

# ***Artificial Intelligence***

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## **chapter 7:** Ant Algorithms

### **7.1: Dynamic Navigation by Ants and its Simulation**

# Nature sets the standard

## Ants as traffic participants

Ants find good paths

- Coordination for seeking food
- Adaptation for changes in the environment

Targets in traffic network optimization

- Shortest path
- Fastest path
- Most comfortable path
- Use dynamic information



# Nature sets the standard

## Fundamental principle of ant coordination

- Each ant deposits pheromones continuously.
- For junctions, the probability that an ant proceeds on a specific segment is proportional to the pheromone concentration on this segment.
- It can be distinguished if an ant is on the way towards the food supply or on the way back (carrying food):
  - a) Each ant returns the same way back (as soon as it found food).
  - b) For the ways forth and back, different types of pheromones are used.

# Nature sets the standard

## Communication abilities of ants

### Pheromones as information carriers

- Chemical matter which can be smelled by all ants
- Permanent and constant dropping
- Changes the local environment
- Base for the own path making decision

### Stigmergy as communication principle

- Communication is always indirect via pheromones
- Pheromones can be read only in a limited area
- Pheromones give information referring to a limited area only

# Nature sets the standard

## Example for the advantage of probabilistic decision making

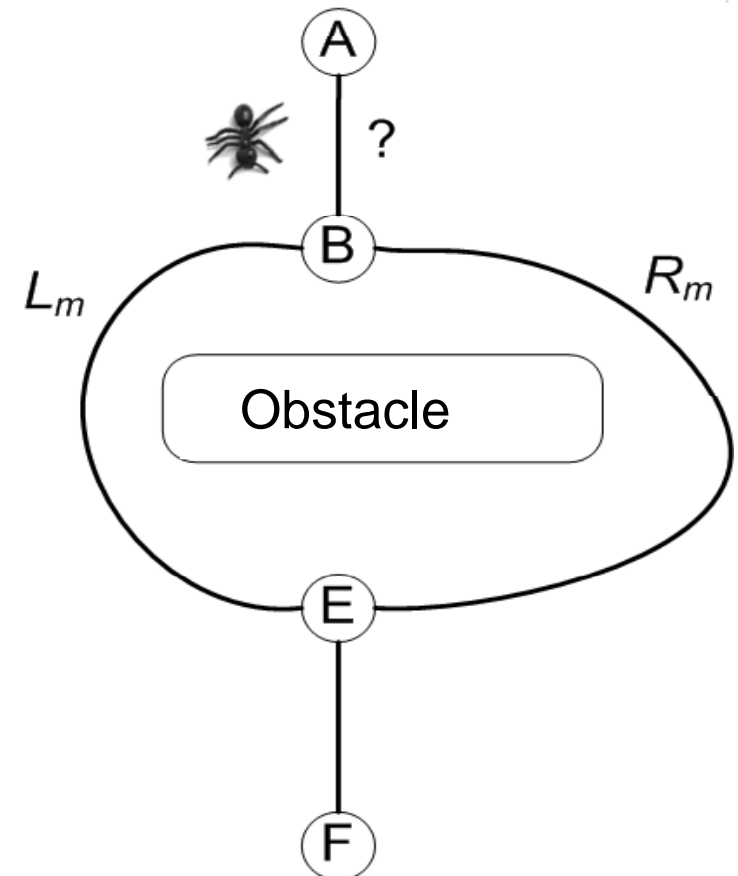
Simple path experiment:

- Simplifying assumption: no evaporation
- $m$  ... total number of ants
- $L_m$  ... number of ants using left path
- $R_m$  ... number of ants using right path

$$P_L(m) = \frac{(L_m + k)^h}{(L_m + k)^h + (R_m + k)^h}$$

$$P_R(m) = 1 - P_L(m)$$

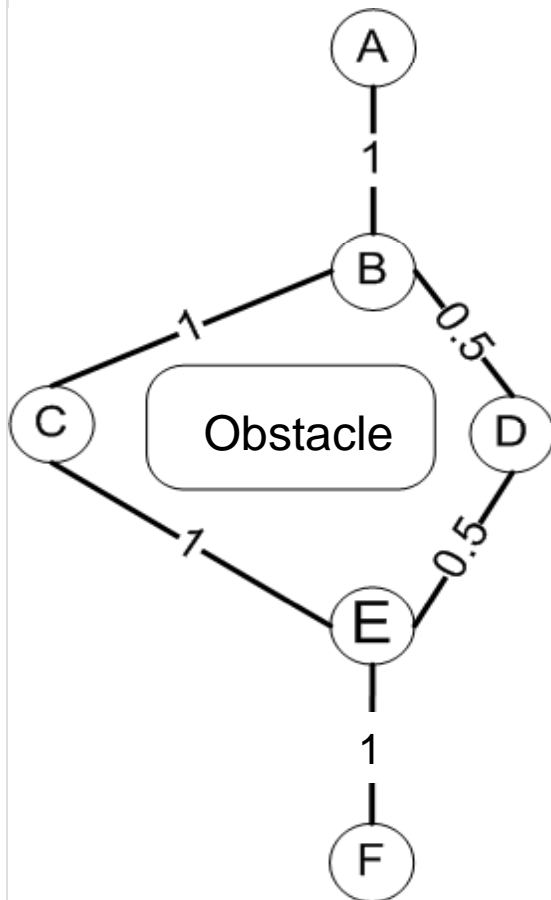
$$k = 20; h = 2$$



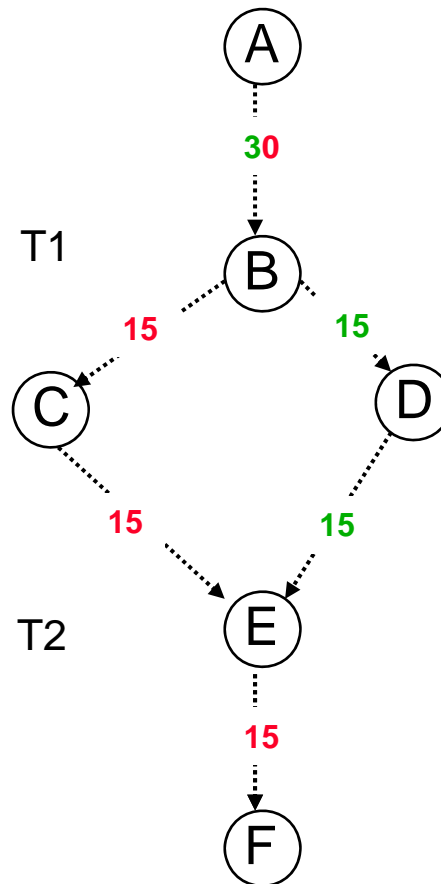
# Nature sets the standard

## Advantages of probabilistic decision making: Example (type a)

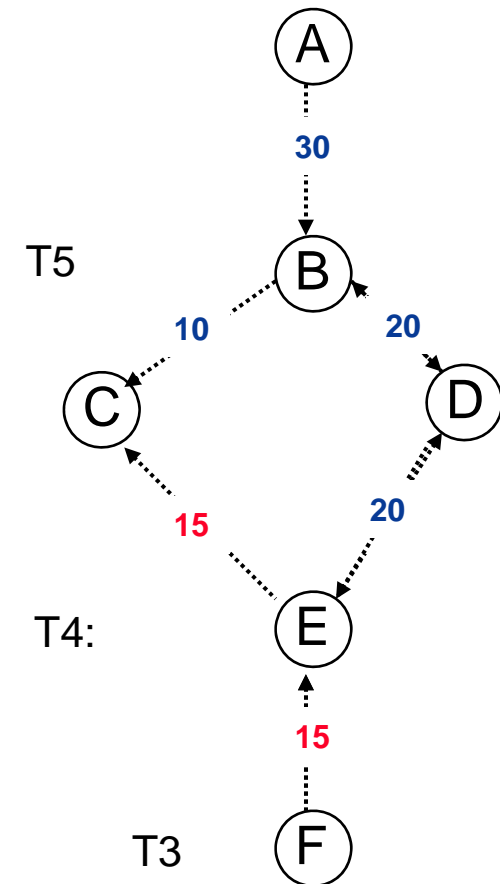
Distances



T0: 30 pioneer ants



T4: 30 new ants



# Nature sets the standard

## Advantages of probabilistic decision making: summary

### Autocatalysis

- Positive feedback using pheromones
- The higher the pheromone concentration, the more ants will use the path and increase pheromone concentration.

### Implicite problem solving

- The shorter a path, the more ants use it in the same time which makes pheromone concentration increasing faster.

### Conclusion from these properties

- The shorter a path, the more ants will use it.

# Nature sets the standard

## Advantages of natural evaporation

### Problem: Stagnation

- Fairly good solutions at the beginning get enforced quickly.
- Risk: Average ants find only average solution.
- Algorithm converges too fast before optimum is found.
- Gradual deterioration of path will not be realized.

### Solution: Evaporation of pheromones

- Limitation for the difference of pheromone concentration
- New information counts more than old one.
- Compromise between confirmation and new search



# Artificial Ant Systems

## Real ants vs. artificial ants

### Common features

- *Emergence*: Super-organism made of simple communicating individuals
- *Stigmergy*: Indirect communication via pheromones
- Decisions are limited to a short local range
- Decision parameters come from a local short-sighted range
- Continuous adaptation to changes

### Features in which artificial ants differ

- Discrete world, discrete transition states via timing cycles
- State variables, memory
- Pheromone dropping may be directly correlated to solution quality.
- Pheromone dropping may be retarded.
- Further problem specific capabilities of the single ants