Swarm Robotics - Chain Formation Strategy

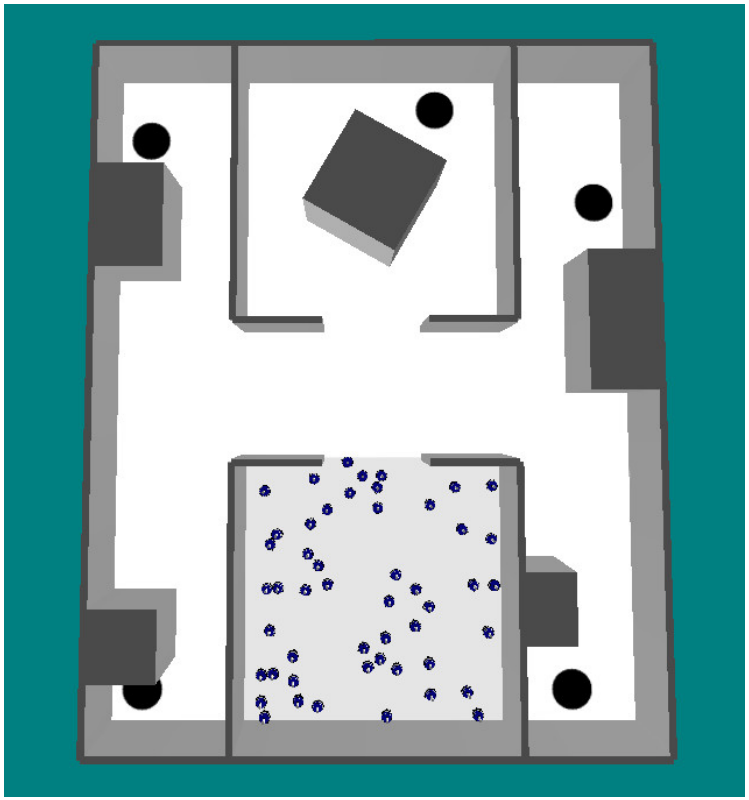
INFO-H-414 - Swarm Intelligence

Jacopo De Stefani

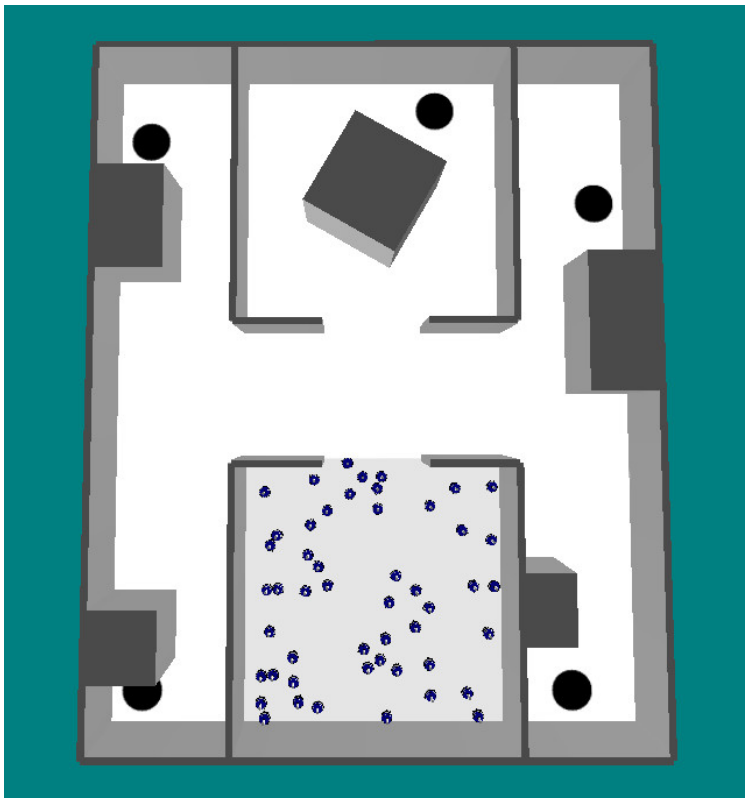
Universite' Libre de Bruxelles

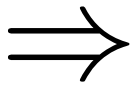
September 3, 2013

Introduction

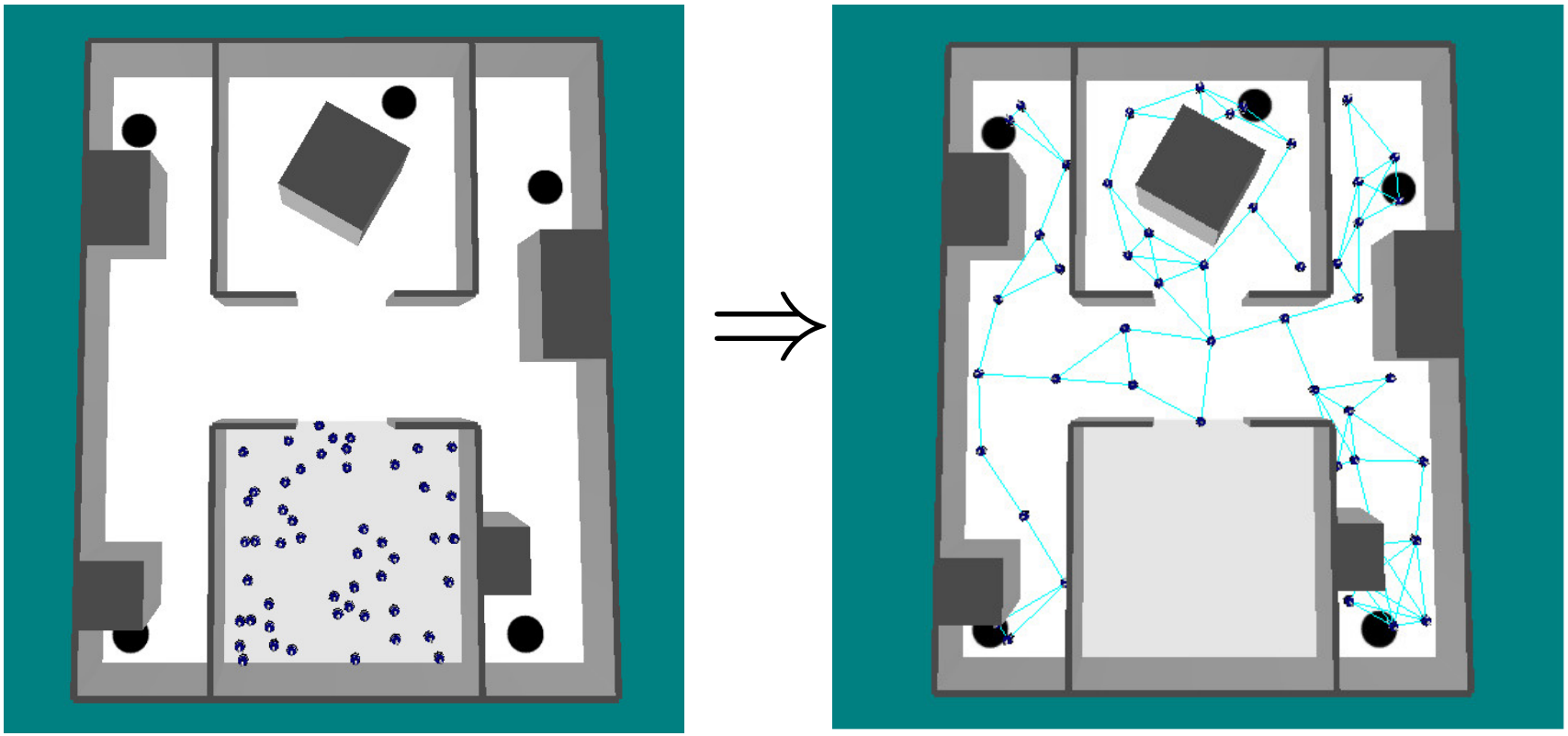


Introduction





Introduction



What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

What does the method use?

ECOLE POLYTECHNIQUE DE BRUXELLES

Robot equipment

- Wheels

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

- Wheels
- Proximity sensors

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

- Wheels
- Proximity sensors
- Range and Bearing

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

- Wheels
- Proximity sensors
- Range and Bearing
- Ground sensors

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

- Wheels
- Proximity sensors
- Range and Bearing
- Ground sensors
- Distance scanner

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Robot equipment

- Wheels
- Proximity sensors
- Range and Bearing
- Ground sensors
- Distance scanner

- *Sense*, *Think*, *Act* paradigm

What does the method use?

ECOLE
POLYTECHNIQUE
DE BRUXELLES

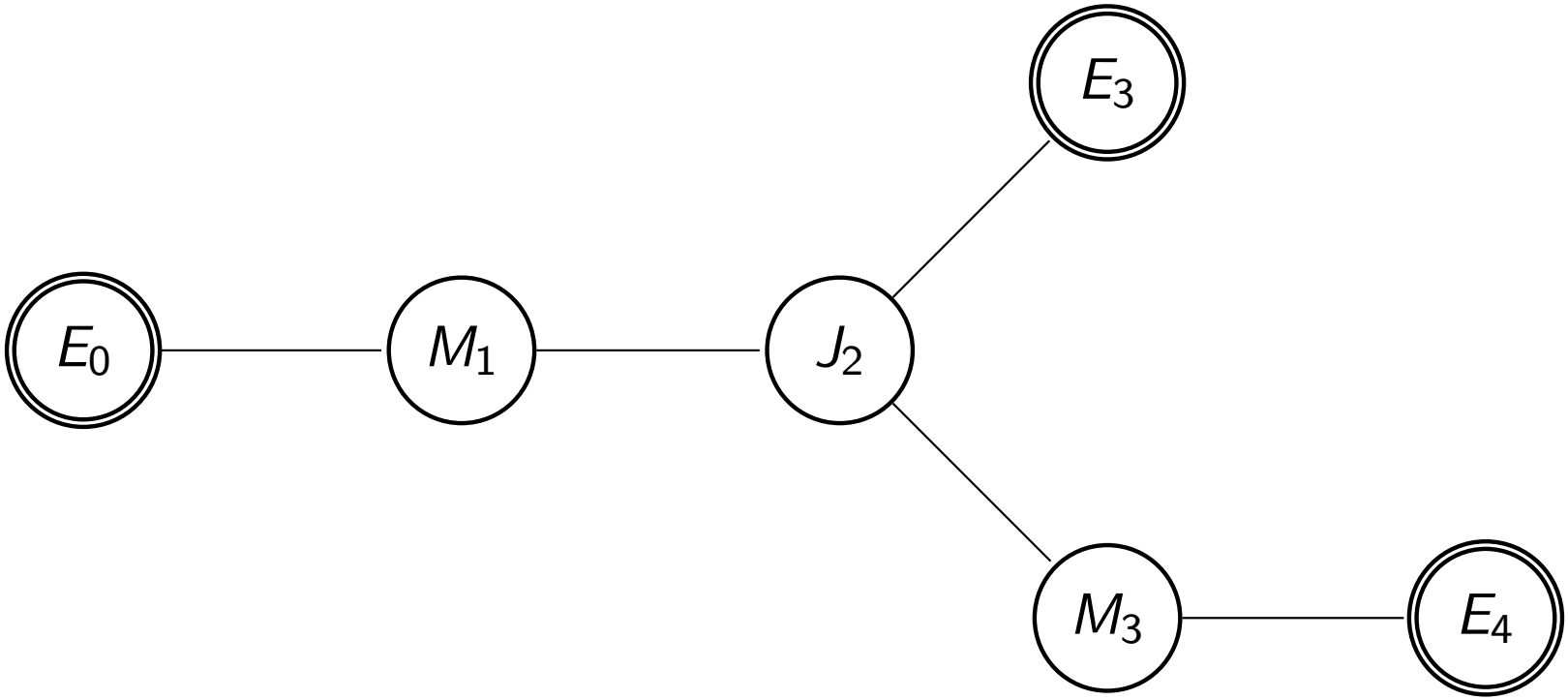
Robot equipment

- Wheels
- Proximity sensors
- Range and Bearing
- Ground sensors
- Distance scanner

- *Sense*, *Think*, *Act* paradigm

- Potential-fields approach [HMS02]

Chain example



Chain example with nodes labeling and id

Controller components

ECOLE
POLYTECHNIQUE
DE BRUXELLES

Controller components

1. Chain beginning

Controller components

1. Chain beginning
2. Chain following

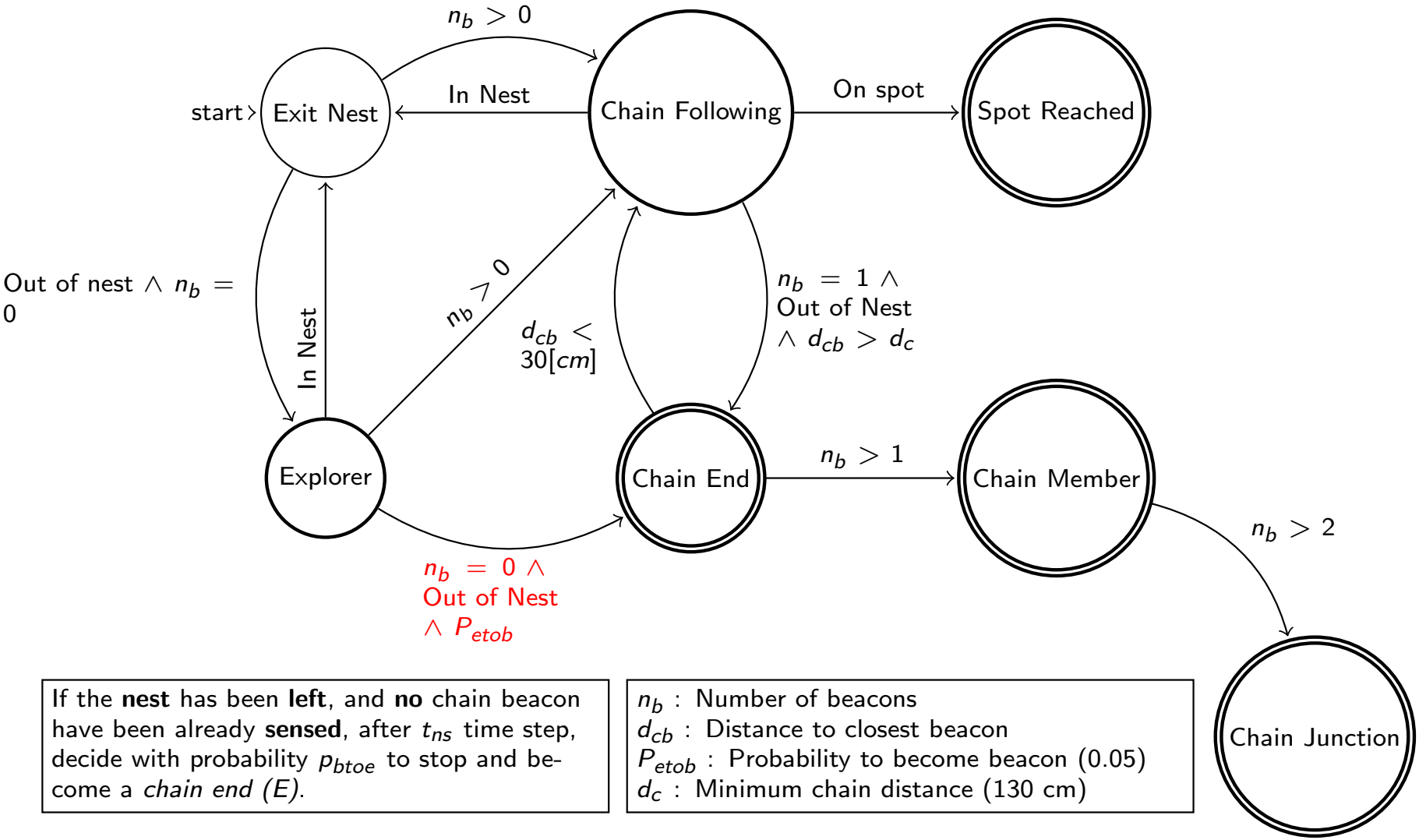
Controller components

1. Chain beginning
2. Chain following
3. Chain building

Controller components

1. Chain beginning
2. Chain following
3. Chain building
4. Chain state updating

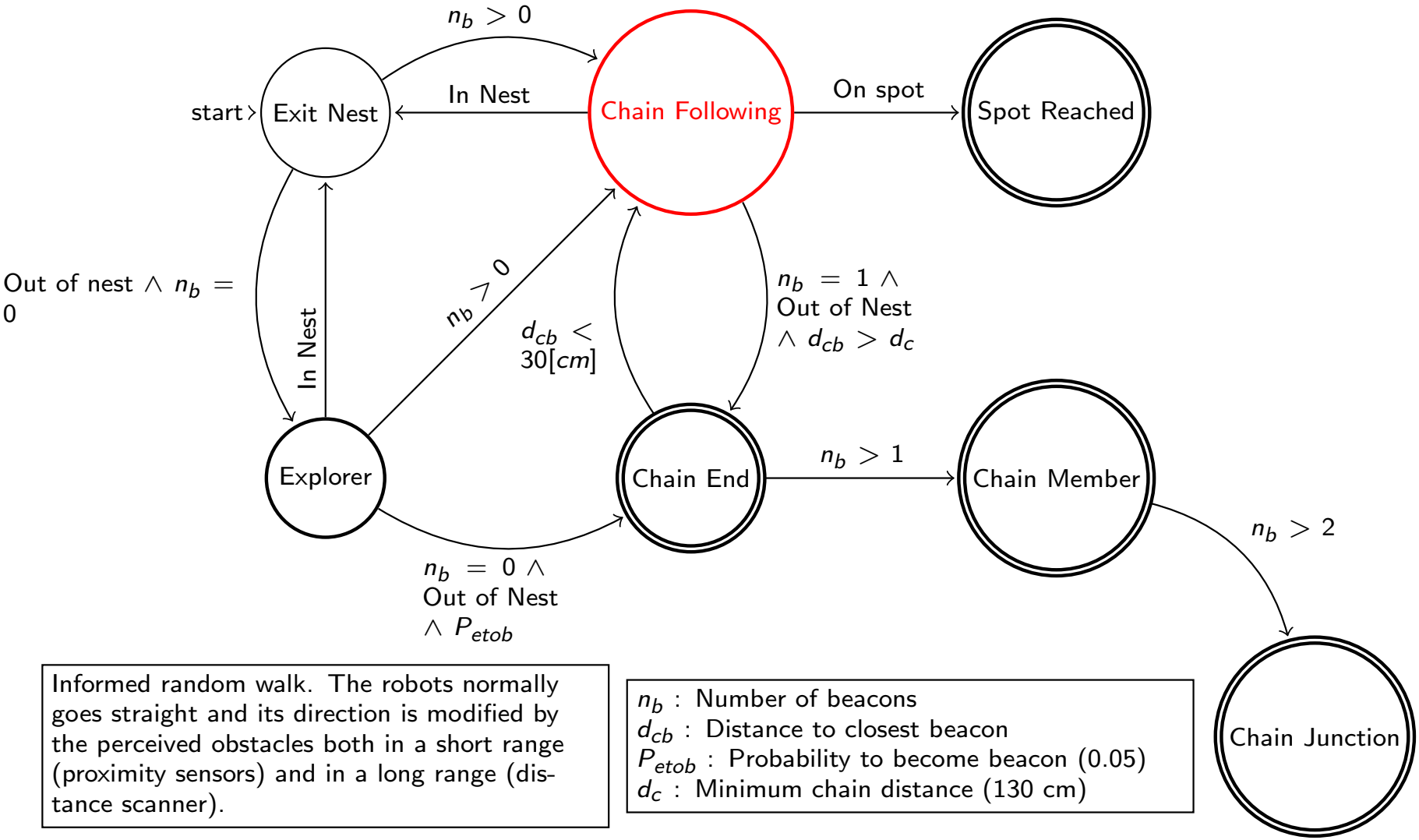
Chain beginning



If the **nest** has been **left**, and **no** chain beacon have been already **sensed**, after t_{ns} time step, decide with probability p_{btoe} to stop and become a *chain end (E)*.

n_b : Number of beacons
d_{cb} : Distance to closest beacon
P_{etob} : Probability to become beacon (0.05)
d_c : Minimum chain distance (130 cm)

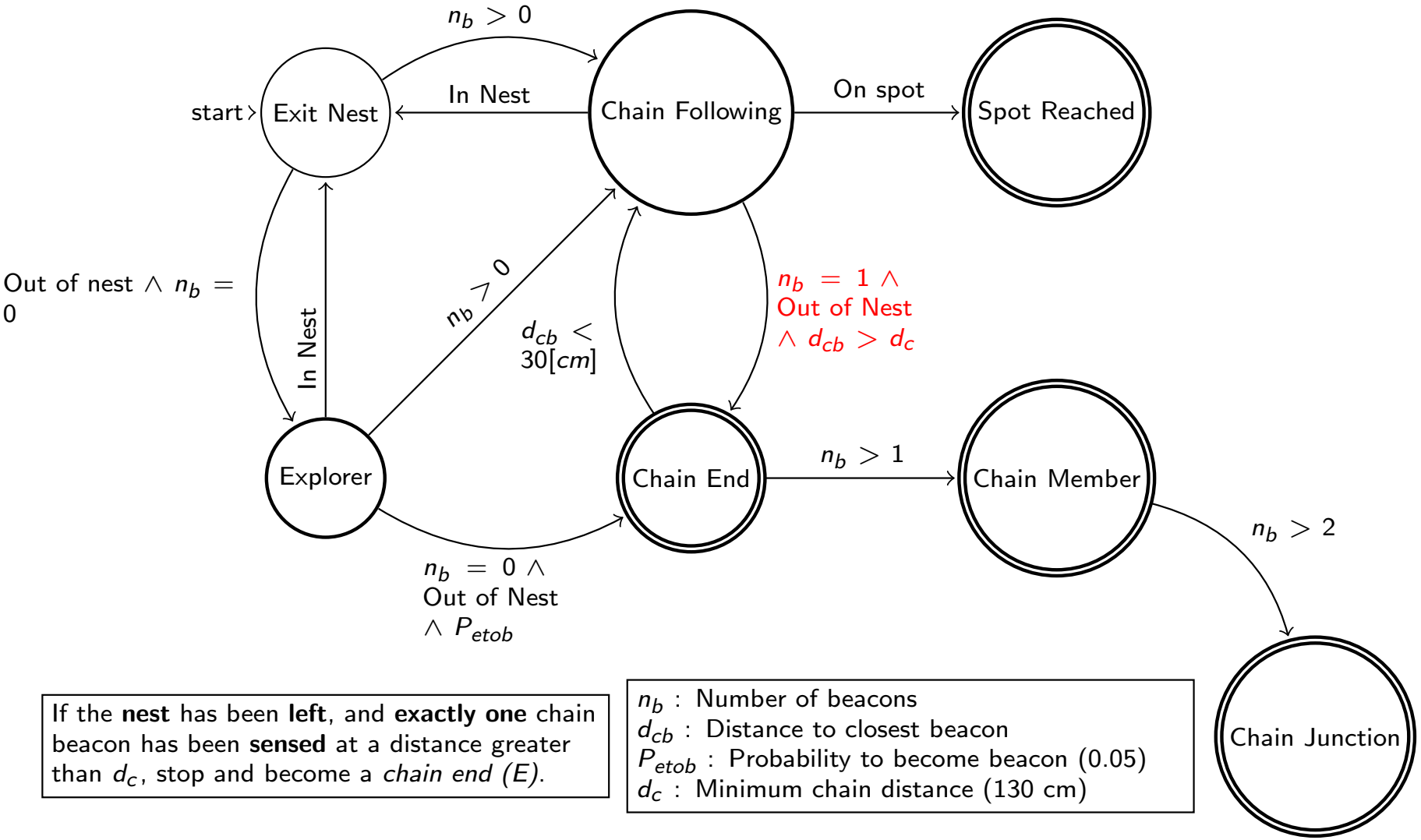
Chain following



Informed random walk. The robots normally goes straight and its direction is modified by the perceived obstacles both in a short range (proximity sensors) and in a long range (distance scanner).

n_b : Number of beacons
d_{cb} : Distance to closest beacon
P_{etob} : Probability to become beacon (0.05)
d_c : Minimum chain distance (130 cm)

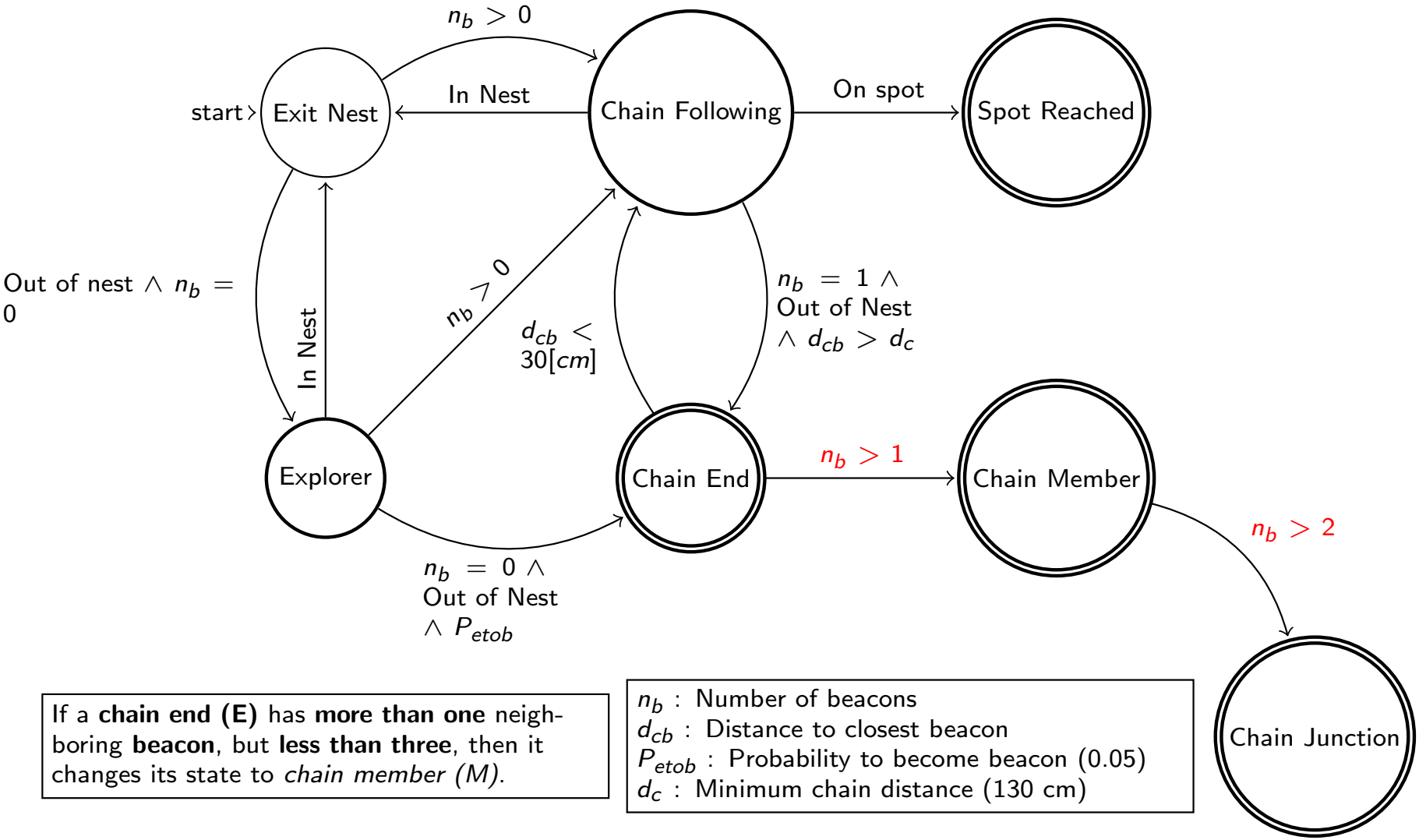
Chain building



If the **nest** has been **left**, and **exactly one** chain beacon has been **sensed** at a distance greater than d_c, stop and become a *chain end (E)*.

n_b : Number of beacons
d_{cb} : Distance to closest beacon
P_{etob} : Probability to become beacon (0.05)
d_c : Minimum chain distance (130 cm)

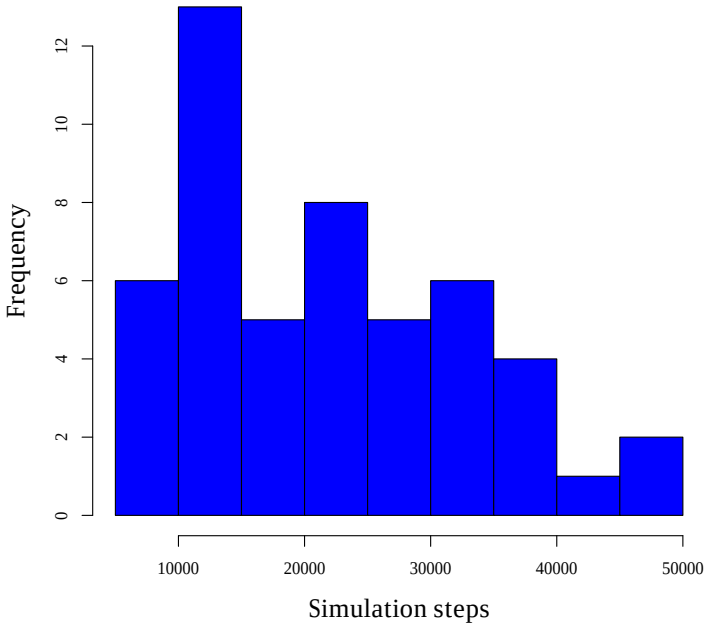
Chain updating



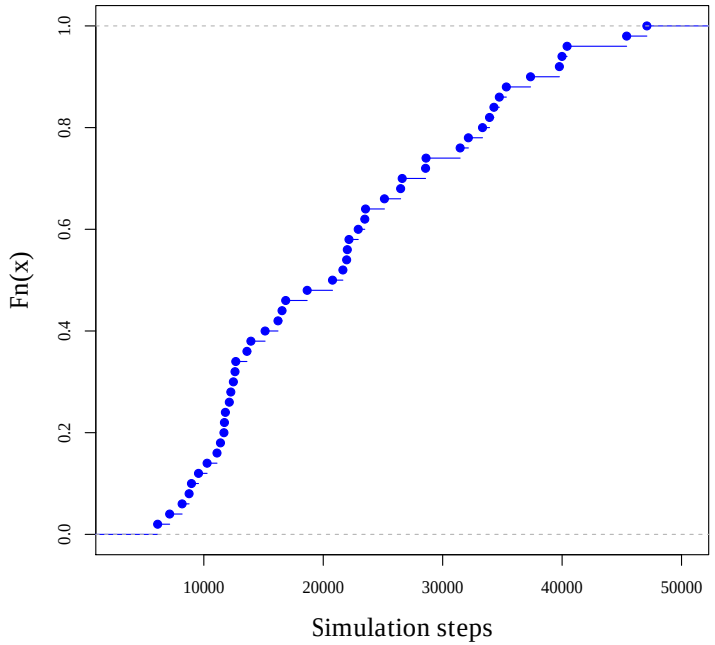
If a **chain end (E)** has **more than one** neighboring **beacon**, but **less than three**, then it changes its state to *chain member (M)*.

n_b : Number of beacons
d_{cb} : Distance to closest beacon
P_{etob} : Probability to become beacon (0.05)
d_c : Minimum chain distance (130 cm)

Completion time



(a)

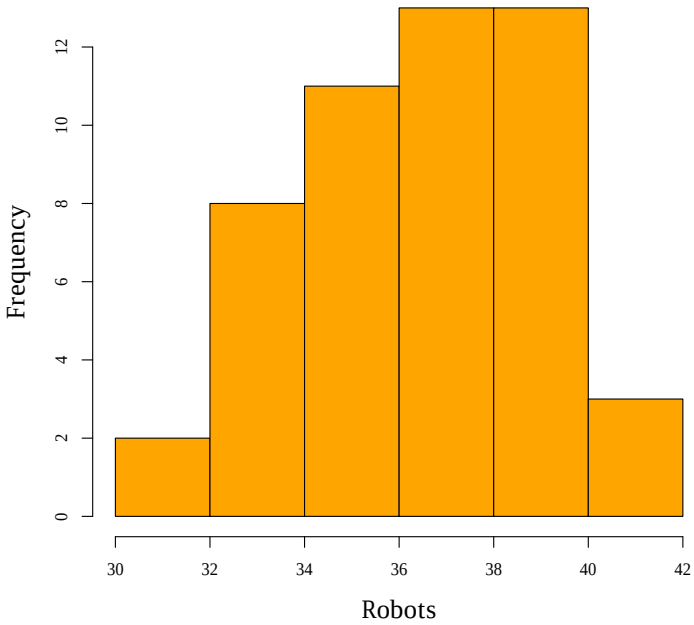


(b)

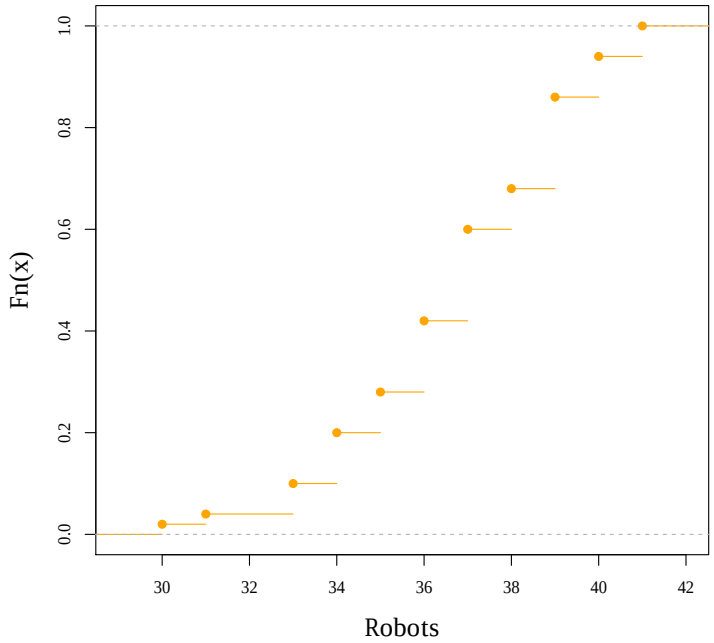
Observed distribution of the experiments' completion times over 50 trials displayed as histogram (a) and empirical cumulative density function (b).

50 Robots. RAB Range: 150[cm].

Robots in chain



(a)

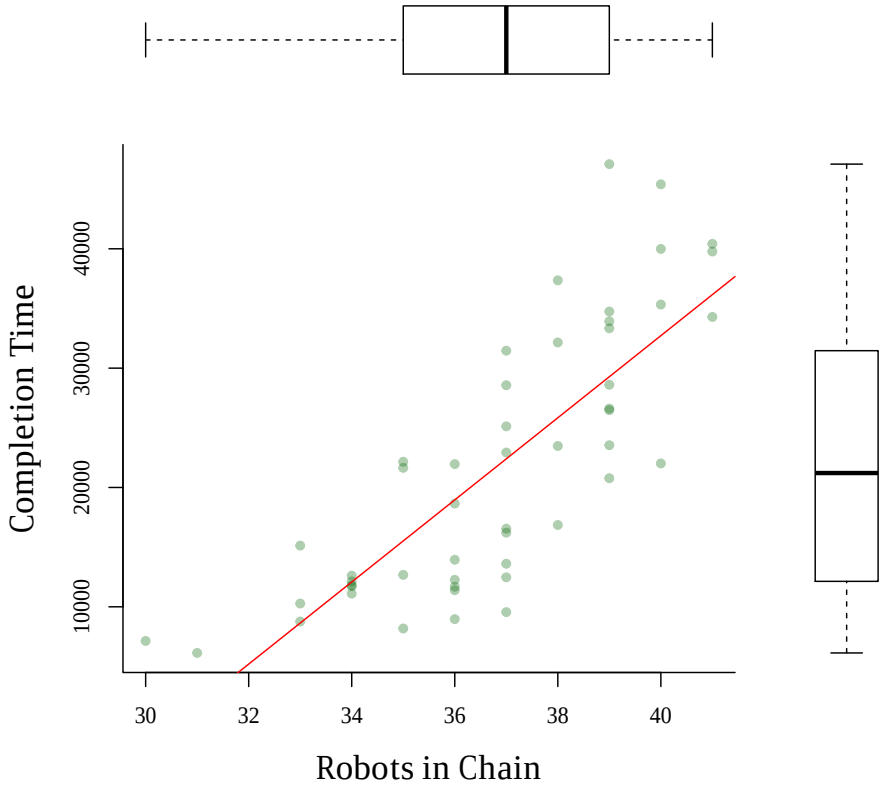


(b)

Observed distribution of the number of robots in chain over 50 trials displayed as histogram (a) and empirical cumulative density function (b).

50 Robots. RAB Range: 150[cm].

Correlation



Scatterplot of the experiments' completion times versus the number of robots in chain on 50 trials.

50 Robots. RAB Range: 150[cm]. $r = 0.7934599$.

Conclusions

- Simple method:
  - Random walk
  - Limited communication

Conclusions

- Simple method:
  - Random walk
  - Limited communication
- Here, simplicity entails:
  - Lack of placement optimality
  - High results variability

Conclusions

- Simple method:
  - Random walk
  - Limited communication
- Here, simplicity entails:
  - Lack of placement optimality
  - High results variability
- The width of the communication range impacts on:
  - Completion time
  - Number of robots in chain

Conclusions

- Simple method:
  - Random walk
  - Limited communication
- Here, simplicity entails:
  - Lack of placement optimality
  - High results variability
- The width of the communication range impacts on:
  - Completion time
  - Number of robots in chain
- Relevant impact of the structure of the environment on the method's performance.

Questions ?

References (1)

Andrew Howard, Maja J Matarić, and Gaurav S Sukhatme. Mobile sensor network deployment using potential fields: A distributed, scalable solution to the area coverage problem. In *Distributed Autonomous Robotic Systems 5*, pages 299–308. Springer, 2002.