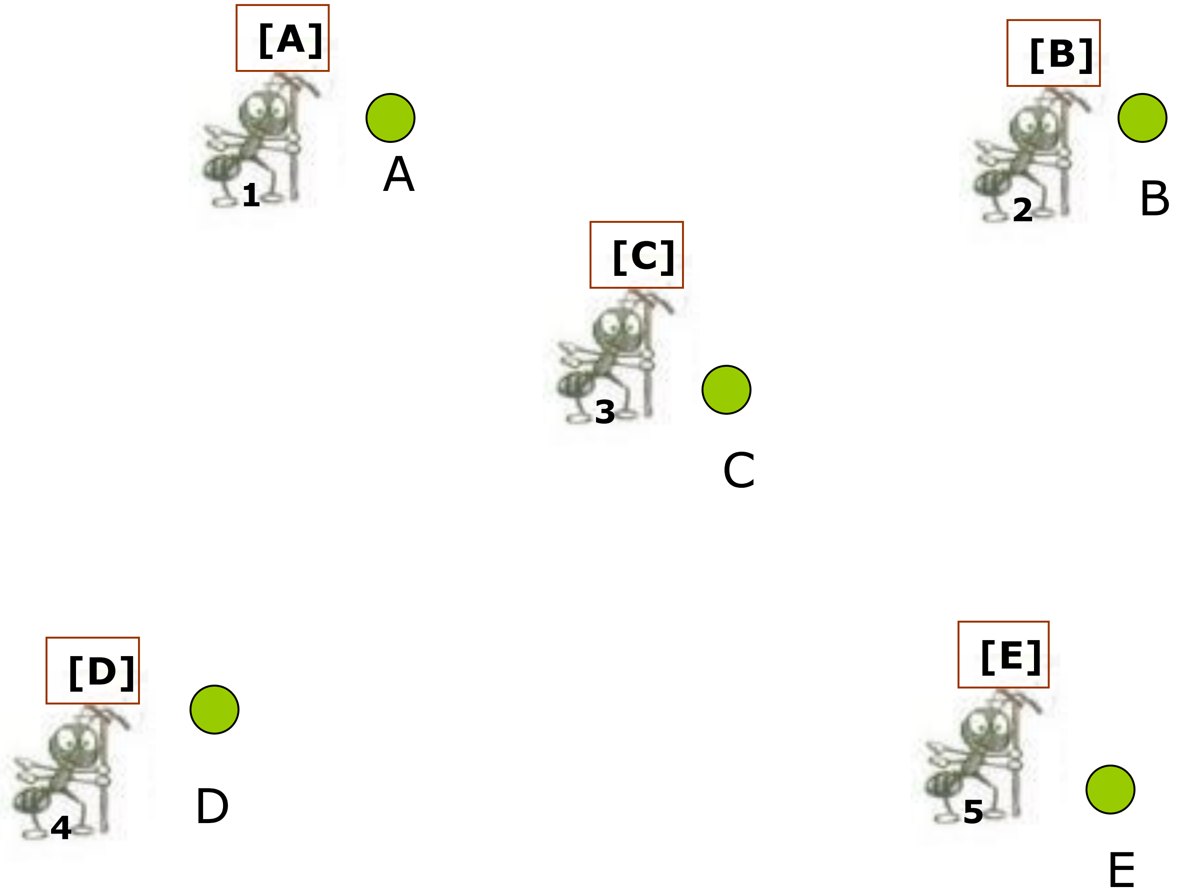
- Discrete time steps
- Memory Allocation
- Quality of Solution
- Time of Pheromone deposition
- Distance Estimation

ARTIFICIAL ANT

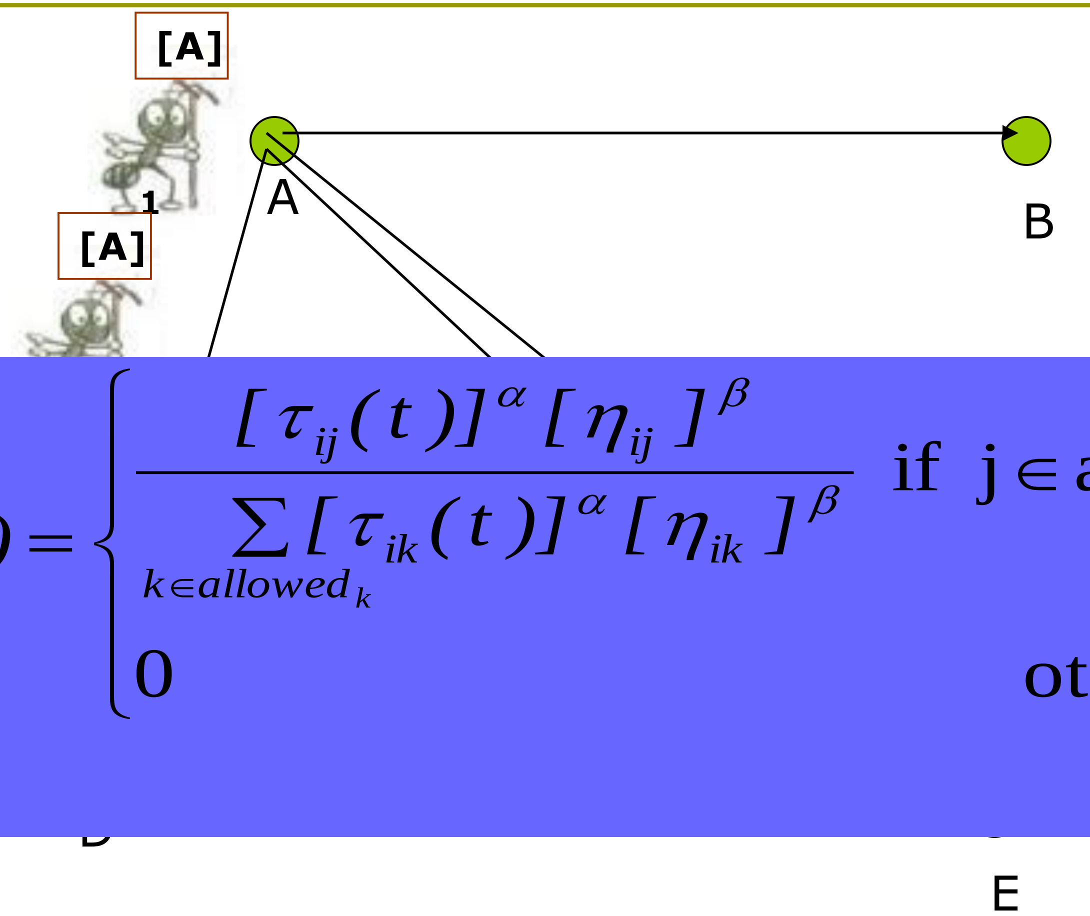
A simple TSP example



Iteration 1

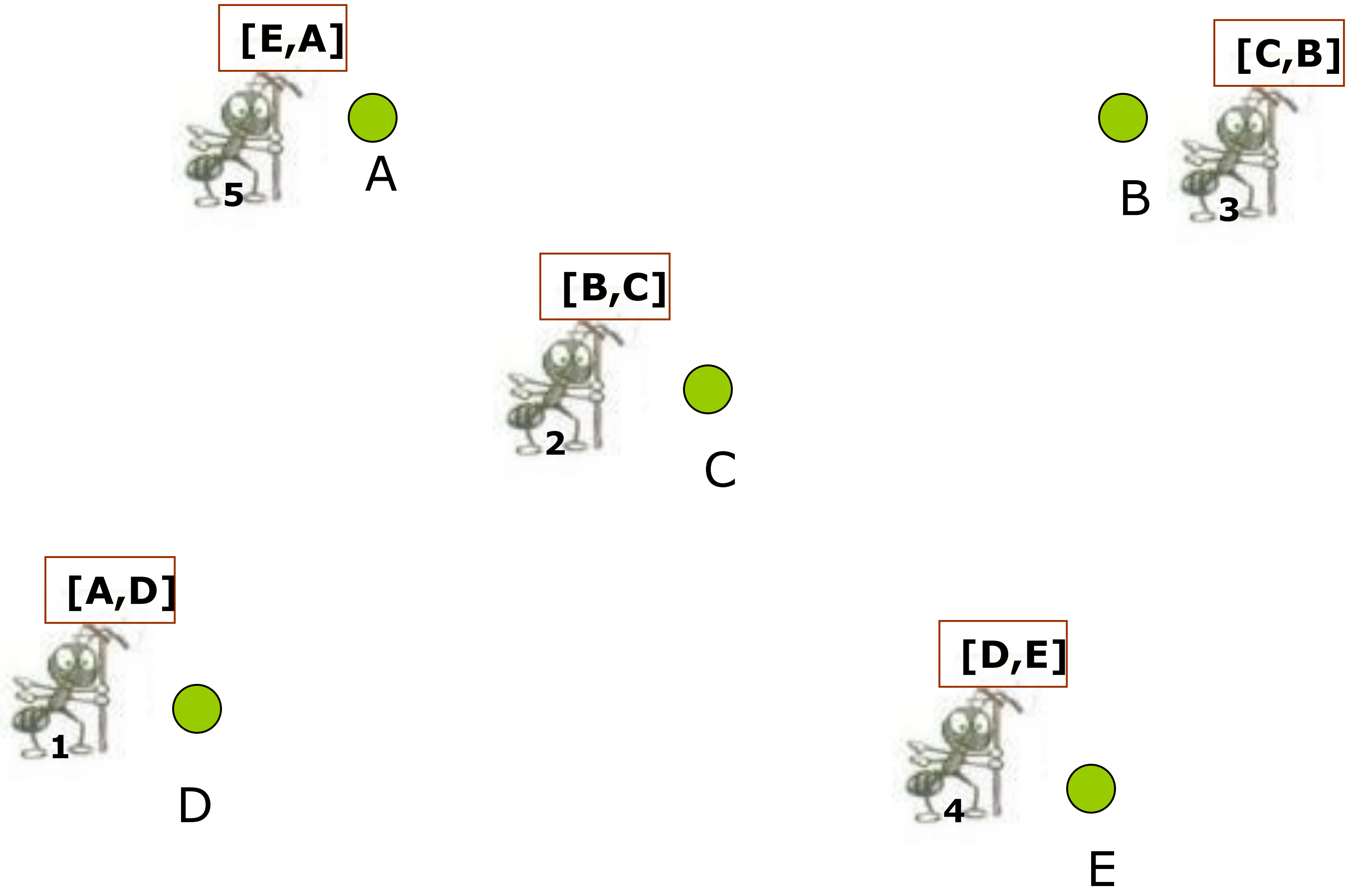


How to build next sub-solution?

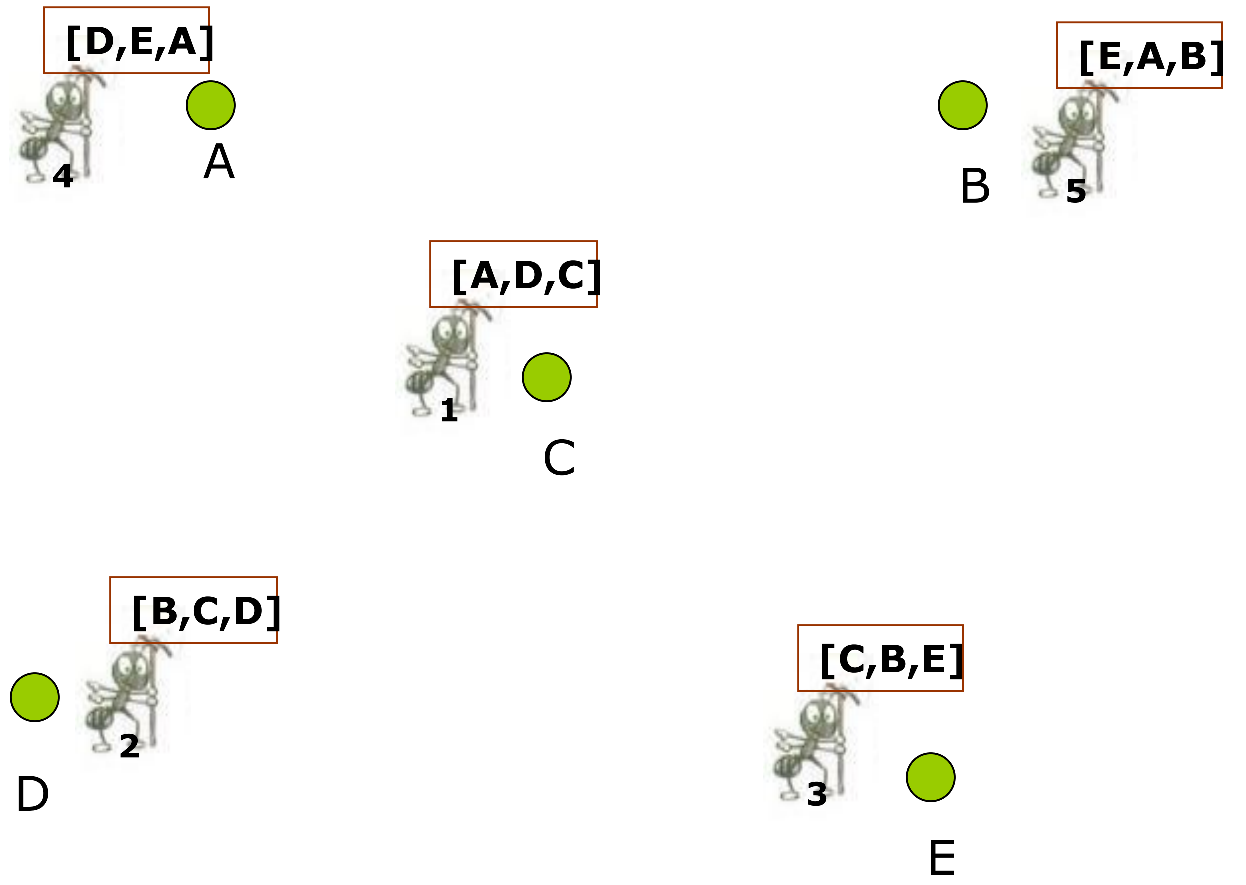


$$p_{ij}^{k}(t)=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}}{\sum\limits_{k\in allowed_k}[\tau_{ik}(t)]^{\alpha}[\eta_{ik}]^{\beta}} & \text{if } \ \mathrm{j}\in \mathrm{allowed}_{\mathrm{k}} \\ 0 & \text{otherwise}\end{cases}$$

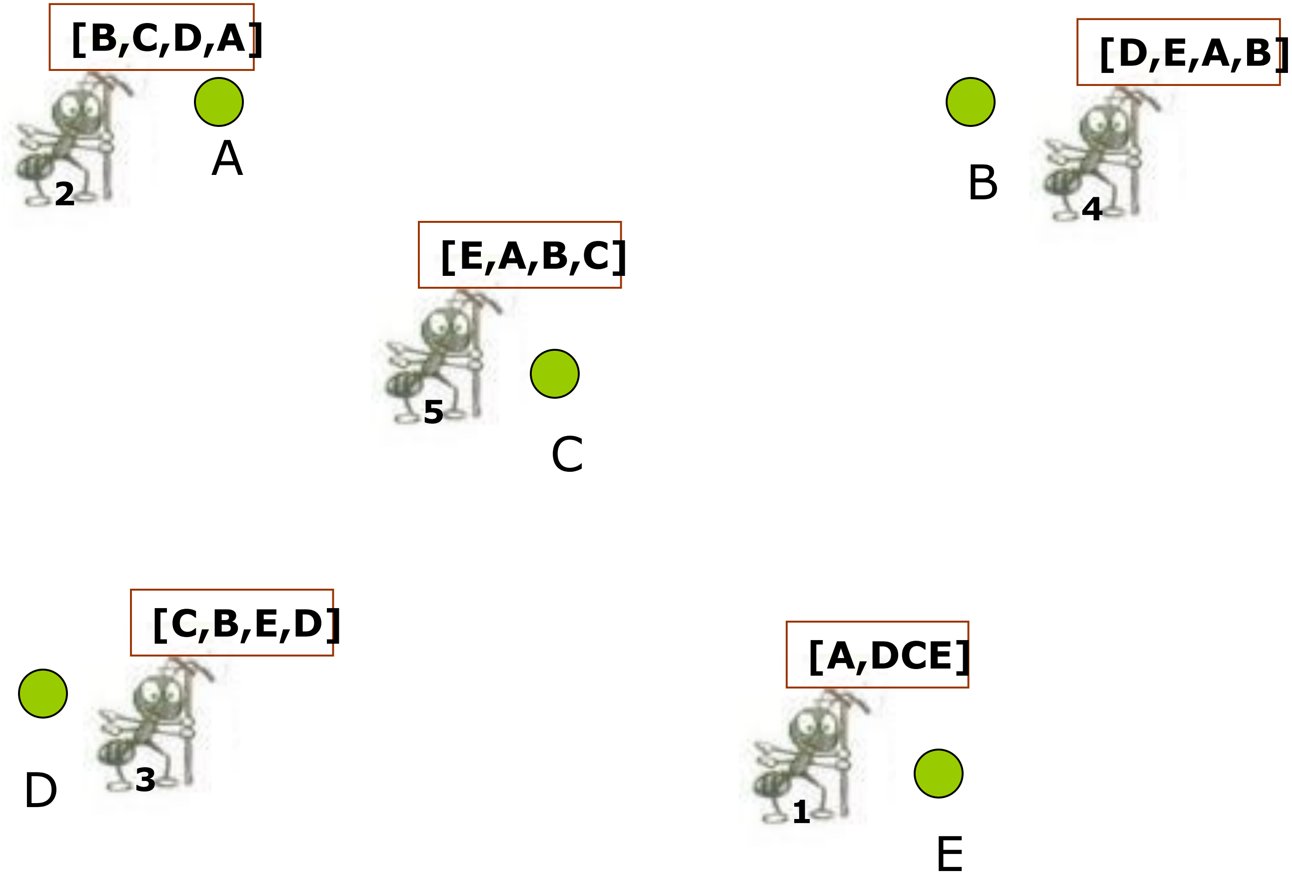
Iteration 2



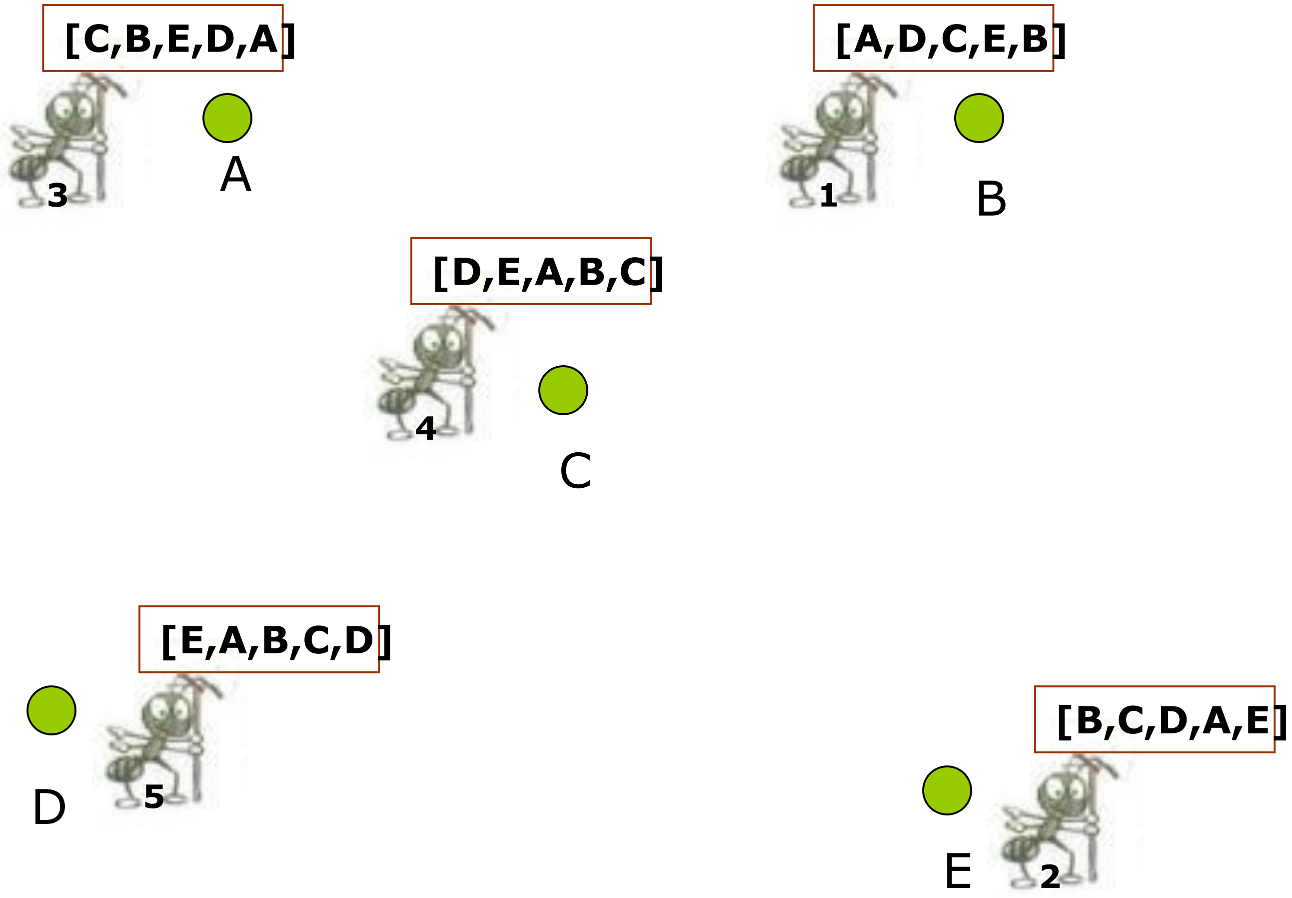
Iteration 3



Iteration 4



Iteration 5



Path and Pheromone Evaluation

[A,D,C,E,B]

1

$L_1 = 300$

[B,C,D,A,E]

2

$L_2 = 450$

[C,B,E,D,A]

3

$L_3 = 260$

[D,E,A,B,C]

4

$L_4 = 280$

[E,A,B,C,D]

5

$L_5 = 420$

$$\Delta\tau_{i,j}^{k} = \begin{cases} \dfrac{Q}{L_k} & if(i,j) \in \text{tour} \\ 0 & \text{otherwise} \end{cases}$$

End of First Run

Save Best Tour (Sequence and length)

All ants die

New ants are born

Ant Systems Algorithm & Flowchart

Loop

Randomly position m artificial ants on n nodes

For **nodes**=1 to n

For **ants**=1 to m

{*Each ant builds a solution by adding one node after the other*}

Select probabilistically the next nodes according to exploration and exploitation mechanism

Apply the **local trail updating** rule

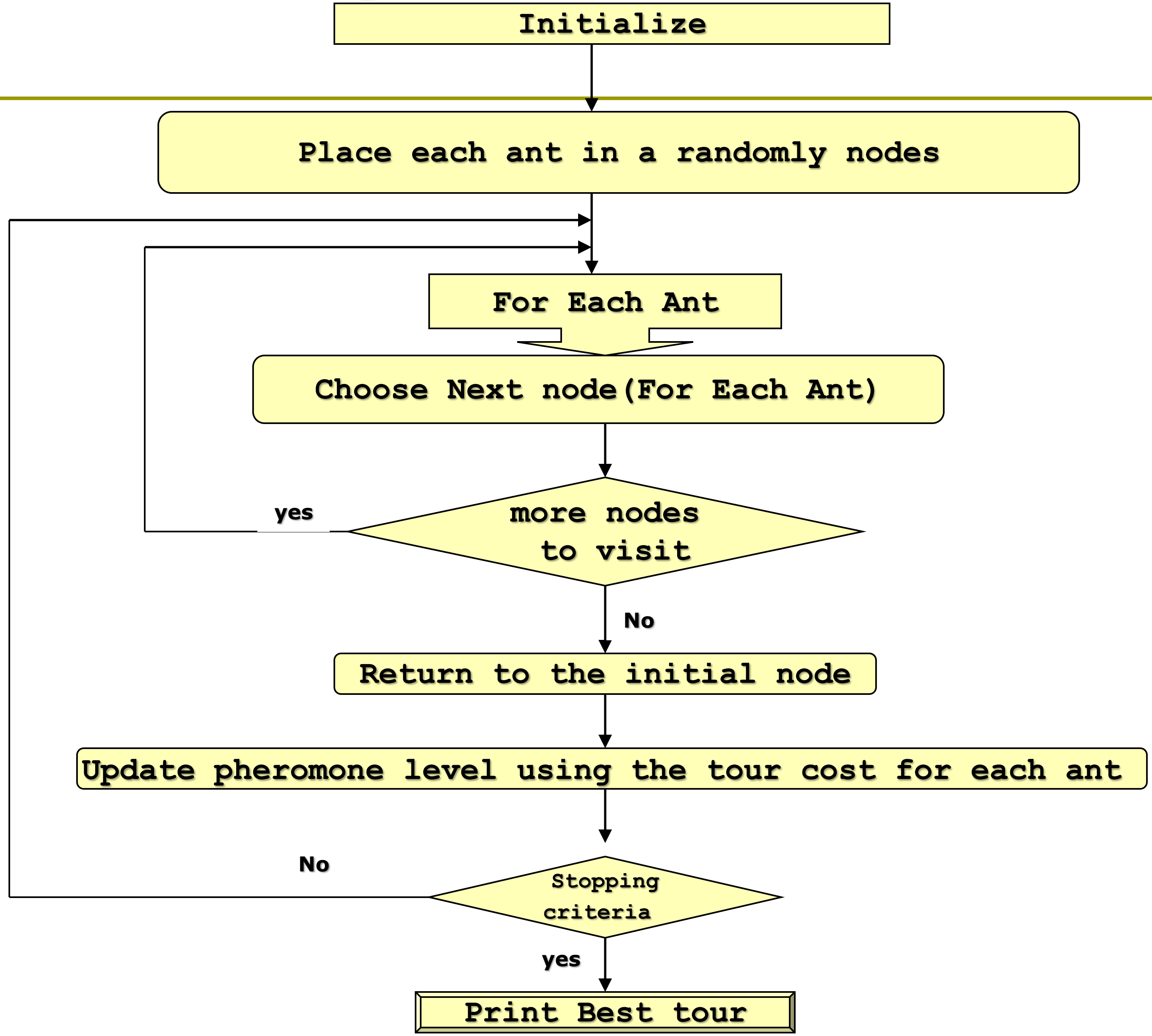
End for{ants}

End for {nodes}

Apply the **global trail updating** rule using the best ant tour

Until End_condition{convergence of solution}

Ant Systems Algorithm & Flowchart



Application

- Solution to wide variety of problem
  - Text featuring(ASNET,AS-rank)
  - Travelling salesperson problem(ANT-Q,ASNET)
  - Scheduling problem(AS-JS,ACO-SMTTP)
  - Vehicle routing(AS-VRP,HAS-VRP)
  - Connection and connection less Network routing (ABC,ASNET-FS,ANTnet,ABC-backward)
  - Graph colouring(ANTcol)

Examples of effective implementations

- RIP and OSPF replaced by ANTnet(15%,10%).
- Routing protocols :
  - For wired networks

    1.ABC, Ant Based routing algorithm

    2.MARA, Multiple-agents Ants-based Routing Algorithm
  - For MANET

    1.AntNet

    2.ARA, Ant-Colony-Based Routing Algorithm

    3.AntHocNet.

Results of the analysed reports

- AntNet in a complex wired network is more efficient than OSPF & RIP, and show very stable performances.
- Text featuring using ASNET was more efficient then genetic ,information gain and CHS algorithm.
- ARA, for 50 mobile nodes in 1500x300m area, give the same performance than DSR for less overhead traffic.
- AntHocNet, simulated: over 1000 nodes, data rate 2Mbit/s. twice more efficient than AODV to deliver packets, more scalable

Conclusion

- ACO is a recently proposed meta heuristic approach for solving optimization problems.
- Artificial ants implement a randomized construction heuristic which make probabilistic decisions.
- Exploit a positive feedback mechanism help in discovering solution rapidly.
- Demonstrate a distributed computational architecture
- Exploit a global data structure that changes dynamically as each ant transverses the route
- Multi objective ACO

References

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Questions ?

Thank you !