# INFO-H-414 - Swarm Intelligence

## Swarm Robotics - Chain Formation Strategy

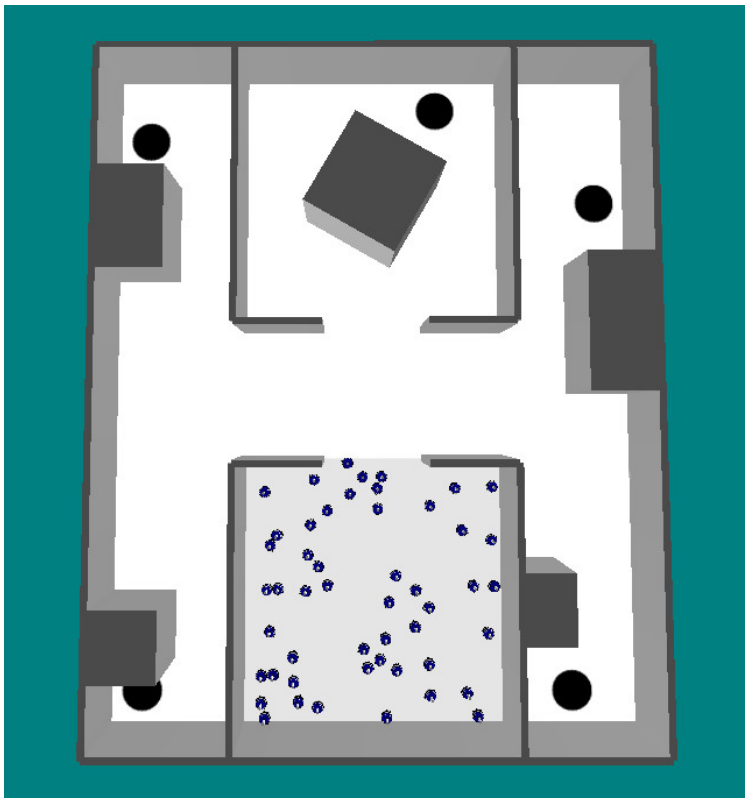

Jacopo De Stefani

Universite' Libre de Bruxelles

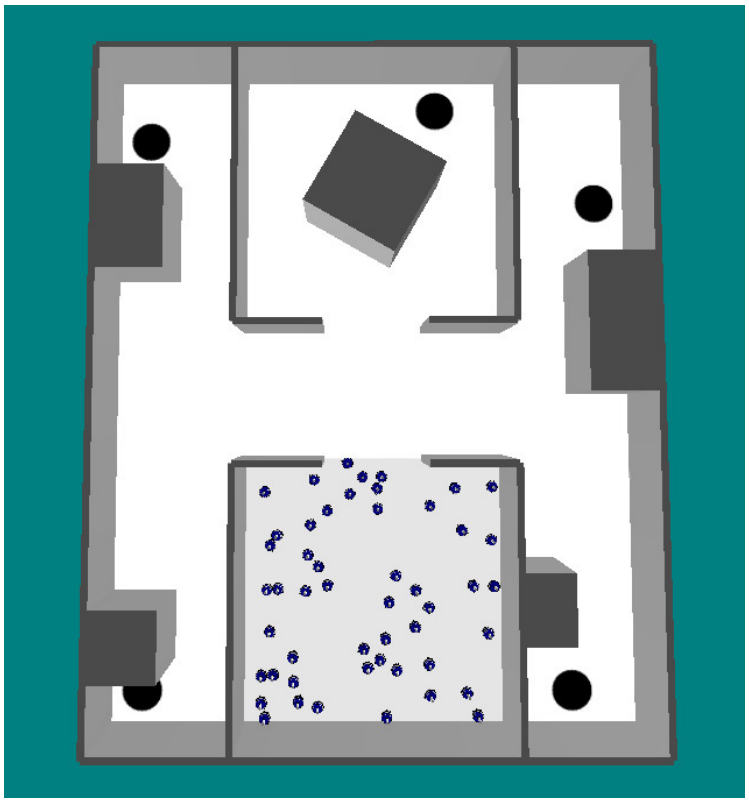
August 27, 2013

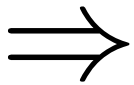

ECOLE
POLYTECHNIQUE
DE BRUXELLES

# Introduction

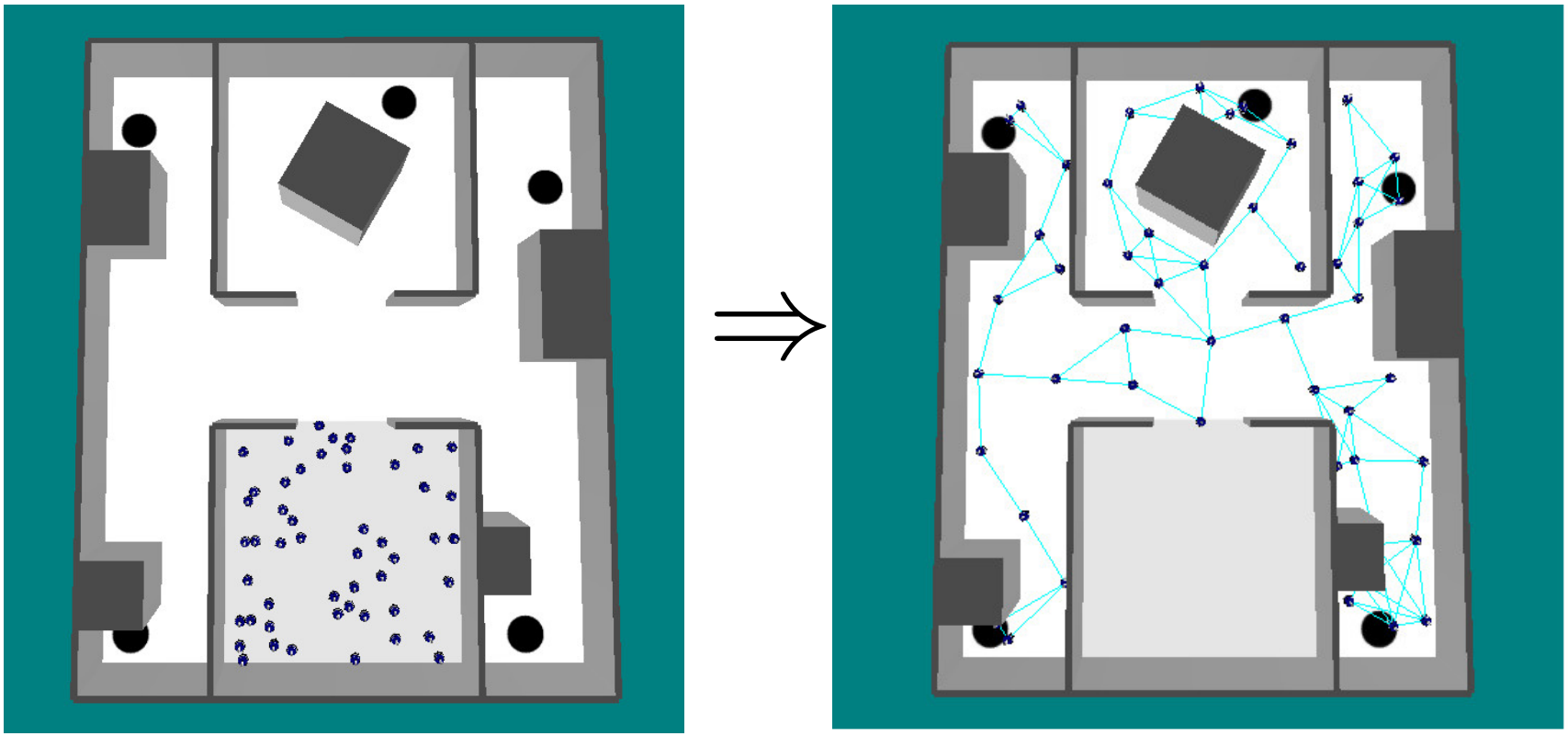


# Introduction





# Introduction



# What does the method use?

ULB ECOLE POLYTECHNIQUE DE BRUXELLES

## Sensors

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

## Actuators

- Wheels
- Range and Bearing

# What does the method use?

ULB ECOLE POLYTECHNIQUE DE BRUXELLES

## Sensors

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

## Actuators

- Wheels
- Range and Bearing

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

# What does the method use?

ULB ECOLE POLYTECHNIQUE DE BRUXELLES

**Sensors**

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

**Actuators**

- Wheels
- Range and Bearing

- *Sense*, *Think*, *Act* paradigm
- Potential-fields approach [HMS02]

# Chain example

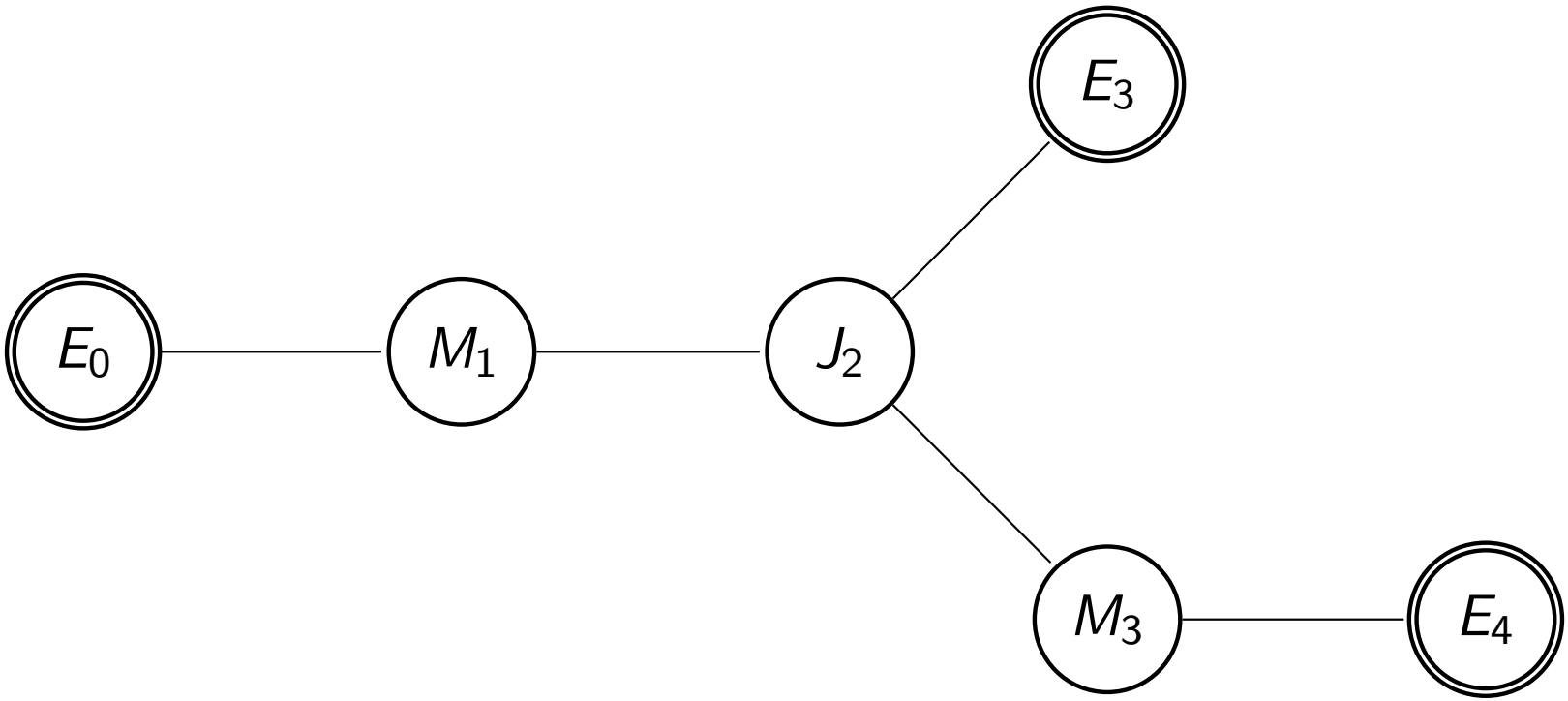



Figure: Chain example with nodes labeling and id

# Chain example

The chain identifier of a new beacon is determined by incrementing of one unit the chain id of the closest beacon.

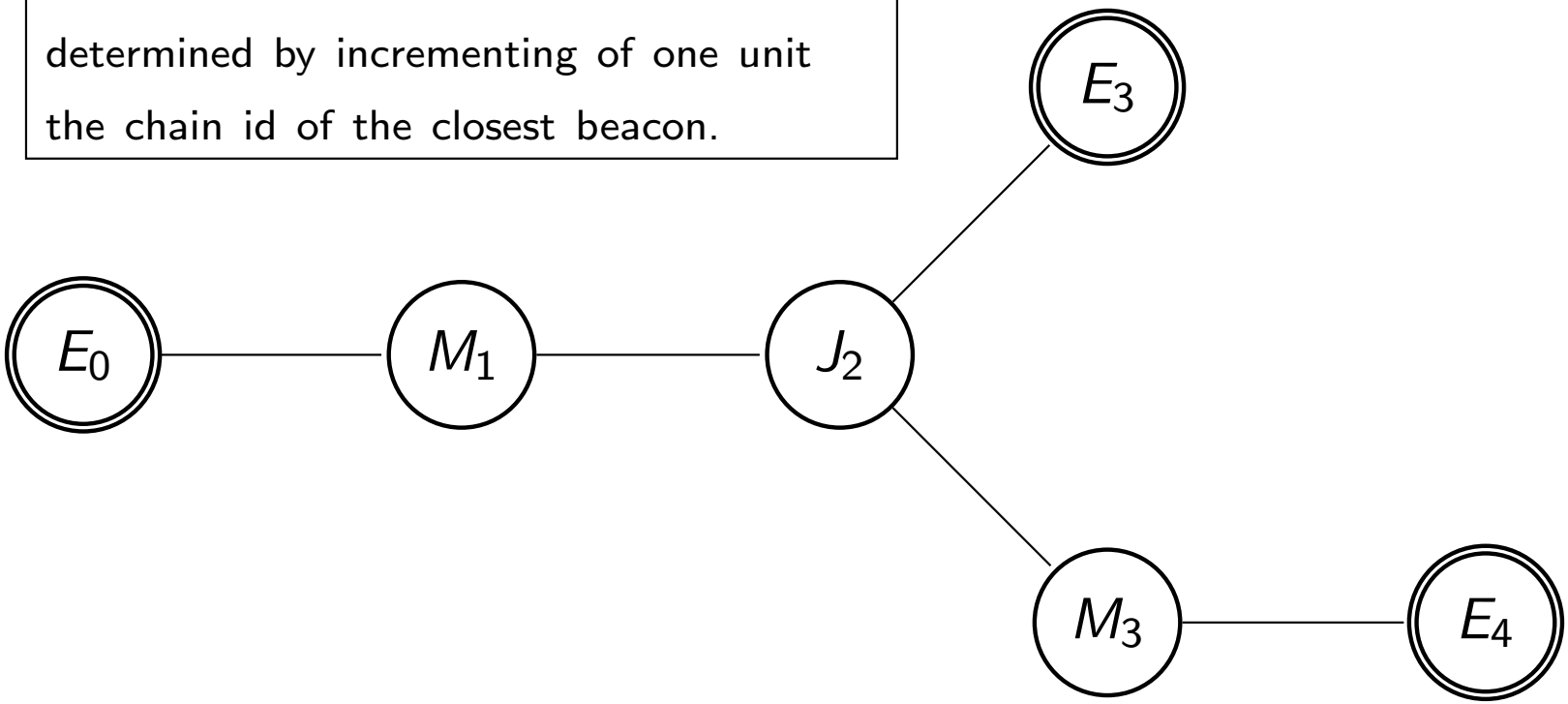


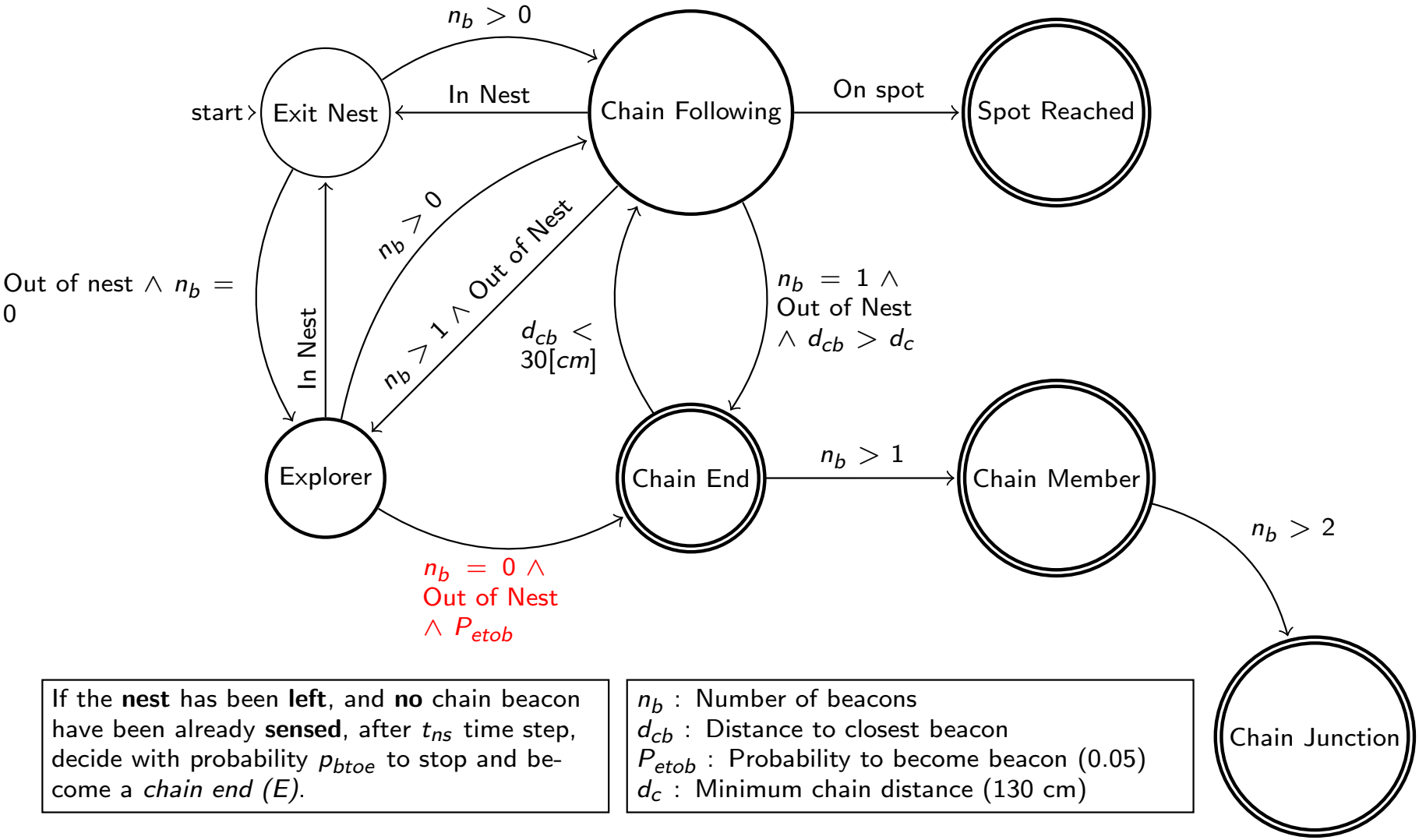

Figure: Chain example with nodes labeling and id

ECOLE POLYTECHNIQUE DE BRUXELLES

# Rules

1. Chain beginning rule
2. Chain building rule
3. *Chain end* to *Chain member* transition
4. *Chain member* to *Chain junction* transition

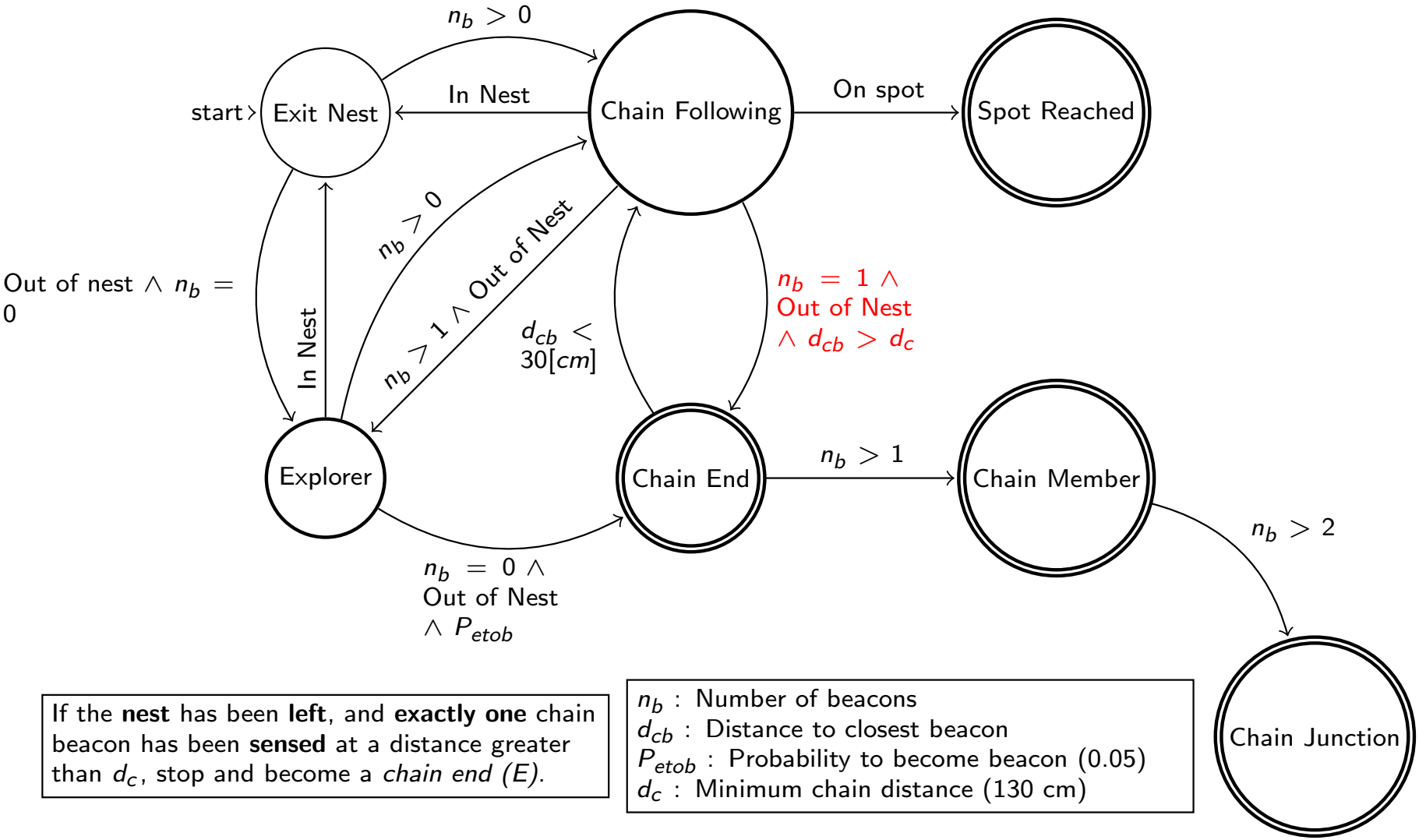
# Chain beginning rule




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)

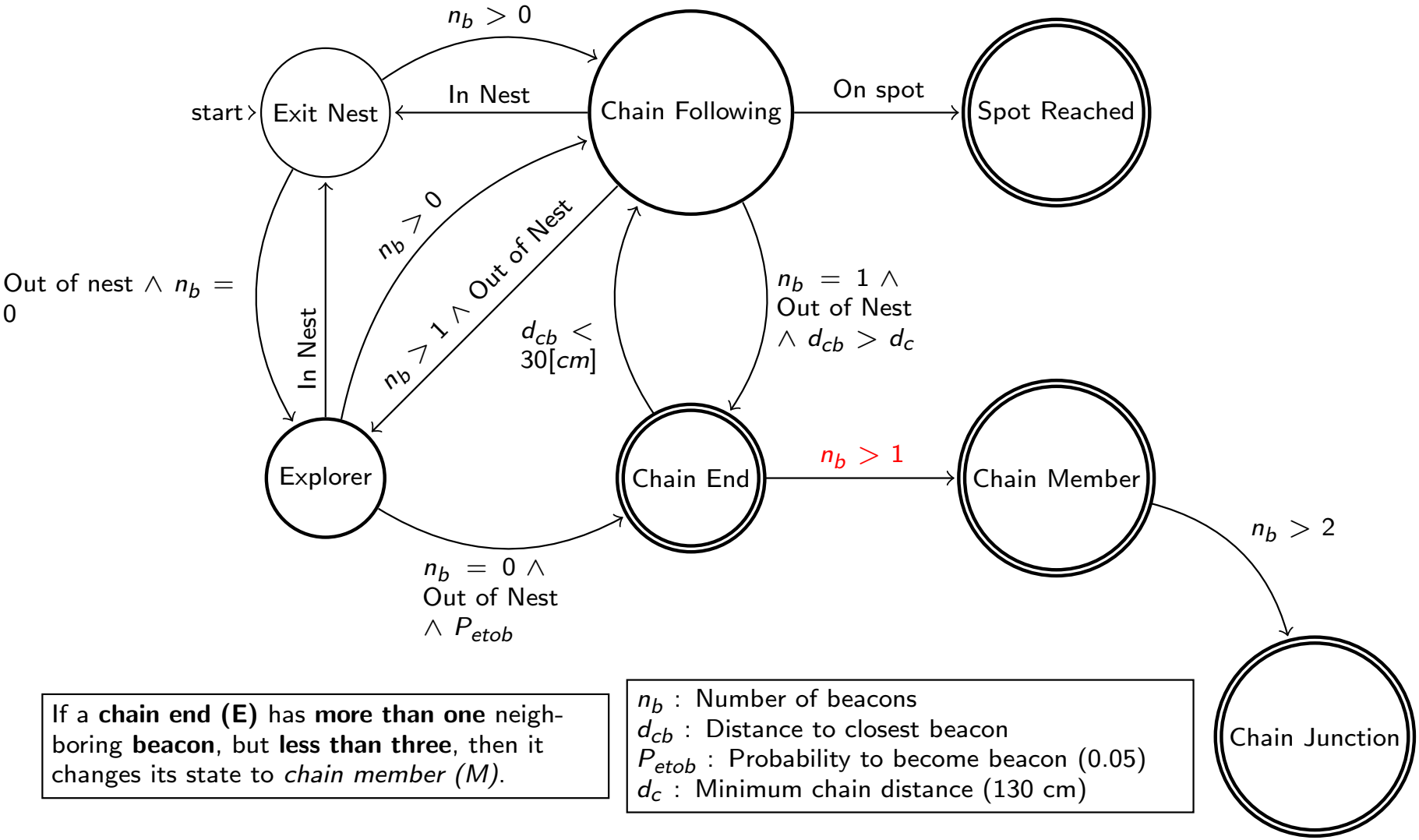
# Chain building rule




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)

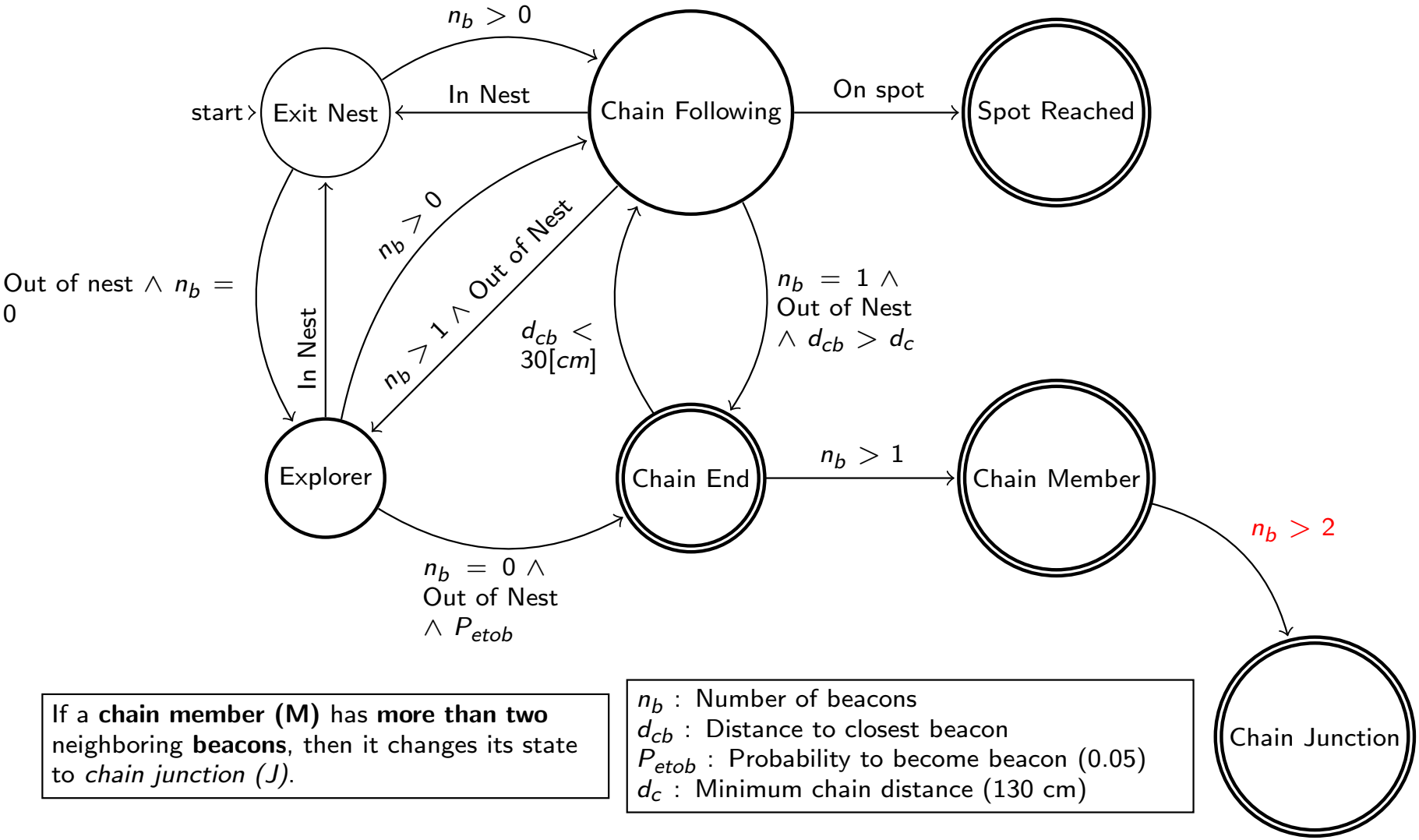
# End to Member




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)

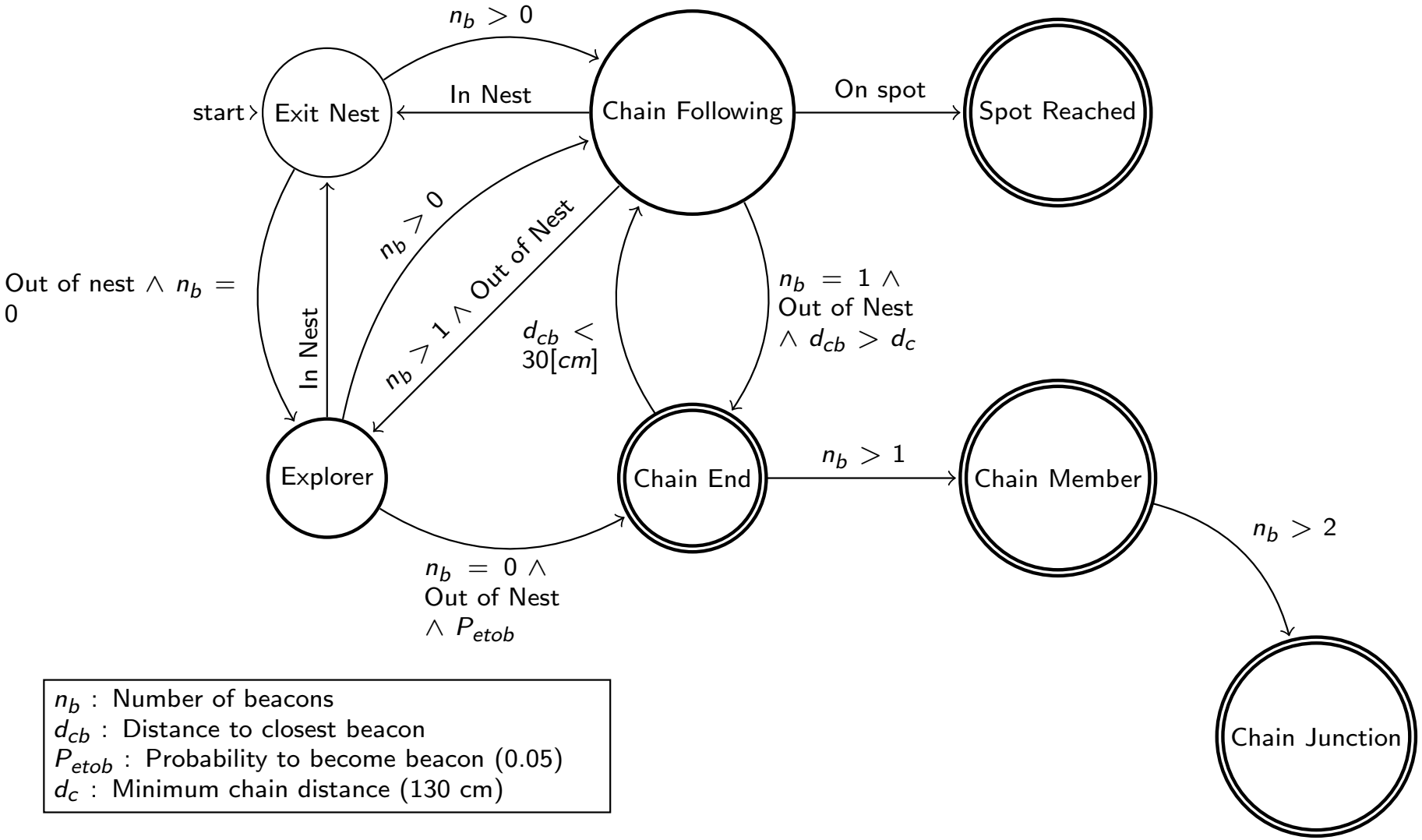
# Member to Junction




If a **chain member (M)** has **more than two** neighboring **beacons**, then it changes its state to *chain junction (J)*.

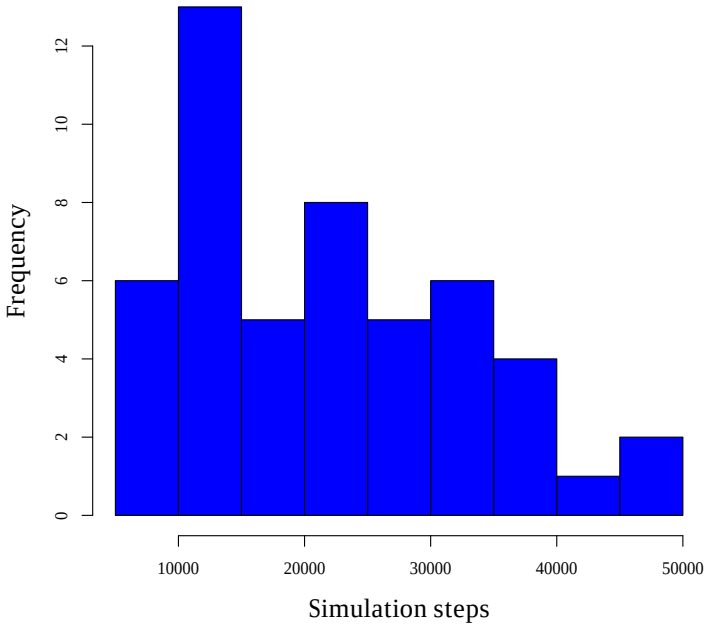
$n_b$ : Number of beacons
$d_{cb}$ : Distance to closest beacon
$P_{etob}$ : Probability to become beacon (0.05)
$d_c$ : Minimum chain distance (130 cm)

# Probabilistic FSM

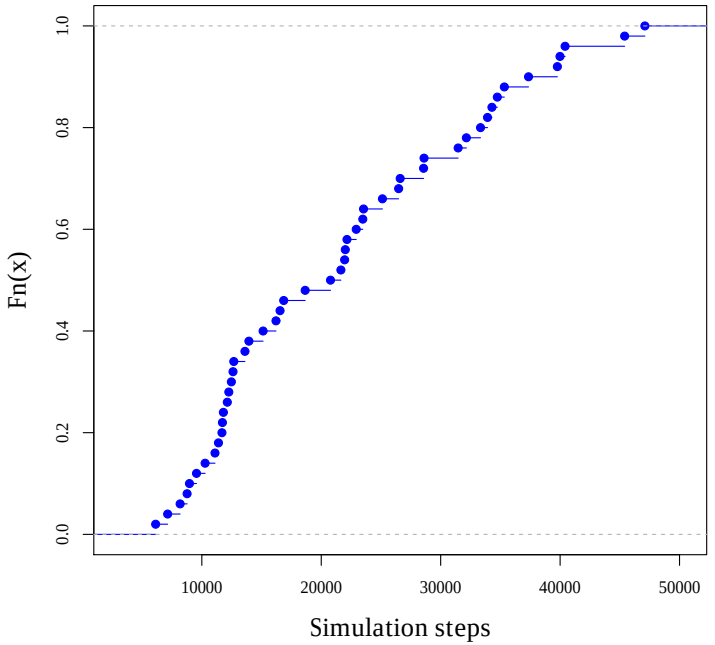



$n_b$ : Number of beacons
$d_{cb}$ : Distance to closest beacon
$P_{etob}$ : Probability to become beacon (0.05)
$d_c$ : Minimum chain distance (130 cm)

# Robots in chain



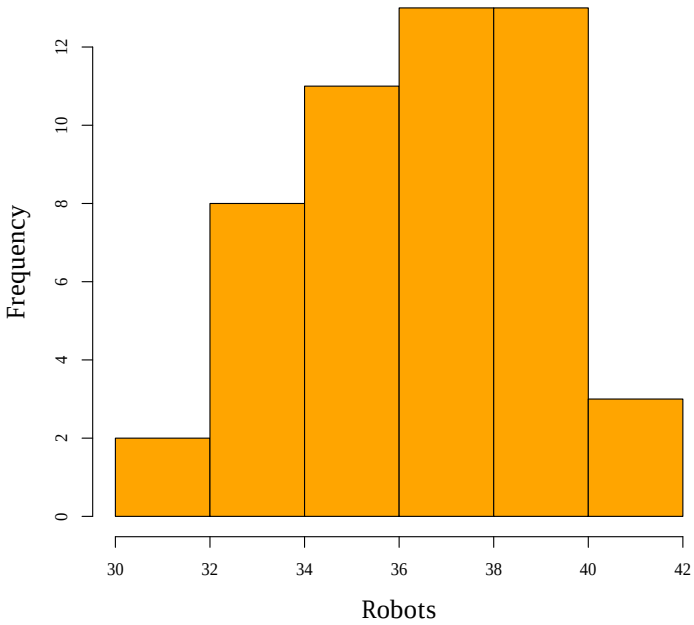

(a)



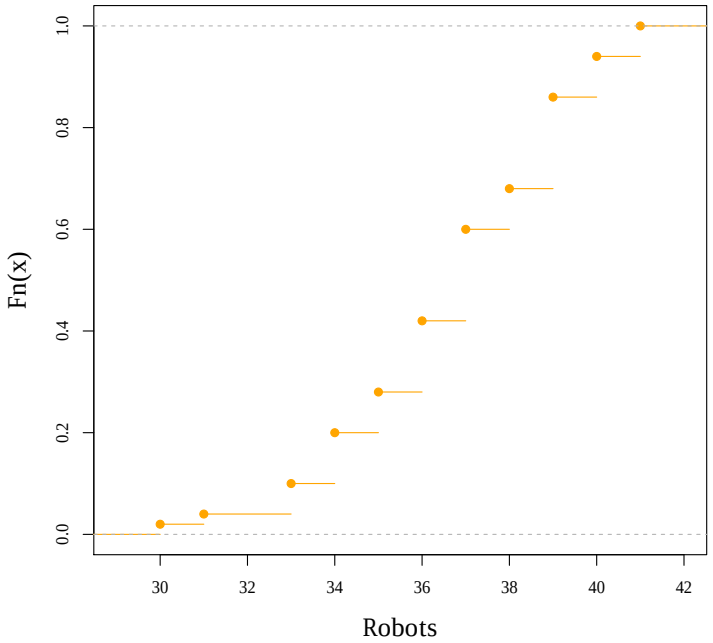

(b)

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

# Completion time




(a)




(b)

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

# Correlation

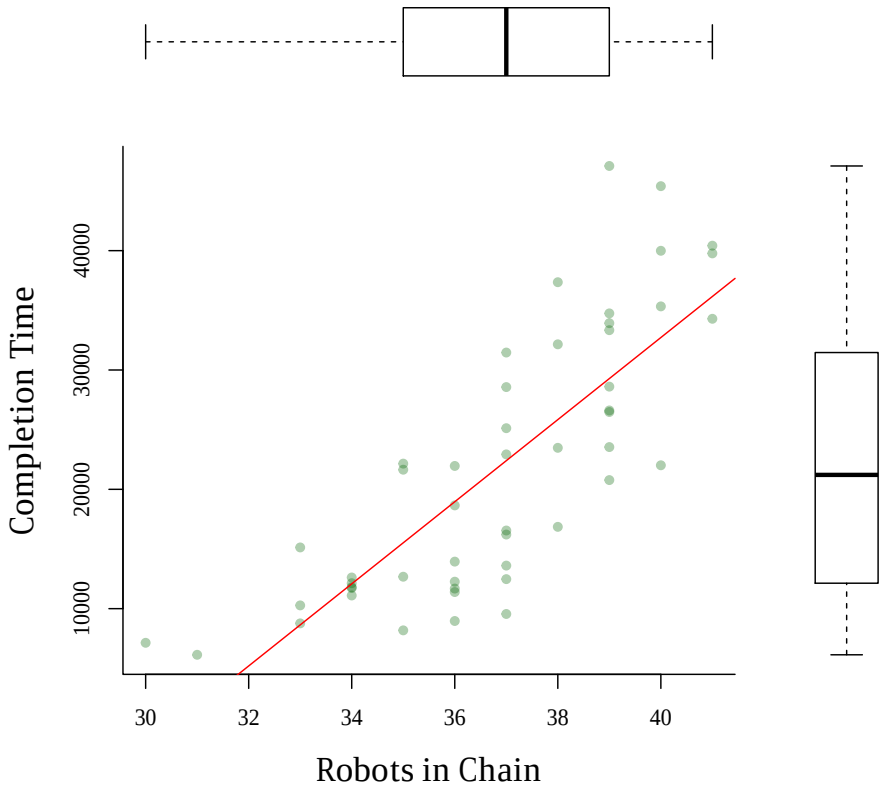



Figure: Scatterplot of the experiments' completion times versus the number of robots in chain on 50 trials. $r = 0.7934599$

# 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.