NOKIA Bell Labs

Inria

Coordinating a Swarm of Micro-Robots

ication

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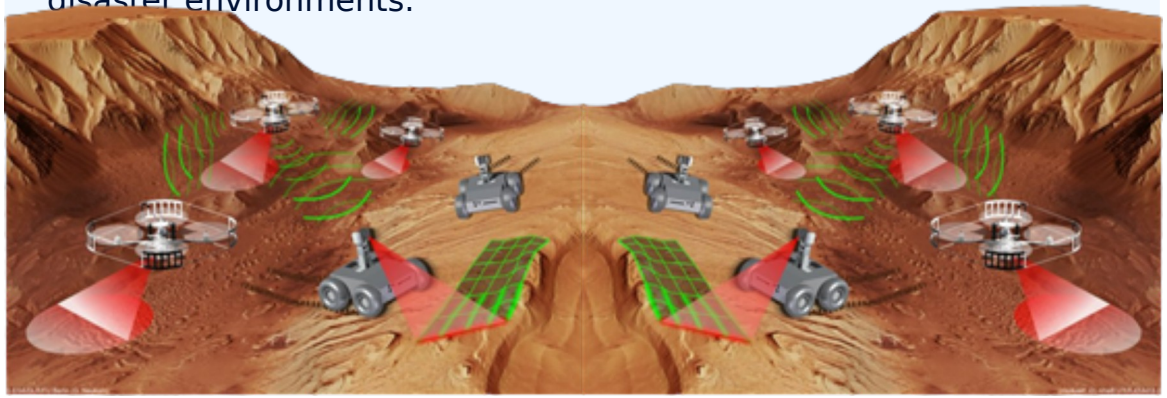
Swarm Robotics

- **A Robotic Swarm** is a potentially large number of robots that carry out a task together, either because it cannot be carried out by a single robot, or it can be done more efficiently by a swarm.

- **Applications** for robotic swarms include carrying equipment throughout a warehouse, collaboratively repairing inaccessible structures, and localizing underground hazards or victims in post disaster environments.

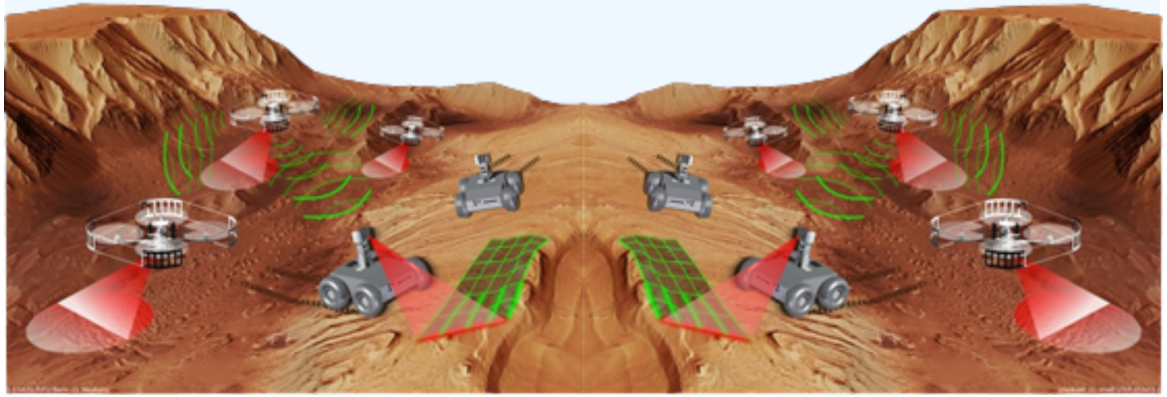


Nowak, *et al.*, “Martian Swarm Exploration and Mapping using Laser SLAM”, ISPRS, 2013.

Exploration and Mapping

- We envision swarms of mm-scale micro-robots to be able to carry out critical missions such as **exploration and mapping** for hazard detection and search and rescue.

- These missions share the need to reach **full coverage** of the explorable space and build a complete map of the environment.



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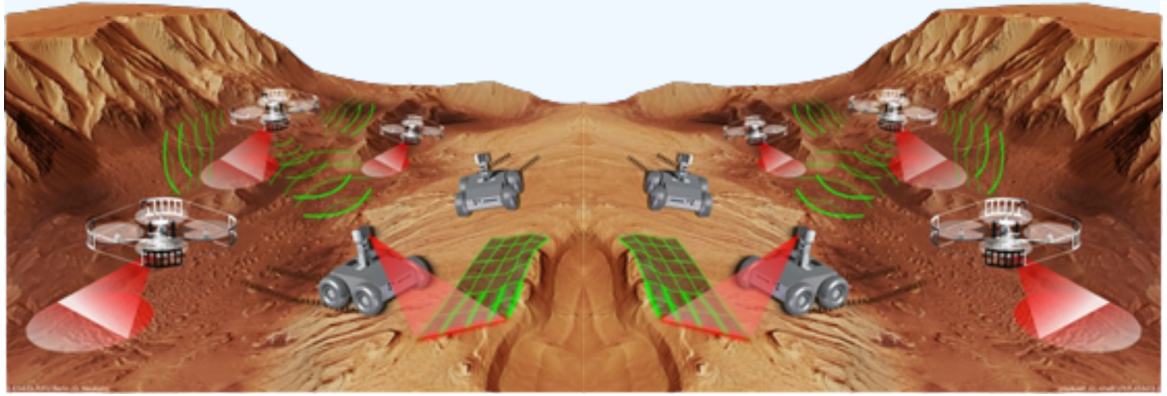
Coordination and Communication

- To minimize completion time, robots in the swarm must be able to exchange information about the environment with each other.
- Communication between swarm members is often assumed to be perfect.
- Perfect communications do not reflect real-world conditions, where impairments can affect the quality of the wireless links.



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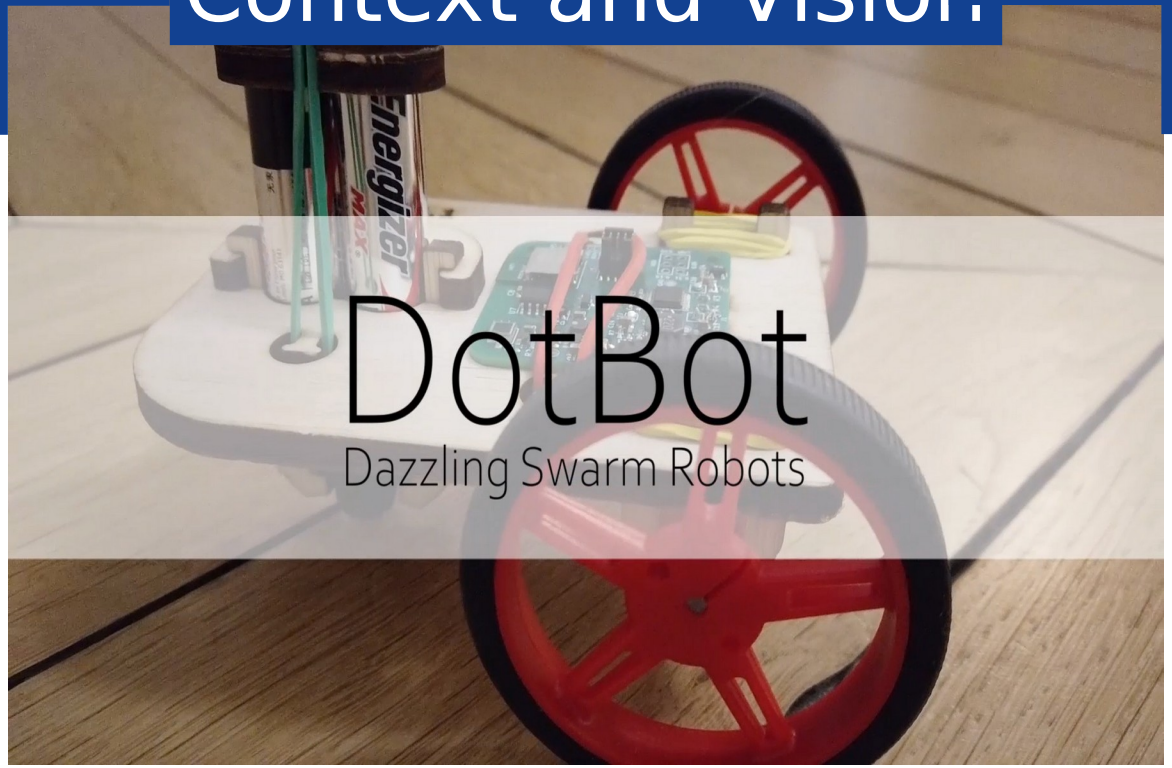
Context and Vision



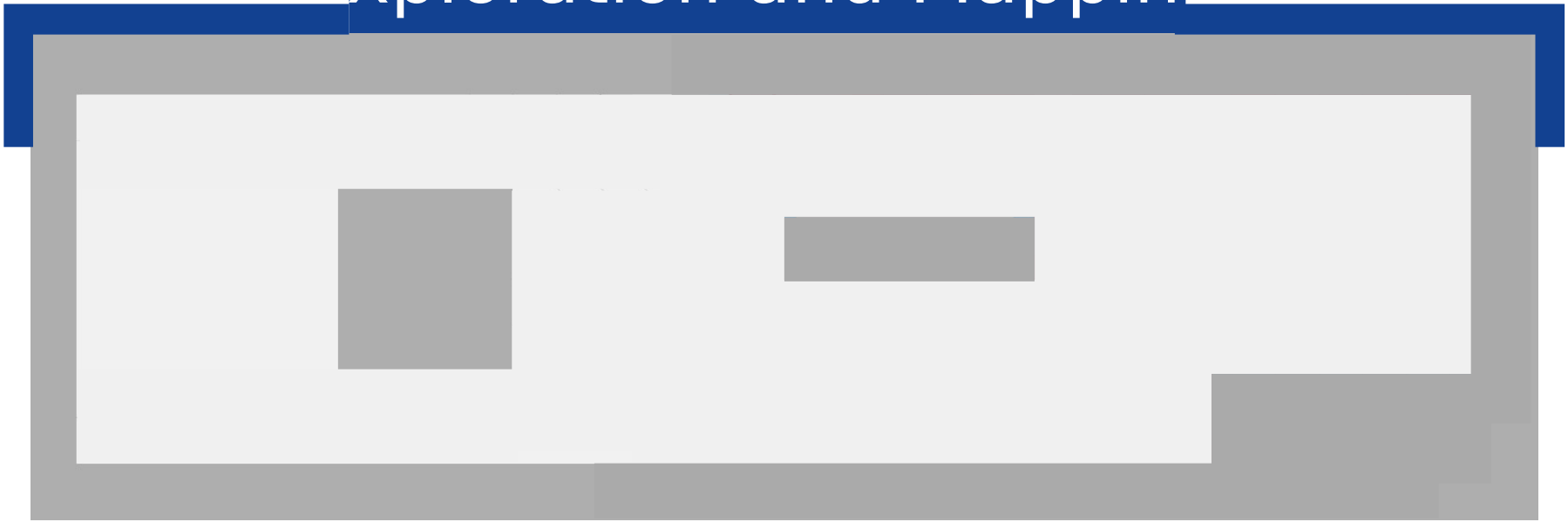
Objectives

- To study the relationship between a swarm of robots and the environment they are in and evaluate how that affects the overall performance of the swarm.
- To use this understanding to build better algorithms that are more robust and that perform better.

Atlas Algorithm and Simulator

- We built our own open-source simulator to test out the algorithms we design
- We designed an exploration and mapping algorithm for a coordinated swarm of robots

xploration and Mappin



Initially environment is fully unknown to robots (all cells are unexplored)

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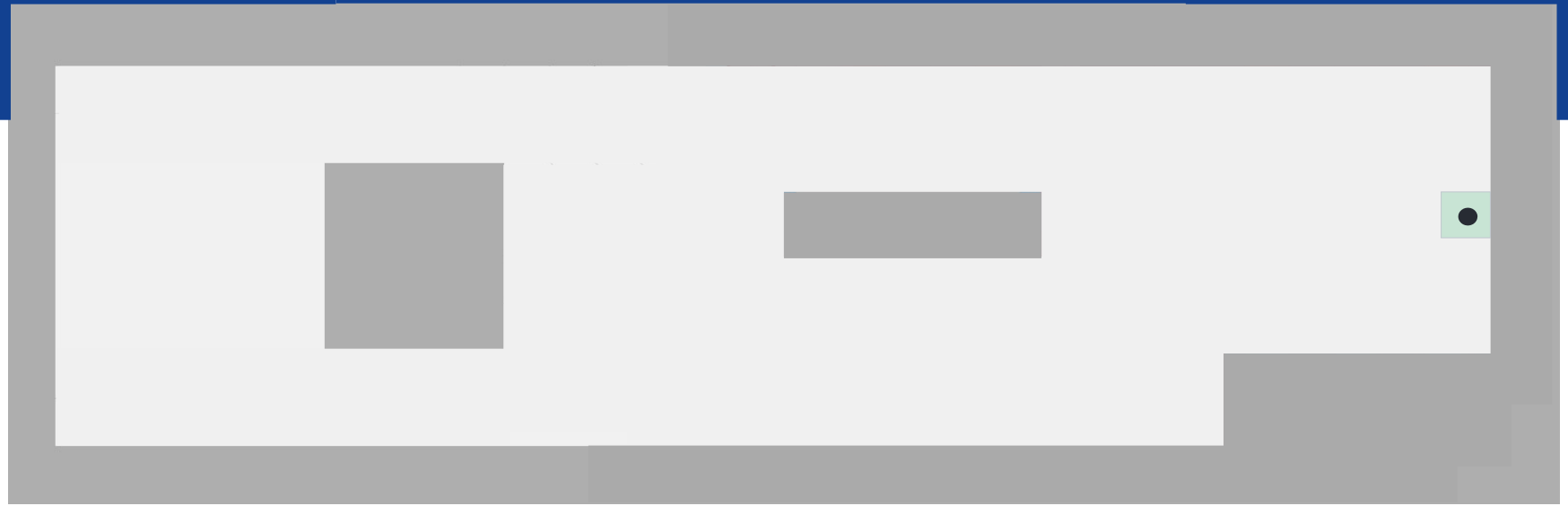

First position robot covers is set as an open cell

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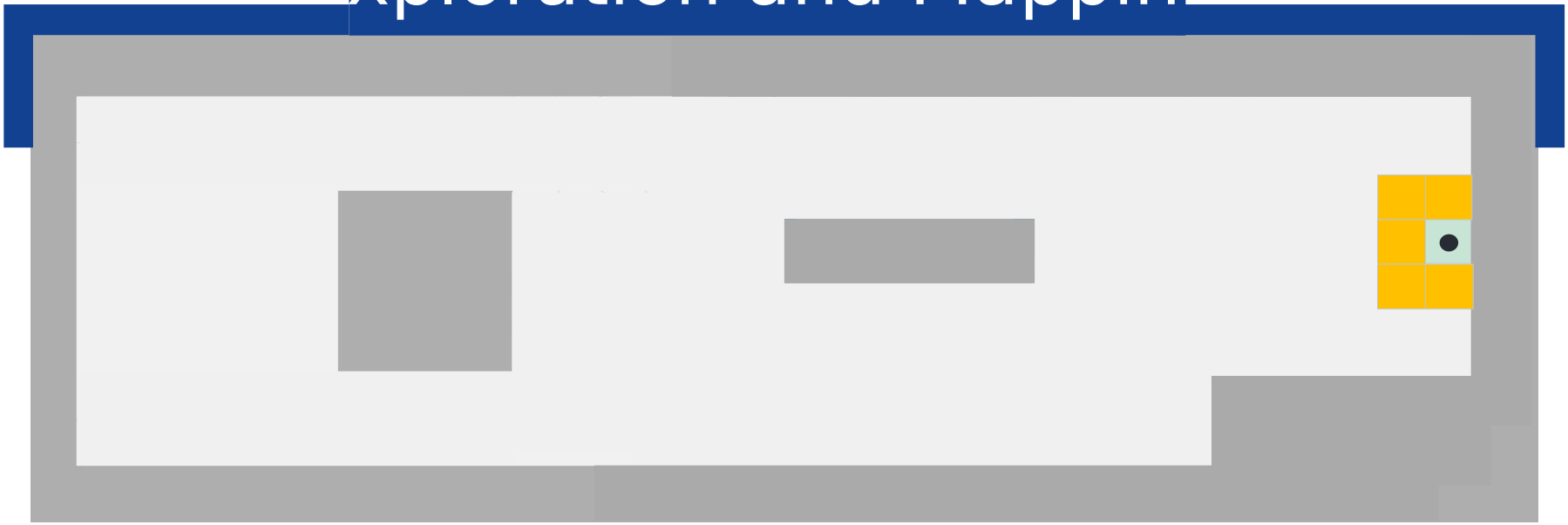

Any unexplored cells 1 step away from the robots are potential targets

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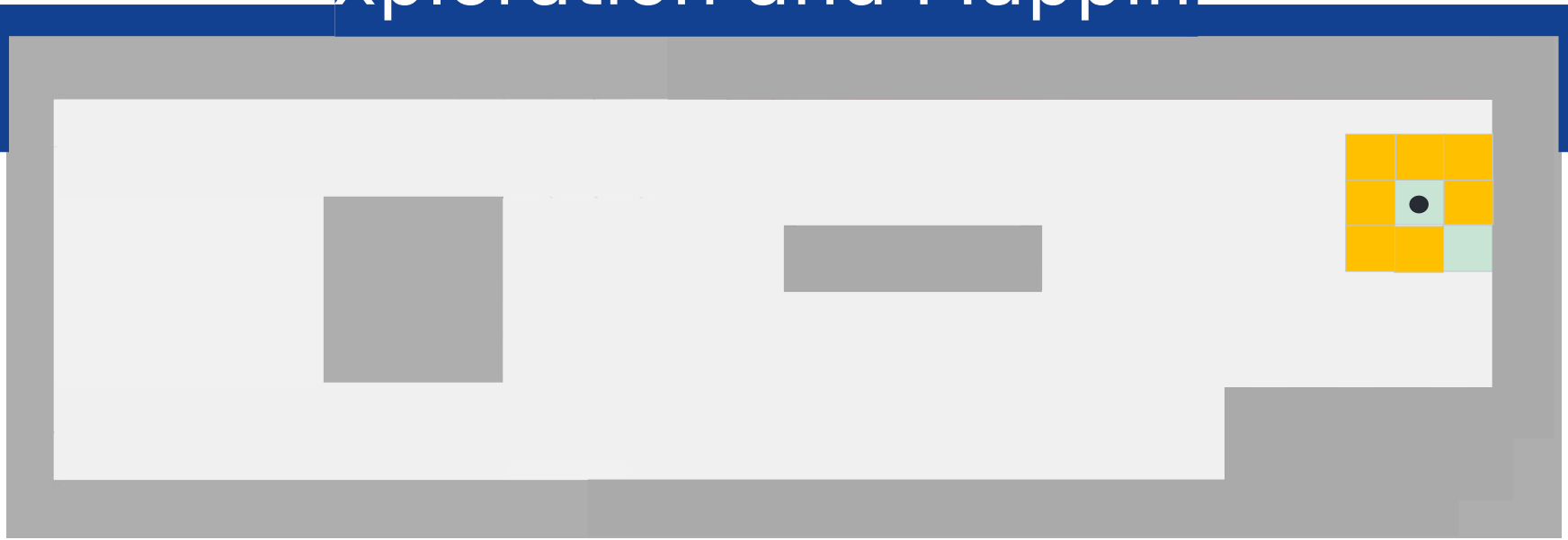
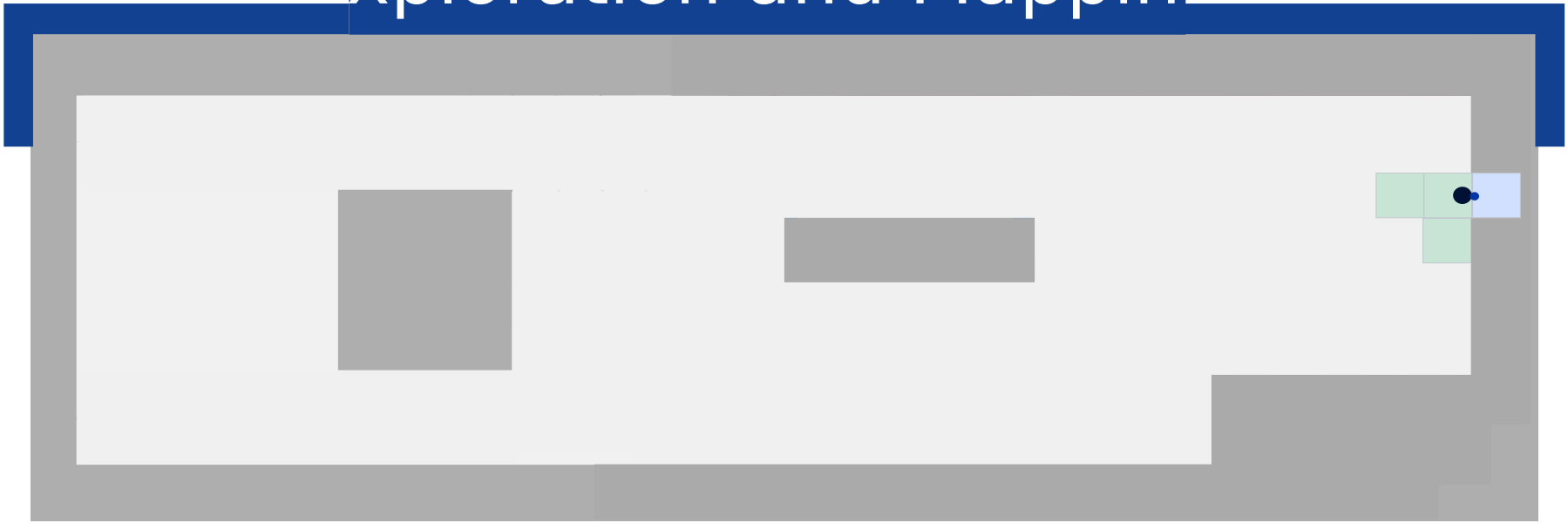


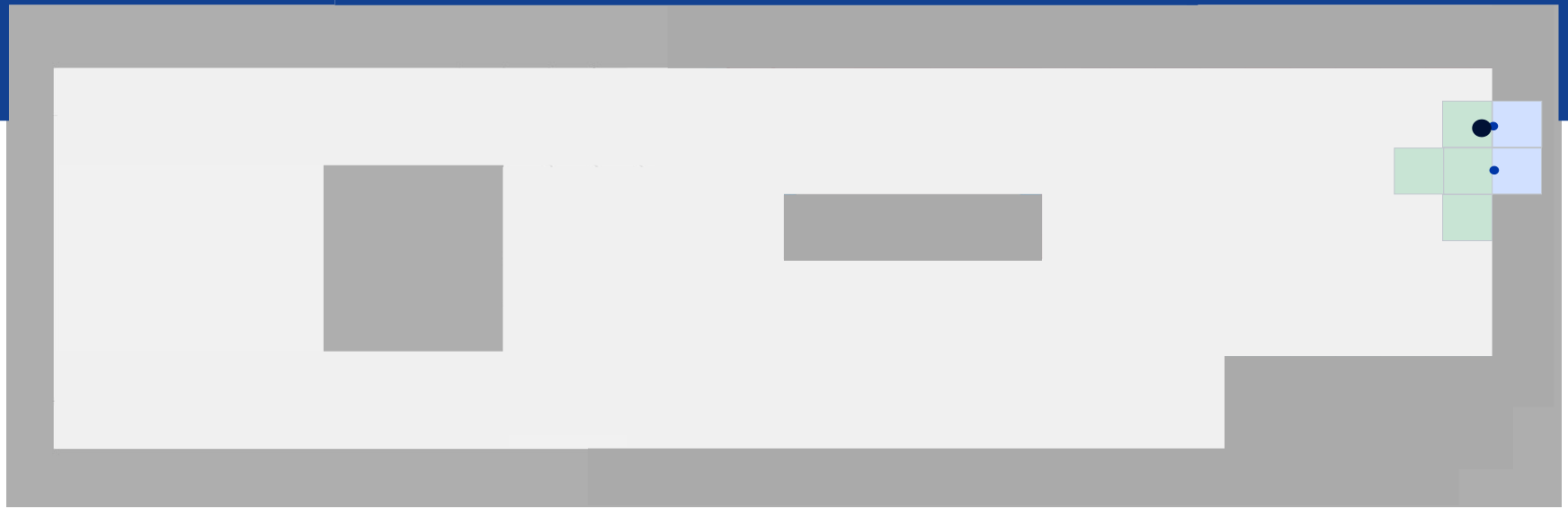
Out of those potential targets the one closest to the starting position is chosen

xploration and Mappin



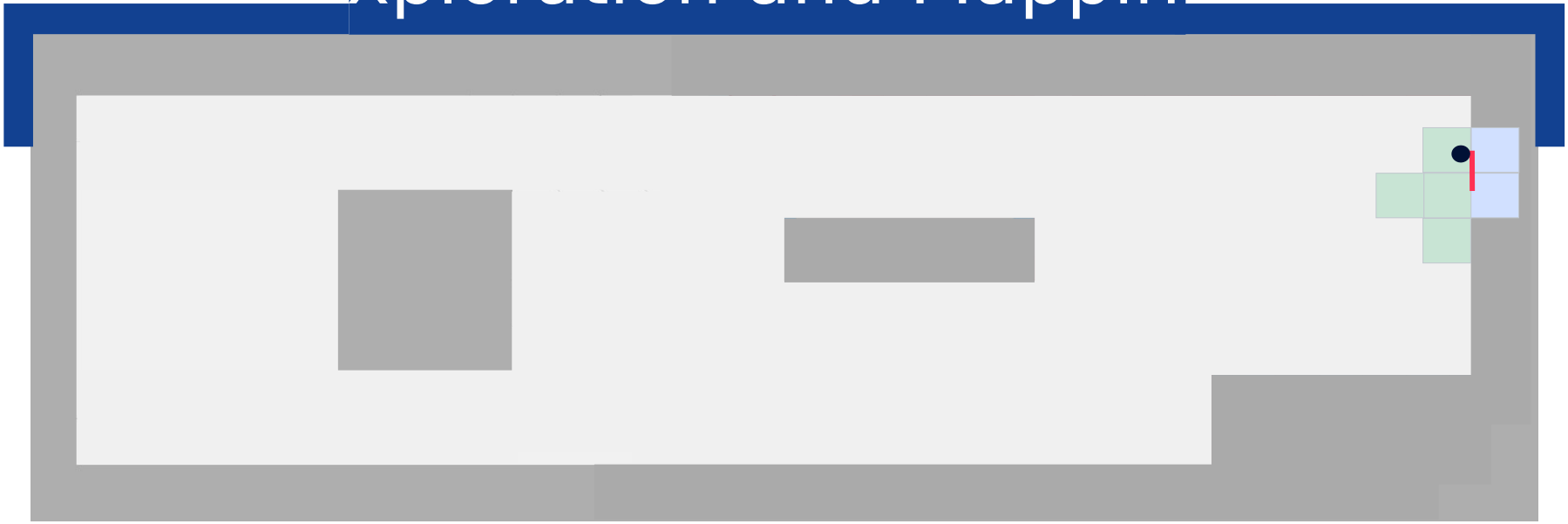
When a robot bumps into an obstacle that cell is set as an obstacle cell and a dot Is added to the map.

xploration and Mappin



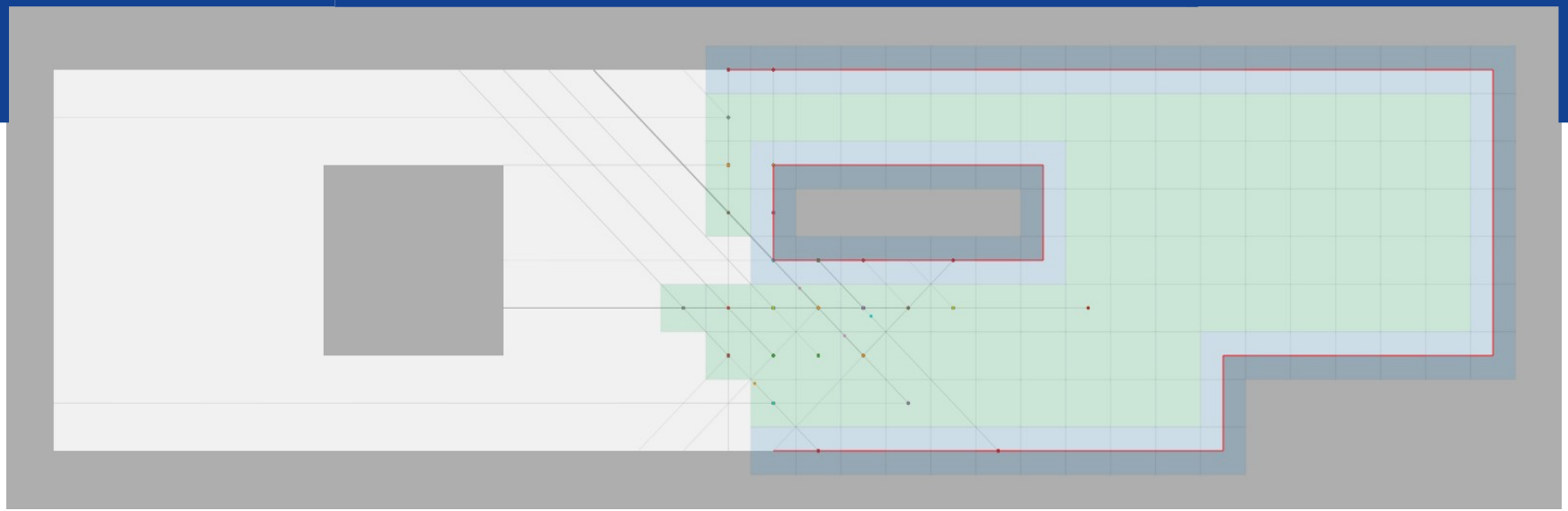
If two dots are close enough to each other they are connected into a line, then the dots are removed from the line.

xploration and Mappin



Lines close to each other are connected into one bigger line. This happens until all lines are connected and there are no dots left.

xploration and Mappin



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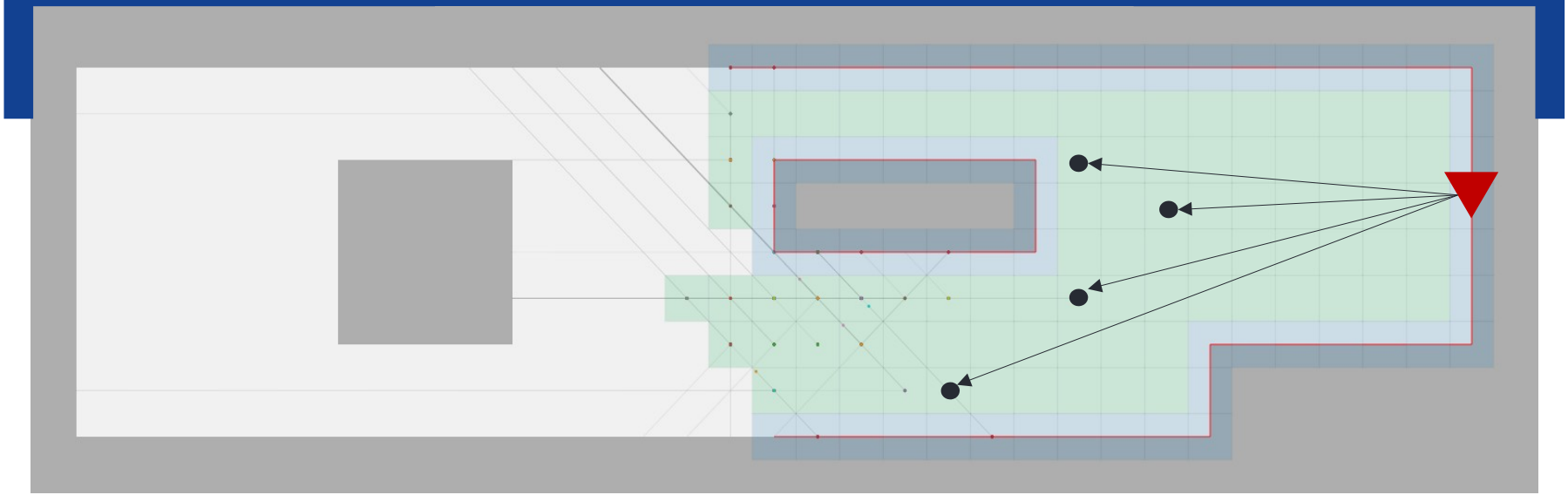
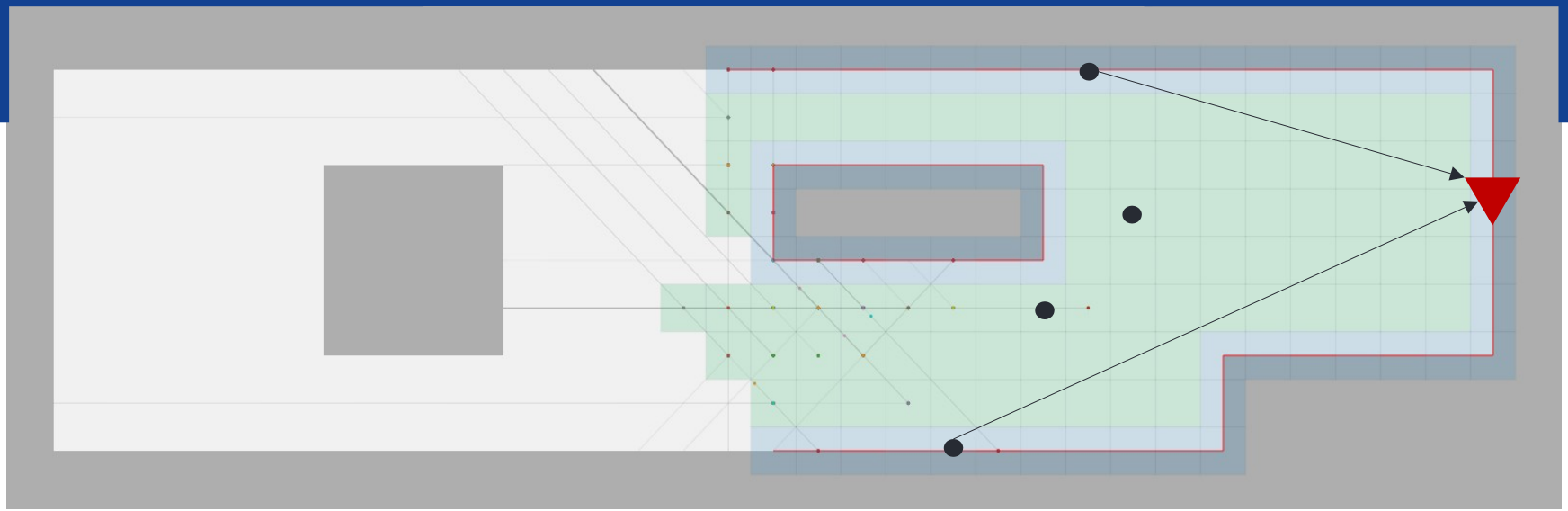
Communication



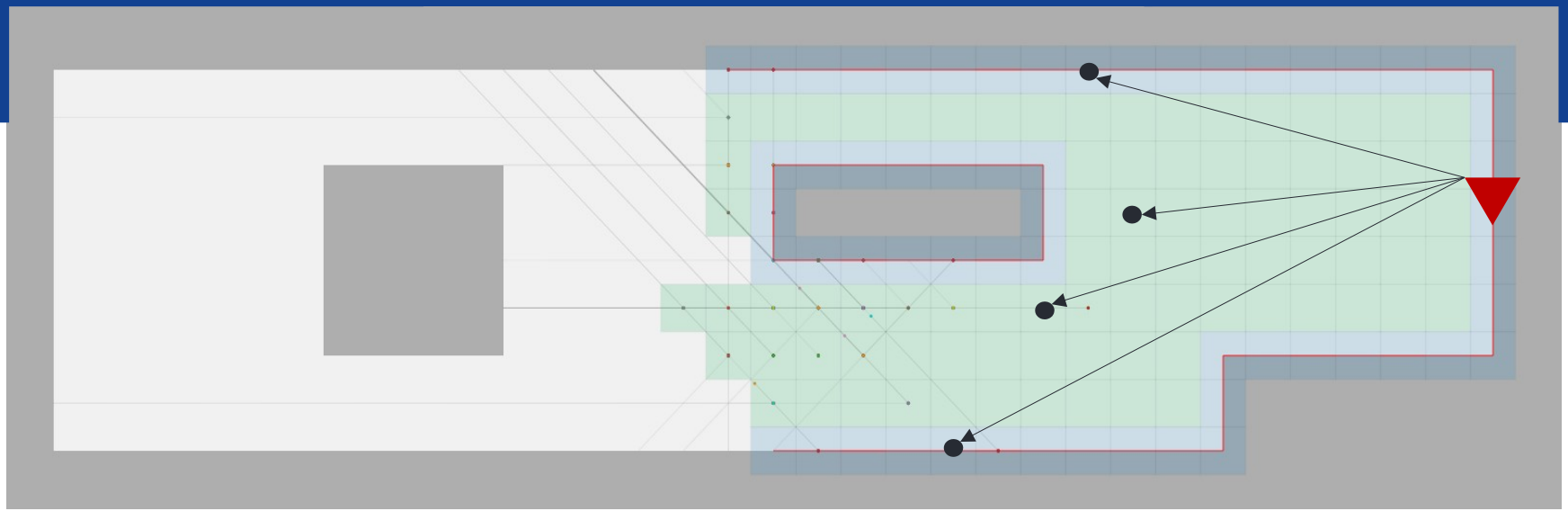
Orchestrator sends command packets to all robots every second

Communication



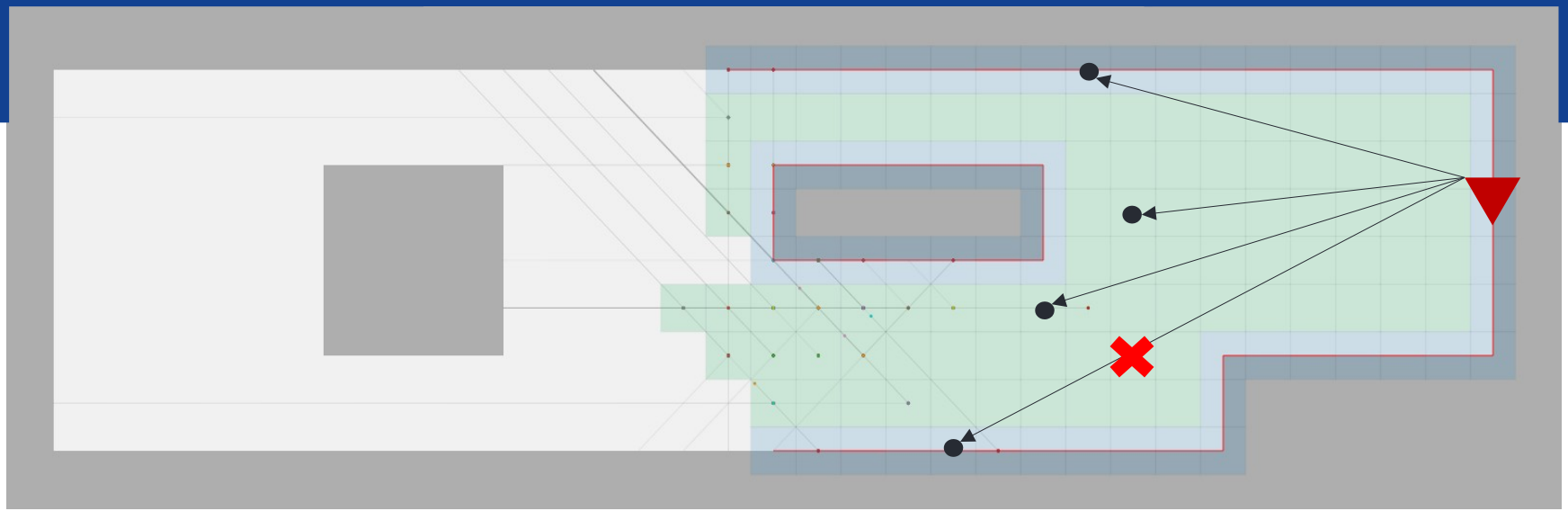
Robots only send notification packets when an event occurs,
otherwise they continue movement in same direction.

Communication



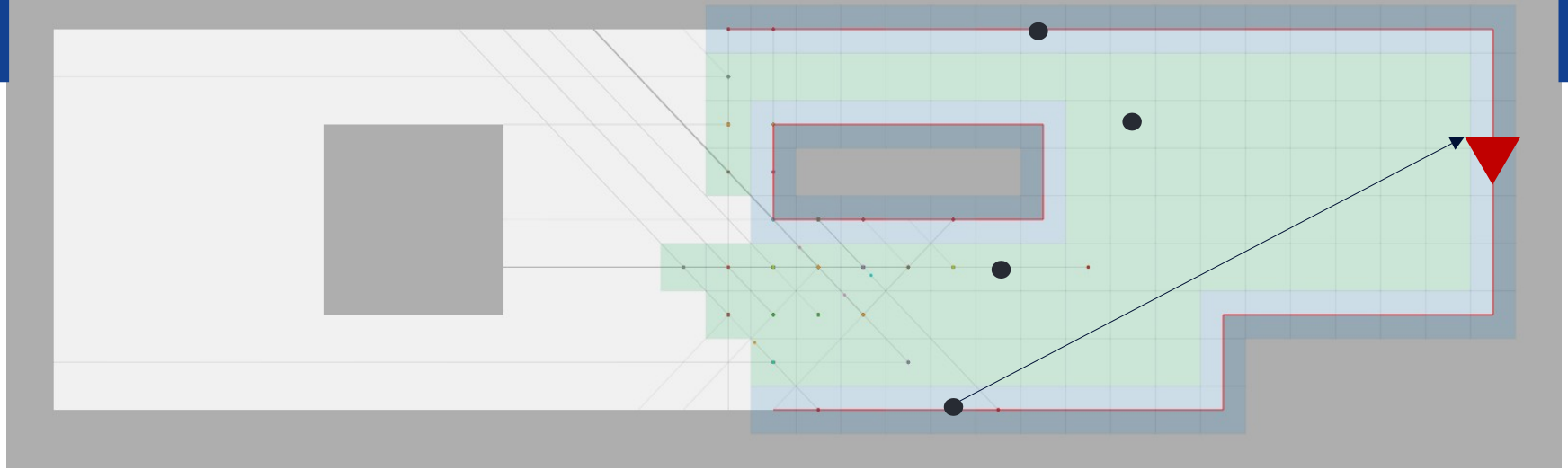
Orchestrator sends new command with updated instructions for robots that sent notifications

Communication



If packet drops and robot doesn’t hear back from orchestrator it re-transmits notification every second until new command is received

Communication



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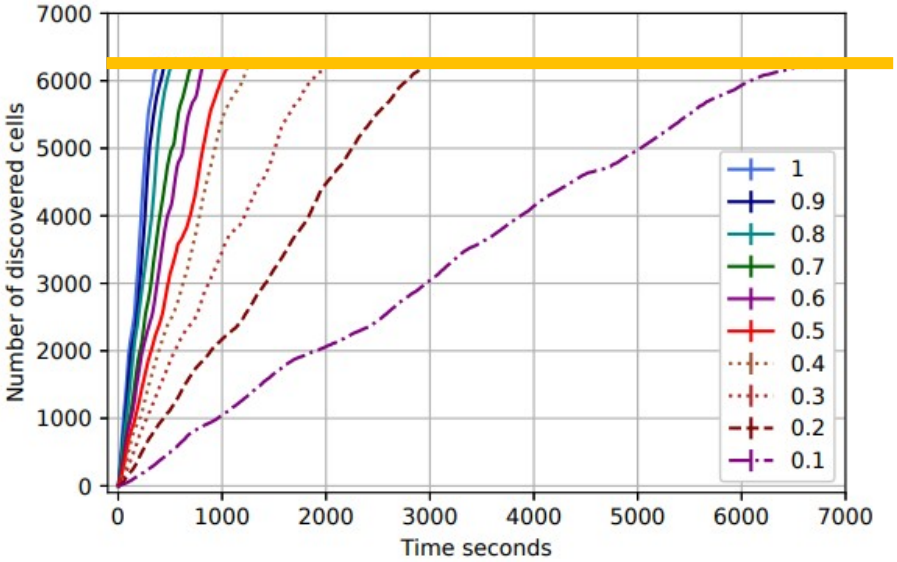
Simulation Resul



Future Work

- Incorporating the context of network connectivity into the logic of our algorithms.
- We are currently working on experimentally validating our work and are therefore building a swarm of 1,000 robots.

Thank you for listening !

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