Advanced ACO Algorithms

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### Successors and Extensions of the AS

- MAX-MIN Ant System (MMAS)
  - Only iteration best or best-so-far ants update pheromone
  - D Pheromone trails have explicit upper and lower limits
  - Pheromone trails initialized to upper limit
  - Pheromone trails are re-initialized when stagnated
- Ant Colony System (ACS)
  - D Pheromone is also updated while building solution
  - Only iteration best or best-so-far ants update pheromone

## The Ant System Algorithm

For #iterations

For each ant

Choose a random starting city

While tour is not complete

Select next city using random proportional transition rule

### End While

End for

Update pheromone information

End for

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## 

### MAX-MIN Ant System (MMAS)

Only iteration best or best-so-far ants update pheromone

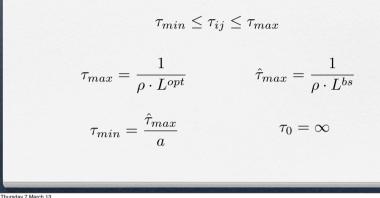
$$\begin{aligned} \tau_{ij} \leftarrow (1-\rho) \cdot \tau_{ij} & \forall (i,j) \\ \tau_{ij} \leftarrow \tau_{ij} + \Delta \tau_{ij}^{best} & \forall (i,j) \\ \Delta \tau_{ij}^{best} = \begin{cases} \frac{1}{L'} & \text{if } arc(i,j) \in T^{best} \\ 0 & 0 & \text{otherwise} \end{cases} \end{aligned}$$

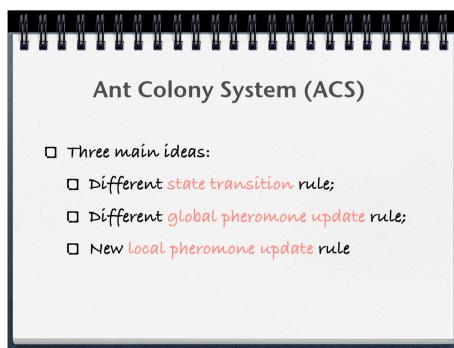
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### MAX-MIN Ant System (MMAS)

D Pheromone trail values are subject to bounds





### MAX-MIN Ant System (MMAS)

Pheromone trails are reinitialized:

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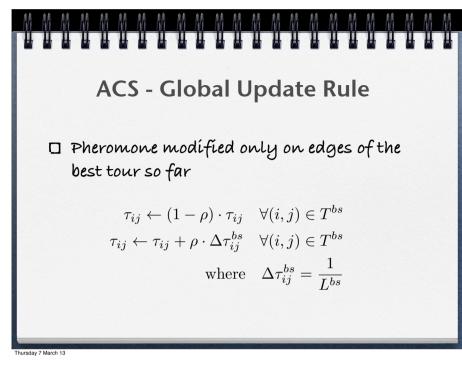
- When the algorithm converges;
- When no improved solutions has been generated for a certain number of consecutive iterations.

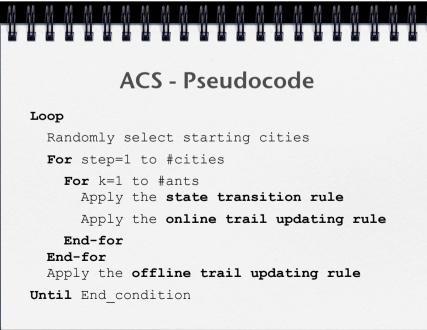
### **ACS - State Transition Rule**

- A.k.a. pseudo-random proportíonal rule:
  - with probability qo, exploitation ;
  - with probability 1 qo, biased exploration

 $j = \begin{cases} \arg \max_{j \in \mathcal{N}_i^k} (\tau_{ij} \cdot \eta_{ij}^\beta) & \text{if } q \le q_0 \quad \text{(Exploitation)} \\ \\ J & \text{otherwise} \quad \text{(Exploration)} \end{cases}$ 

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**ACS - Local Update Rule** 

While building a solution each ants updates pheromone on visited edges:

 $\tau_{ij} \leftarrow (1-\rho) \cdot \tau_{ij} + \rho \cdot \tau_0$ 

This update rule introduces diversification

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