University of Pavia
Department of Computer Science and Systems
Robotics Laboratory

t-bots: a coordinated team of mobile units for searching and occupying a target area at unknown location

Tullio Facchinetti
<tullio.facchinetti@unipv.it>

Overview

- the behavior is based on a Finite State Machine (FSM) that controls the operational modes of each *t-bot*
- the mobility strategy is strongly based on location-awareness;
- location-awareness allows to implement the go-to-point strategy, which is the building block of most operational modes
- the communication is used to broadcast very essential information, useful to update the operational mode of each *t-bot*

Background ideas (and constraints)

t-bots do not implement complex features like mapping or recostruction of the environment

focus on simple mobility and communication strategies that take into account

- the availability of multiple robots
- the size of the arena
- the fact that each run of the simulation will not make use of information collected during previous runs
- ... and the lack of time to develop complex strategies (one-man-project started less than 1 month ago)
- leading in scarce time for testing and fine tuning :-(

The Finite State Machine

1. QUEST: the robots move around the arena independently, on predefined paths, searching for the beacon transmitter
2. BEACON FOUND: the robot found the beacon transmitter, or it has received such information from other robots
3. GROUND FOUND: the robot has received the information about the exact location of the target area from other robots
4. GROUND ACCESS: the robot is over the target area, waiting and performing suitable operations to allow all the robots to access the area

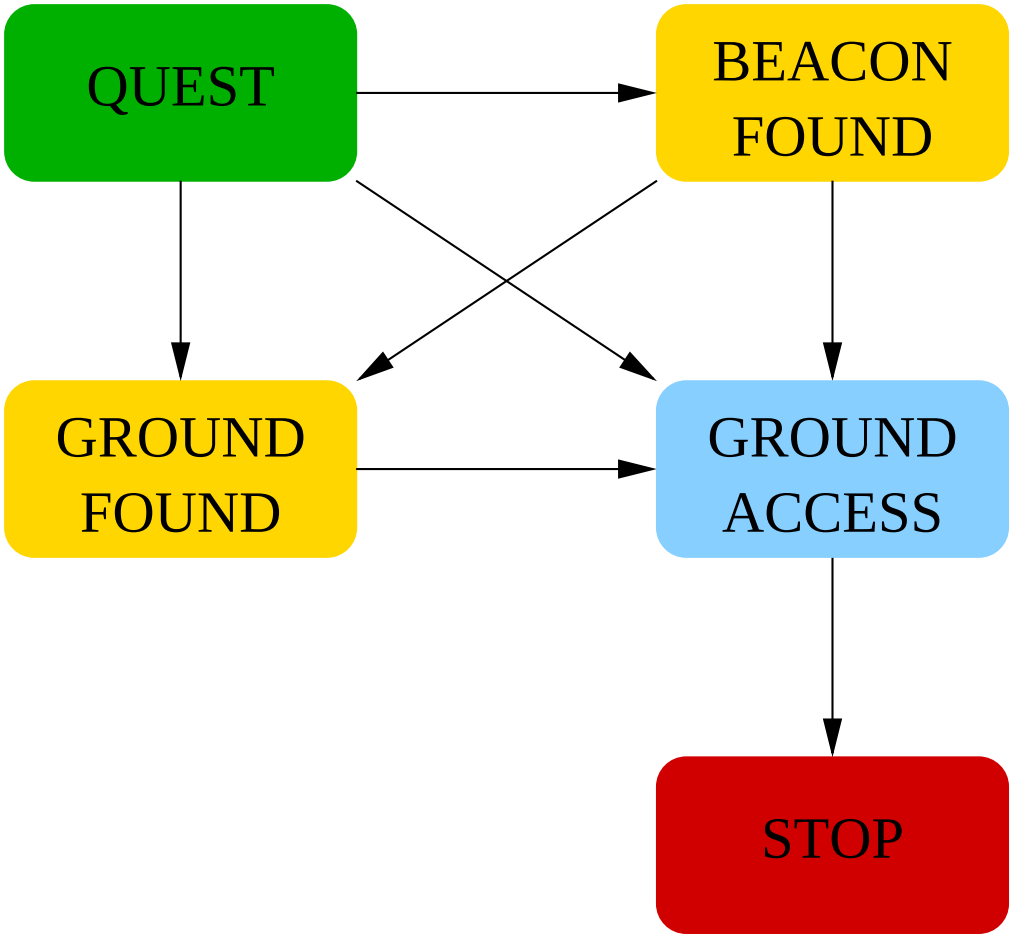
The Finite State Machine

- at the beginning the 5 robots move around the arena, following a path made by a sequence of predefined target locations
- this behavior gives the probabilistic chance to become in contact with the beacon signal
- when one of the robots become in contact with the beacon transmitter, it starts broadcasting the current location and direction to the beacon
- goes towards a new location which is an estimation of the beacon trasmitter location, calculated from the robot's current location and moving into the direction to the transmitter

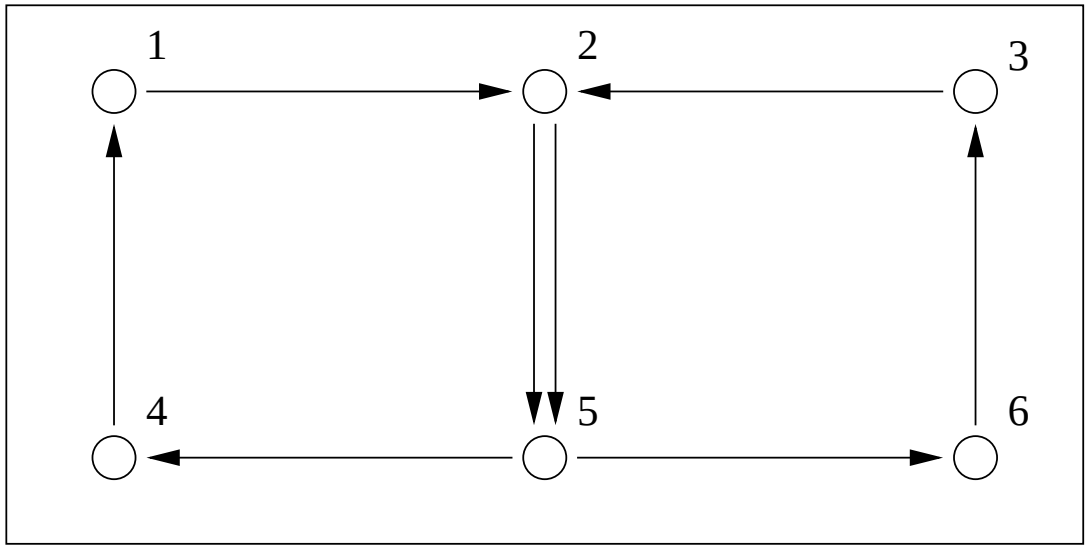
The Finite State Machine

- if a robot enters the target area, it starts broadcasting the exact location
- when a robot receives whether the estimated or the exact location of the target area, it moves towards such location
- when a robot enters the target area, it waits until all robots have also entered, to allow an entering strategy that allows all robots to enter

The Finite State Machine



The path while in QUEST mode



- due to the arena's size, five robots can cover large part of the arena if they are sufficiently spreaded
- the beacon transmission range is large with respect to the arena's size
- the radio transmission range is also large with respect to the arena's size, allowing a reasonable level of connectivity while travelling the arena

BEACON FOUND mode

information kept for driving the robots:

- the location where the beacon has been detected (x_{bcn}, y_{bcn})
- the direction towards the beacon transmitter d_{bcn}, which is the only information retrieved from the beacon sensor

using such information, the robot sets an intermediate goal equal to (x_{estim}, y_{estim}) as follows

$$x_{estim} = x_{bcn} + dist * \cos(d_{bcn})$$

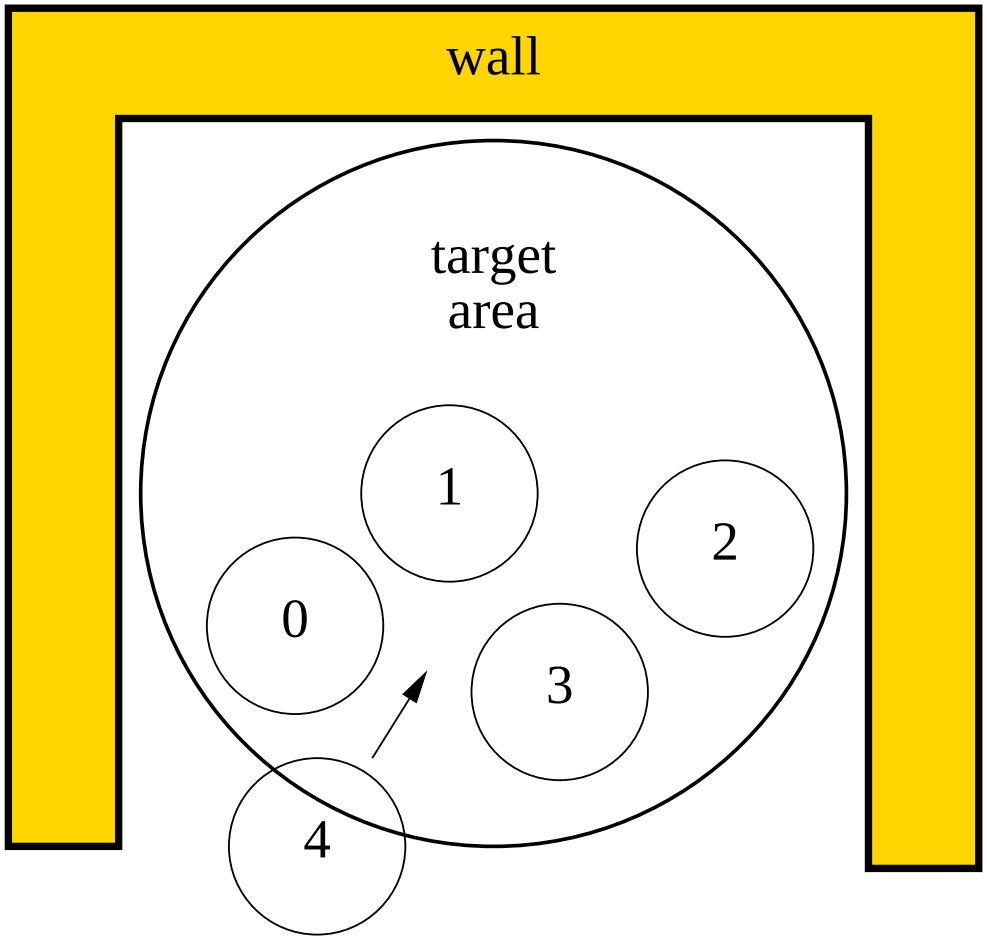
$$y_{estim} = y_{bcn} + dist * \sin(d_{bcn})$$

- fixed distance ahead the robot
- uses the go-to-point function to reach it
- if target area is crossed, switch GROUND ACCESS

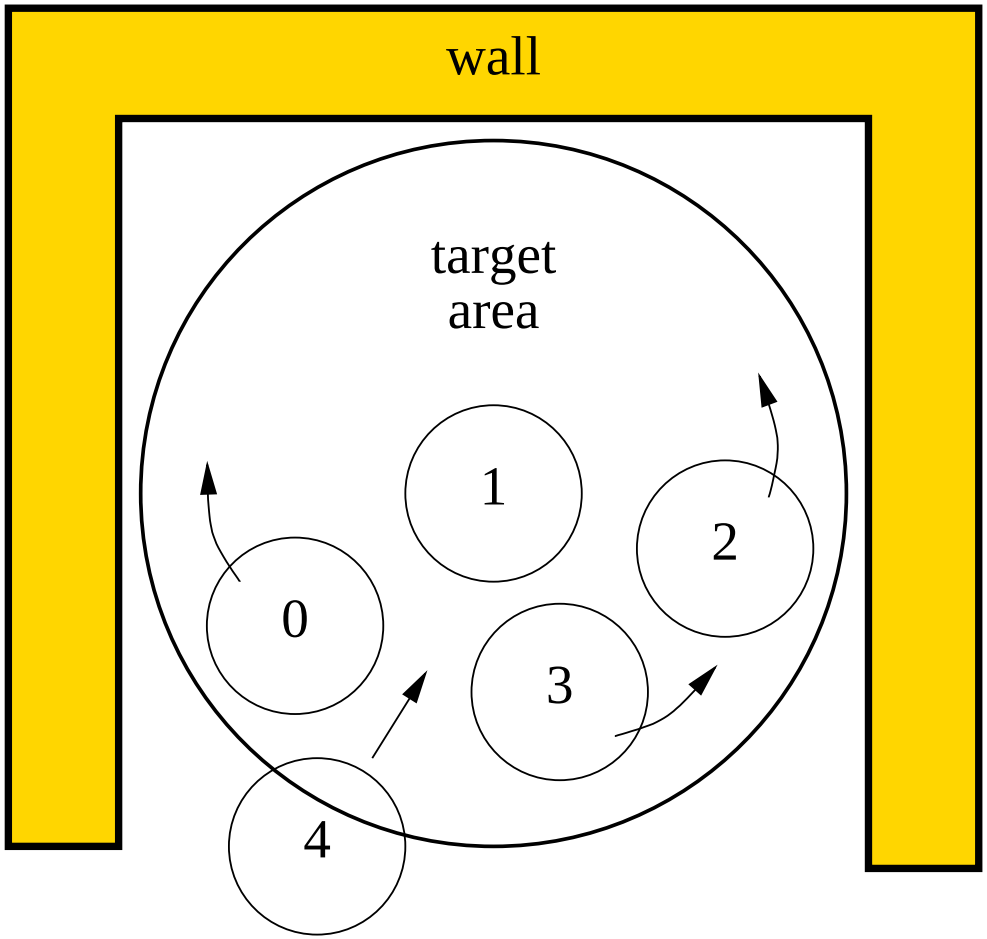
GROUND FOUND mode

- very similar to the BEACON FOUND mode
- the robot sets a goal point to be reached using the go-to-point algorithm
- the robot has the information about the exact location of the goal
- can only entered upon the reception of information from other robots
- when a robot actually enters the target area, it switches to the GROUND ACCESS mode

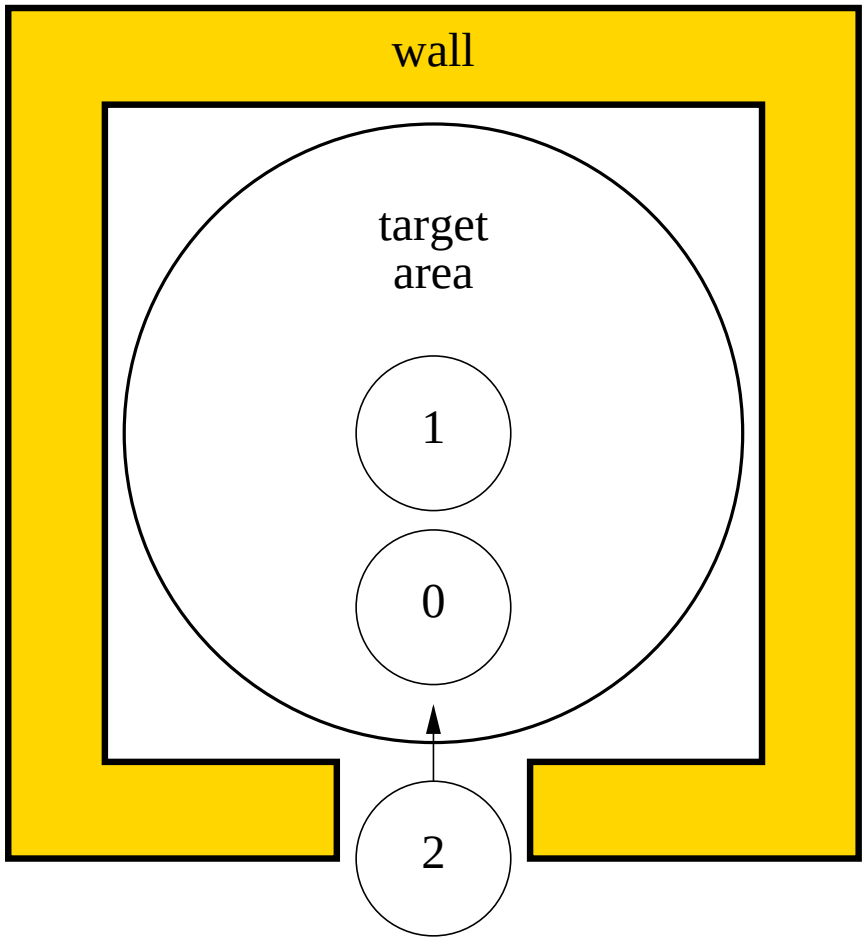
Example of locking...



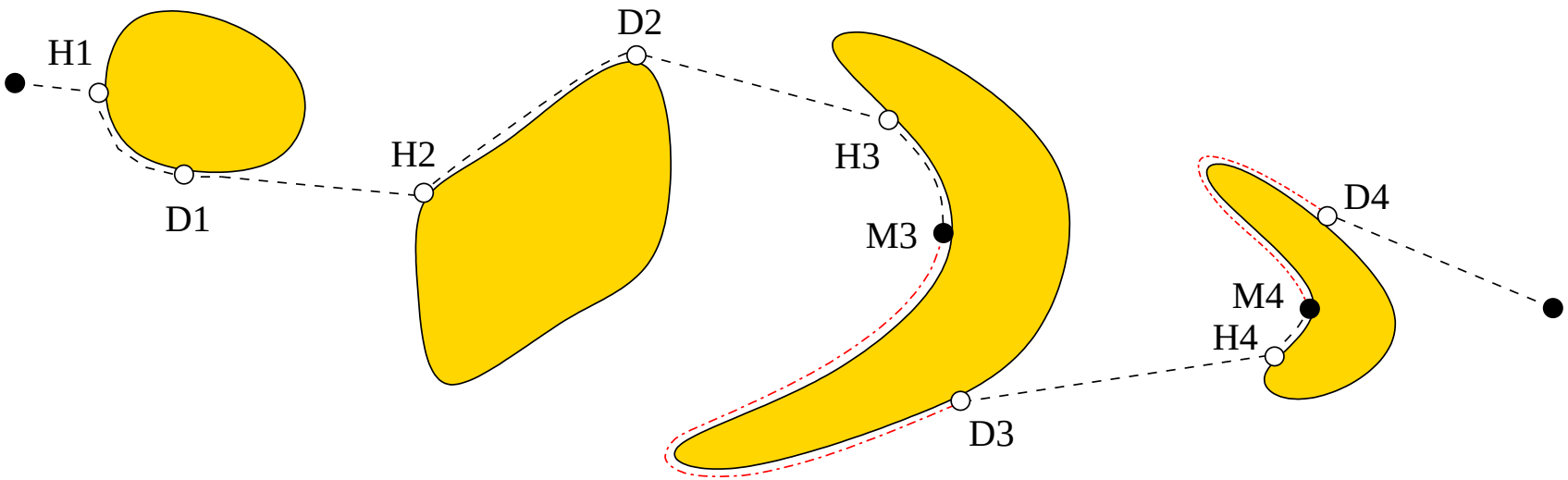
...an unlocking strategy...



...and a bad situation not yet covered



The go-to-point algorithm: tangent bug



- motion-to-goal until the distance to the goal decreases, otherwise switch to boundary following
- boundary-following until the distance is closer to the hitting distance

H. Choset and K. M. Lynch and S. Hutchinson and G. Kantor and W. Burgard and L. E. Kavraki and S. Thrun, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Intelligent Robotics and Autonomous Agents, The MIT Press, 2005.

The communication

1. the FSM state and a *bit mask*, to infer current sender's behavior
2. the sender's location
3. (x_{bcn}, y_{bcn}) and d_{bcn}, (BEACON FOUND mode only)
4. node's co-ordinates when it is over the ground area
5. the current direction of the robot towards the beacon trasmitter, (GROUND ACCESS mode only)
6. the ground flag, to determine if all the robots are over the target ground

- a set of bits to indetify whose robots are aware of the beacon detection
- the same for the ground detection
- a bit indicating whether the leader has been elected
- a bit that indicates that the robot is the leader