RoboCup Rescue Simulation League

TDP:Agent Simulation AIT-Rescue

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Introduction

Task assignment problem in RRS

- Typical problem in RRS that assigns all agents to all tasks (disasters).

Agents

Various approaches

Tasks

**The DCOP algorithm,
which is one of the most effective approaches
to this problem, attracted considerable attention in AAAI-18.**[1]

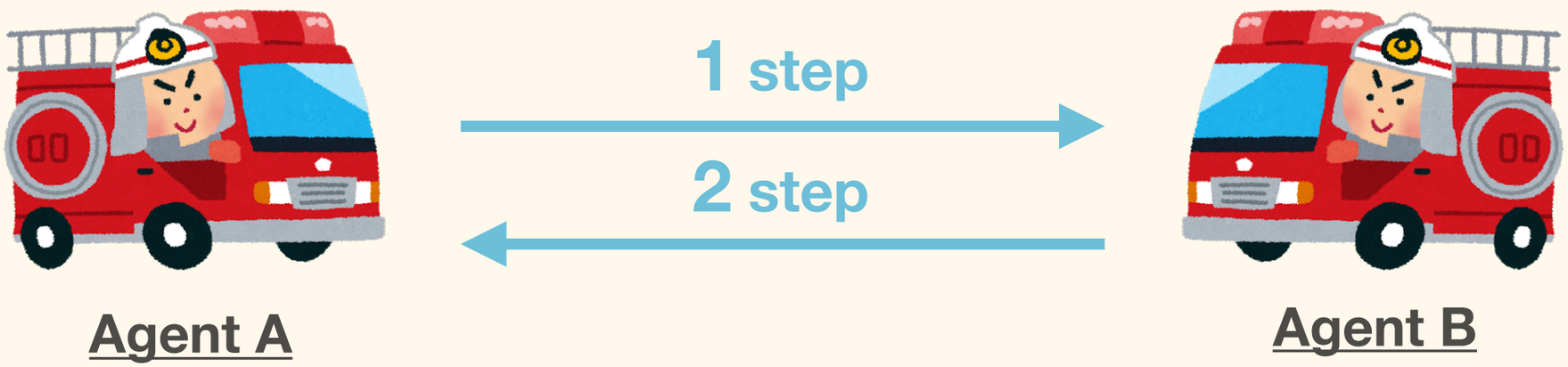
1 Tutorial on Multi-agent Distributed Constrained Optimization @AAAI-18
http://www-personal.umich.edu/~fioretto/cfp/AAAI18/

DCOP and DCOP algorithm in RRS

- DCOP : Decentralized Constraints Optimization Problem
- A typical DCOP algorithm
  needs to perform message propagating numerous times.

However,

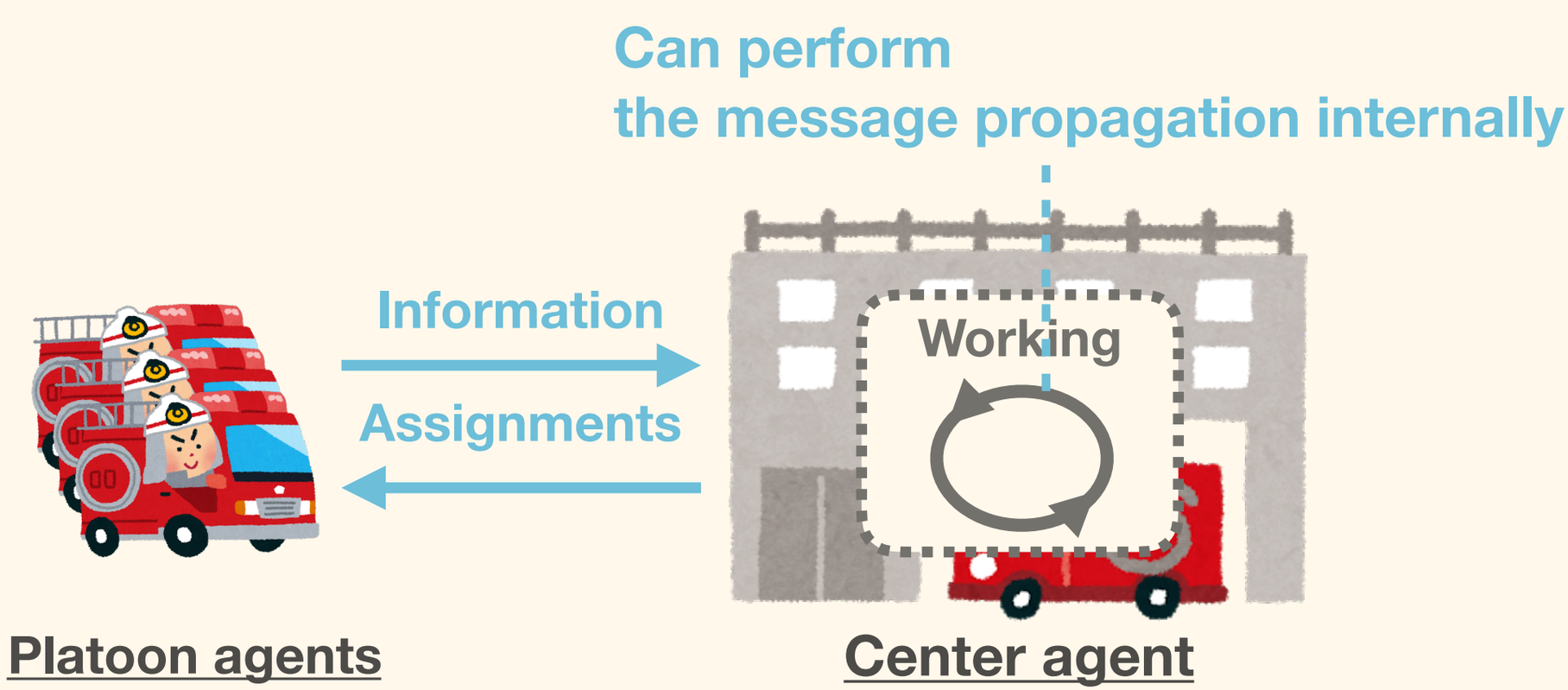
Sending & receiving messages takes 2 simulation steps.



Utilizing the DCOP algorithm on RRS

- Task assignment by the DCOP algorithm might work more effectively inside an agent that gathers all agents and all tasks …

→ The *CenterAgent* can perform this task assignment.



Utilizing the DCOP algorithm on RRS

- Task assignment by the DCOP algorithm might work more effectively inside an agent that gathers all agents and all tasks

→ **The *CenterAgent* can perform this task assignment.**

Can perform
the message propagation internally

In our attempt to implement center agents the task assignment, we used the Max-Sum algorithm,[2]
which is one of the primary DCOP algorithms.

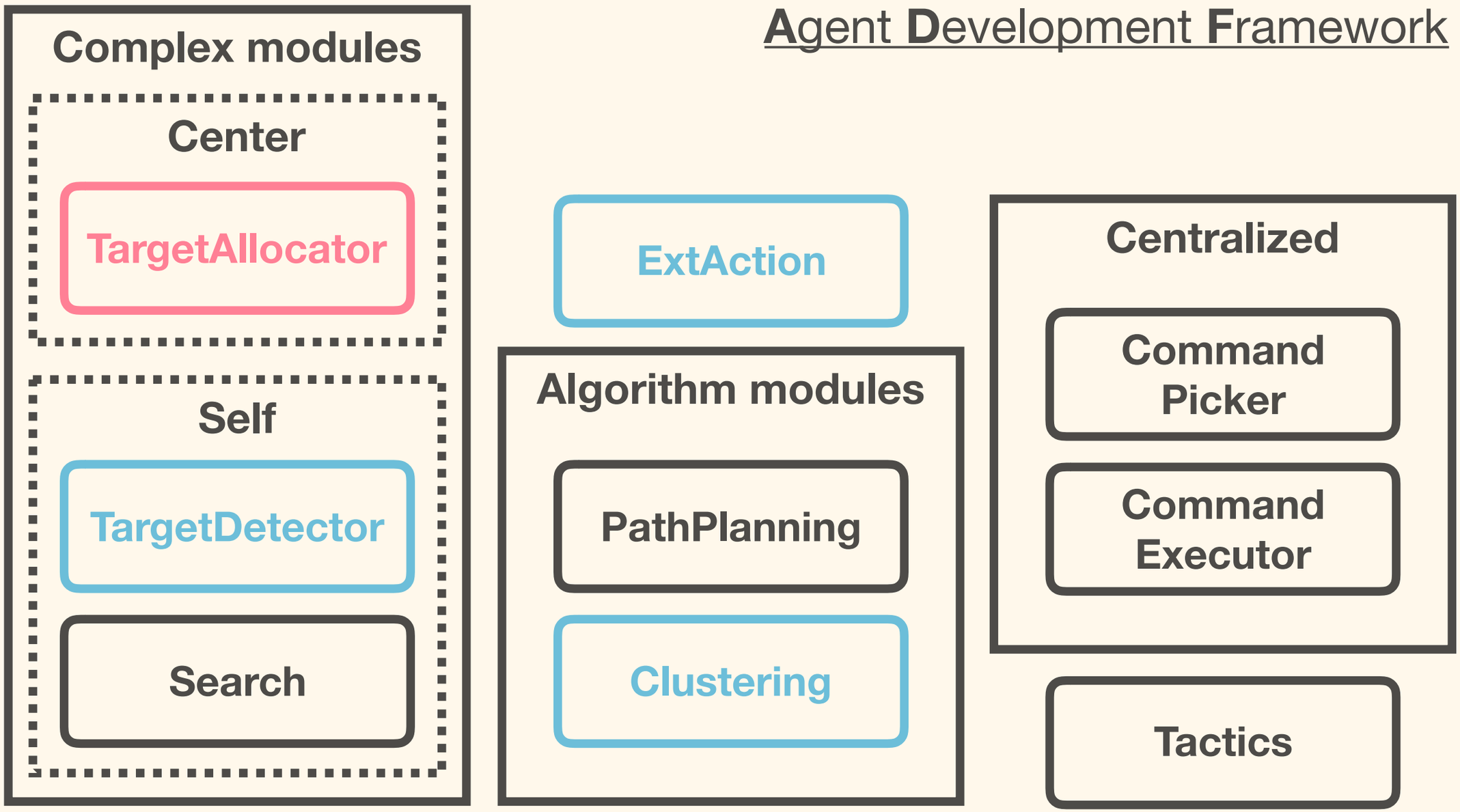
Platoon agents

Center agent

2 Weiss, Y., Freeman, W.T.: On the optimality of solutions of the max-product belief-propagation algorithm in arbitrary graphs. IEEE Trans. Information Theory 47,736-744 (2001)

Improvements of AIT-Rescue 2019

Agent Development Framework



Improvements of AIT-Rescue 2019

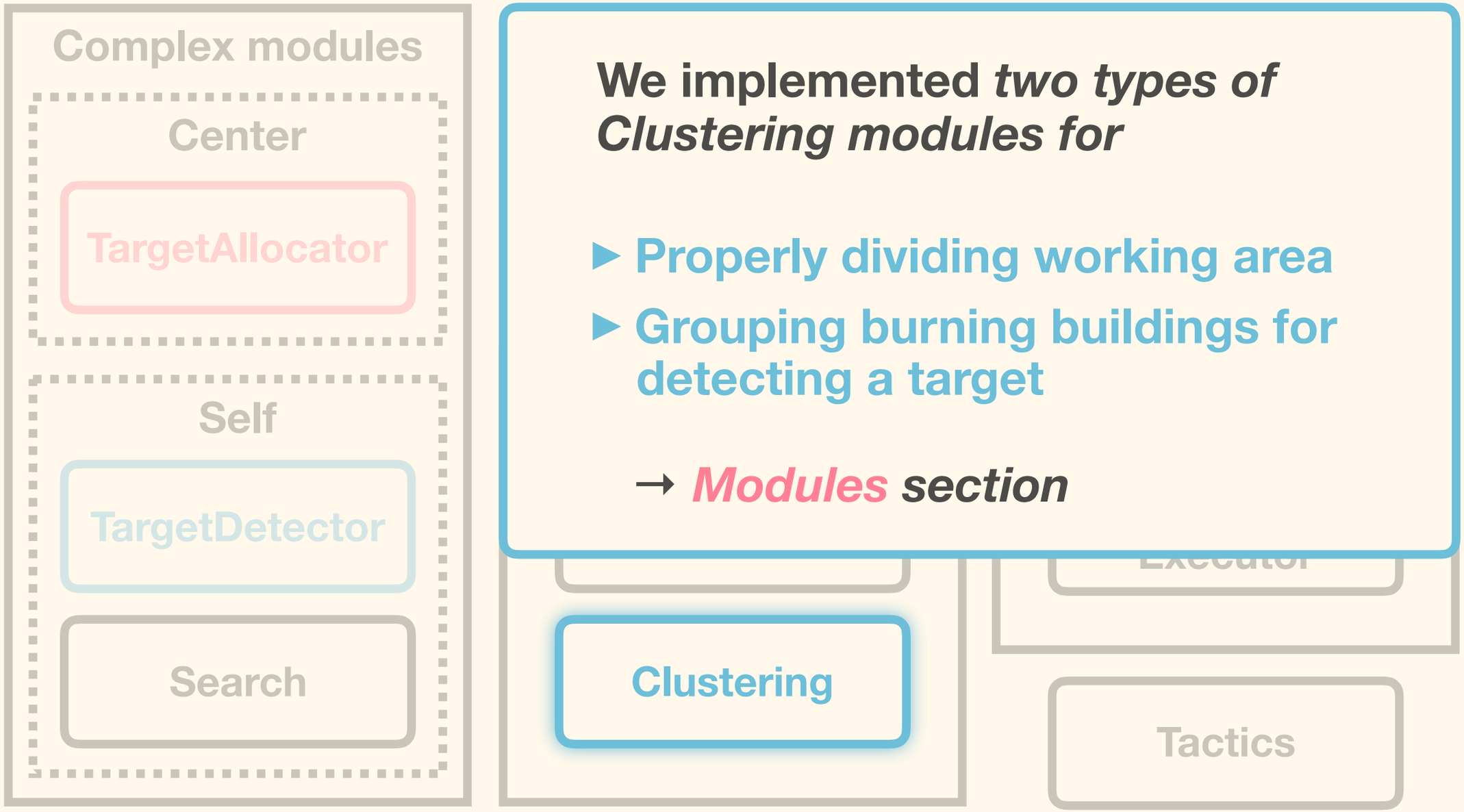
Agent Development Framework

Centralized

We attempted to create an implementation that allows center agents to perform

► Centralized task assignment (by the CenterAgent)

Improvements of AIT-Rescue 2019



We implemented *two types of Clustering modules for*

- ► **Properly dividing working area**
- ► **Grouping burning buildings for detecting a target**

→ ***Modules* section**

Improvements of AIT-Rescue 2019

Complex modules

Center

TargetAllocator

Self

TargetDetector

Search

Agent Development Framework

ExtAction

Centralized

Command

We implemented strategies of *FireBrigade* & *PoliceForce for*

- **Effectively detecting a target**

→ ***Strategies* section**

Improvements of AIT-Rescue 2019

Complex modules

Center

TargetAllocator

Self

TargetDetector

Search

Agent Development Framework

ExtAction

Centralized

Command

We implemented an action of *PoliceForce for*

- *Effectively clearing blockades*

→ *Strategies section*

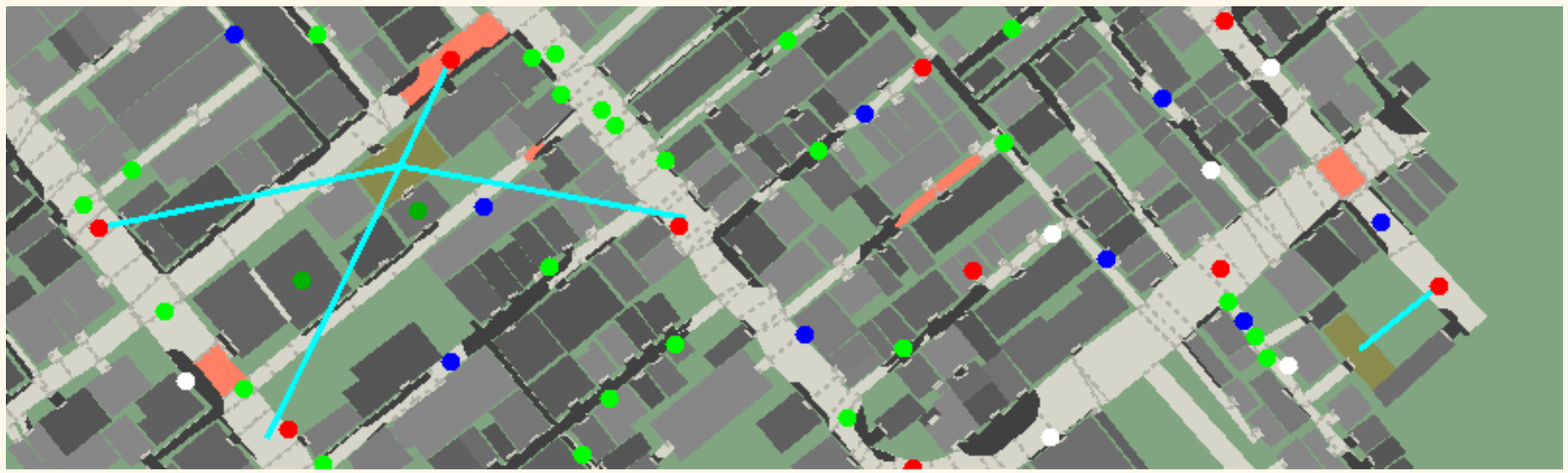
Centralized Task Assignment

(Not In The Template)

CenterAgent : TargetAllocator

- Our center agents performs centralized task assignments for all platoon agents using the Max-Sum algorithm, which is a major DCOP algorithm
- Only works if all platoon agents have two-way communication with the center agents

e.g. **Fire station**

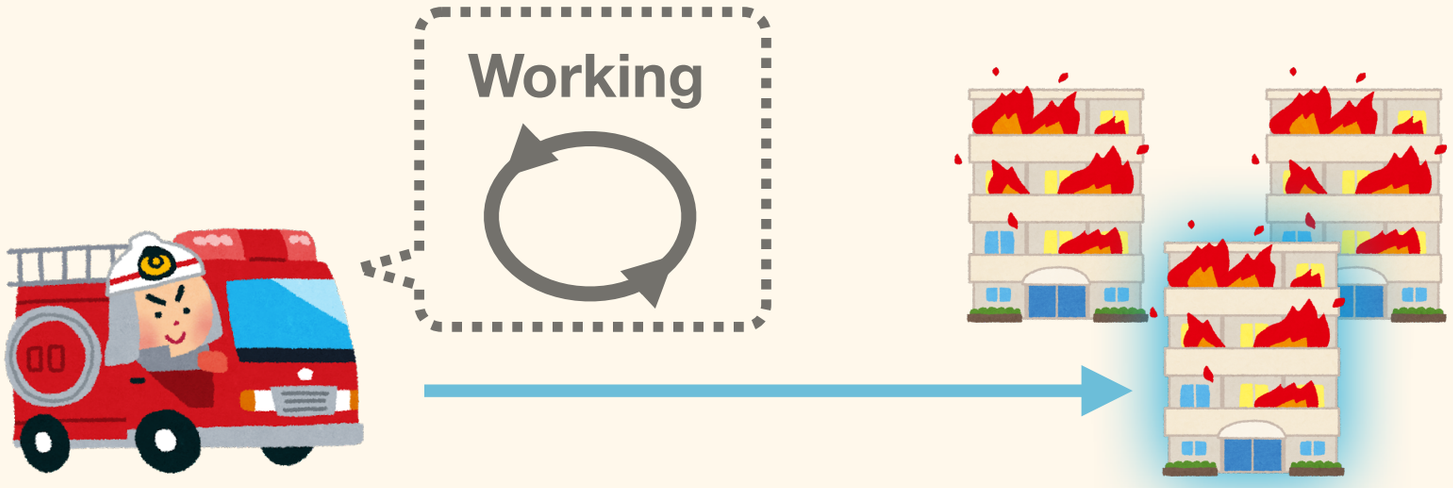


CenterAgent : *TargetAllocator*

- Our center agent performs centralized task assignments for all platoon agents using the Max-Sum algorithm, which is a major DCOP algorithm
- Only works if all platoon agents have two-way communication with the center agents

In other situations,

the platoon agents must detect their own targets individually.



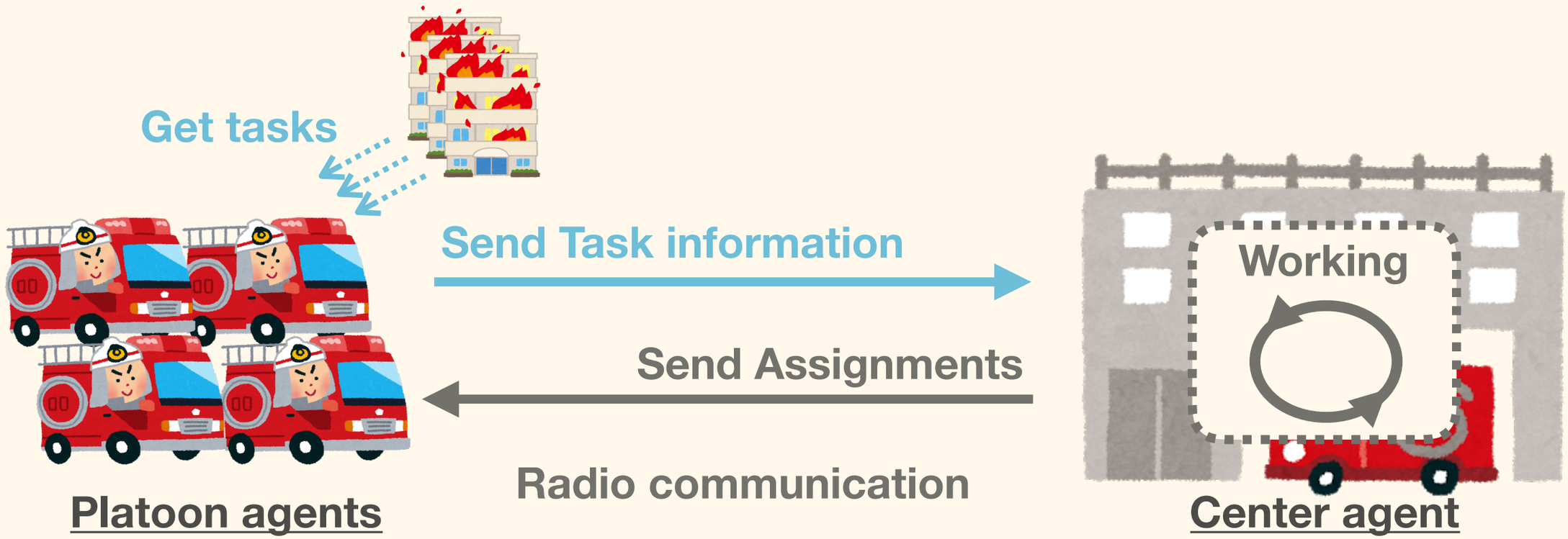
CenterAgent : *TargetAllocator*

How the center agent works : 3 steps

Simulation Step i:

e.g. civilians, buildings, blockades

All platoon agents get **tasks** based on each agent's perceptions and send task information messages to the center agent.

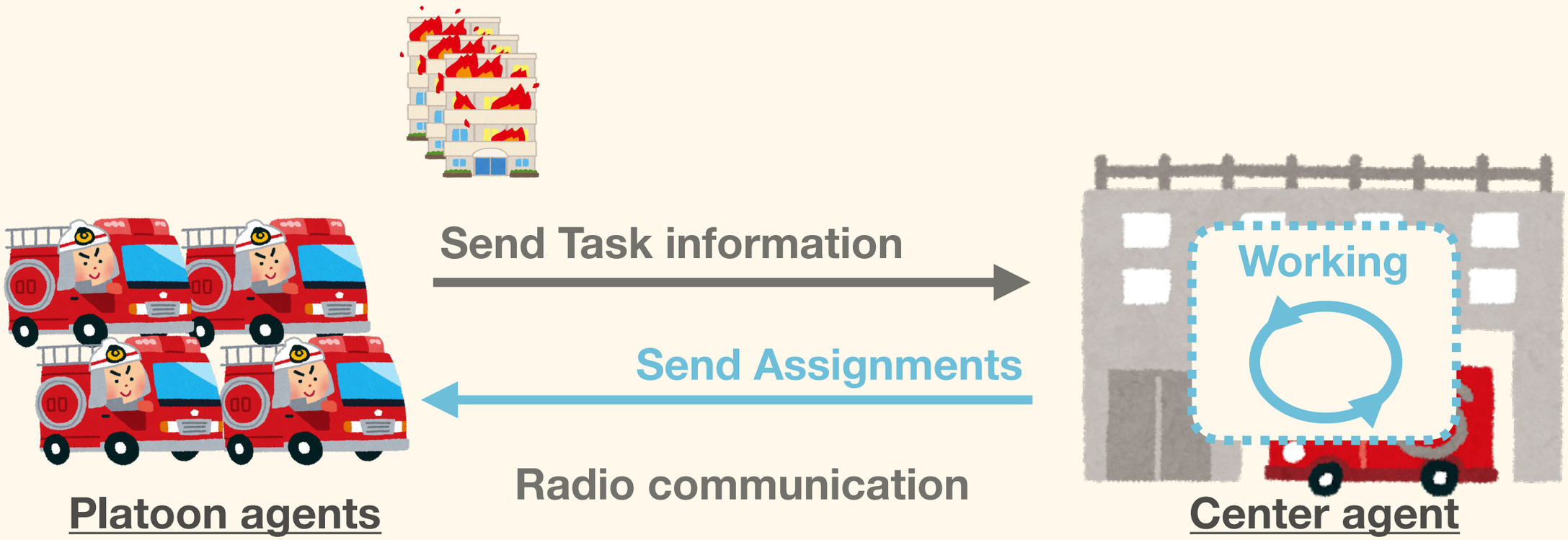


CenterAgent : *TargetAllocator*

How the center agent works : 3 steps

Simulation Step i+1:

The center agent updates own *WorldModel* and finds assignments by repeatedly using the Max-Sum algorithm and then sends assignment messages to each platoon agent via radio.

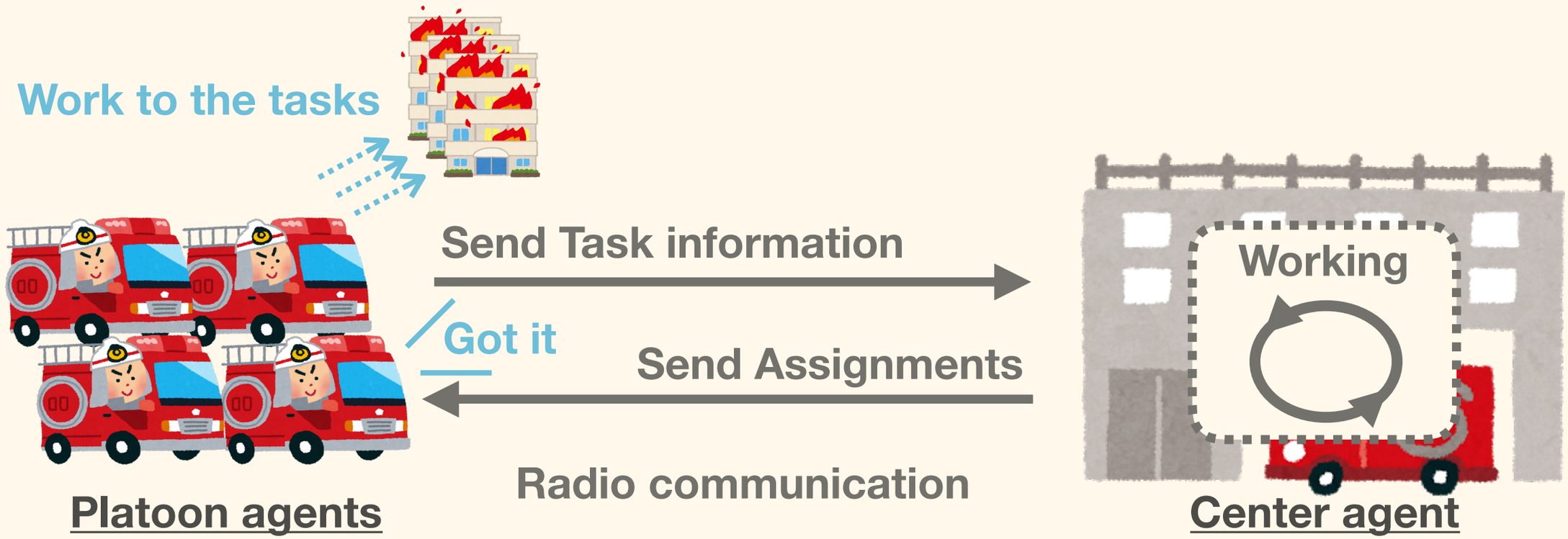


CenterAgent : *TargetAllocator*

How the center agent works : 3 steps

Simulation Step i+2:

All platoon agents get their own assignments and work to complete those assignments.

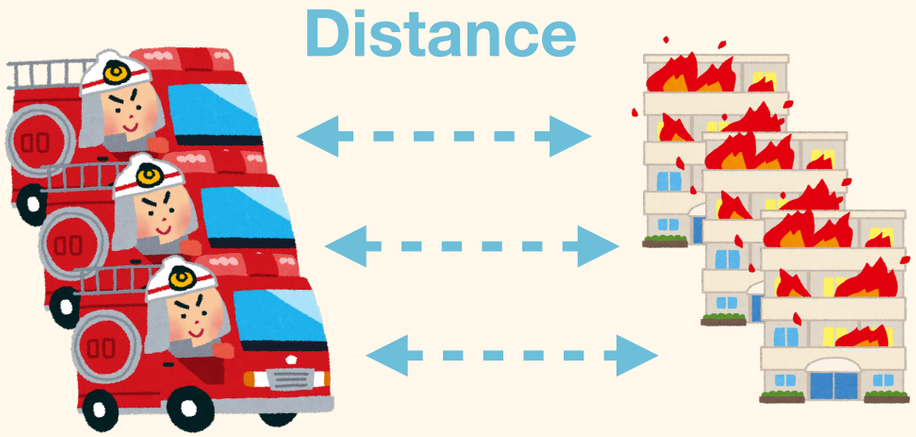


CenterAgent : *TargetAllocator*

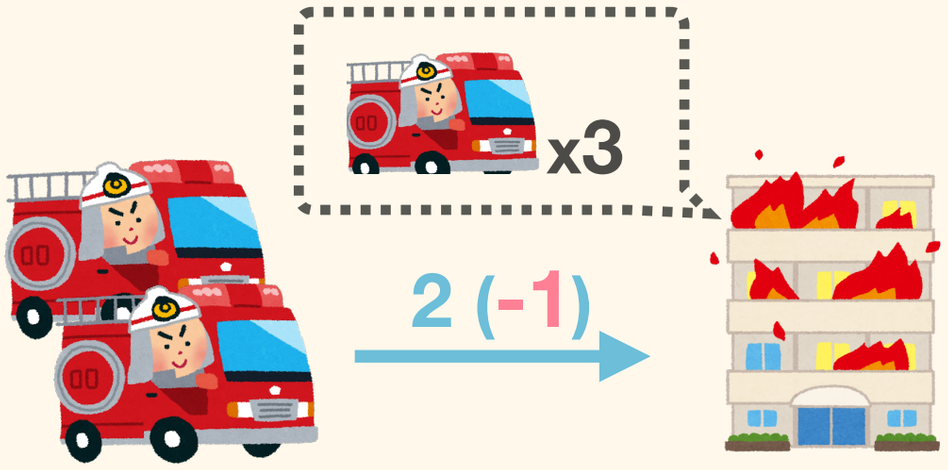
What the center agent evaluates tasks with

- Center agents evaluate tasks to determine assignments as follows:

Cost : Distance
between tasks and assigned agents



Penalty : Shortfall
in the number of necessary agents



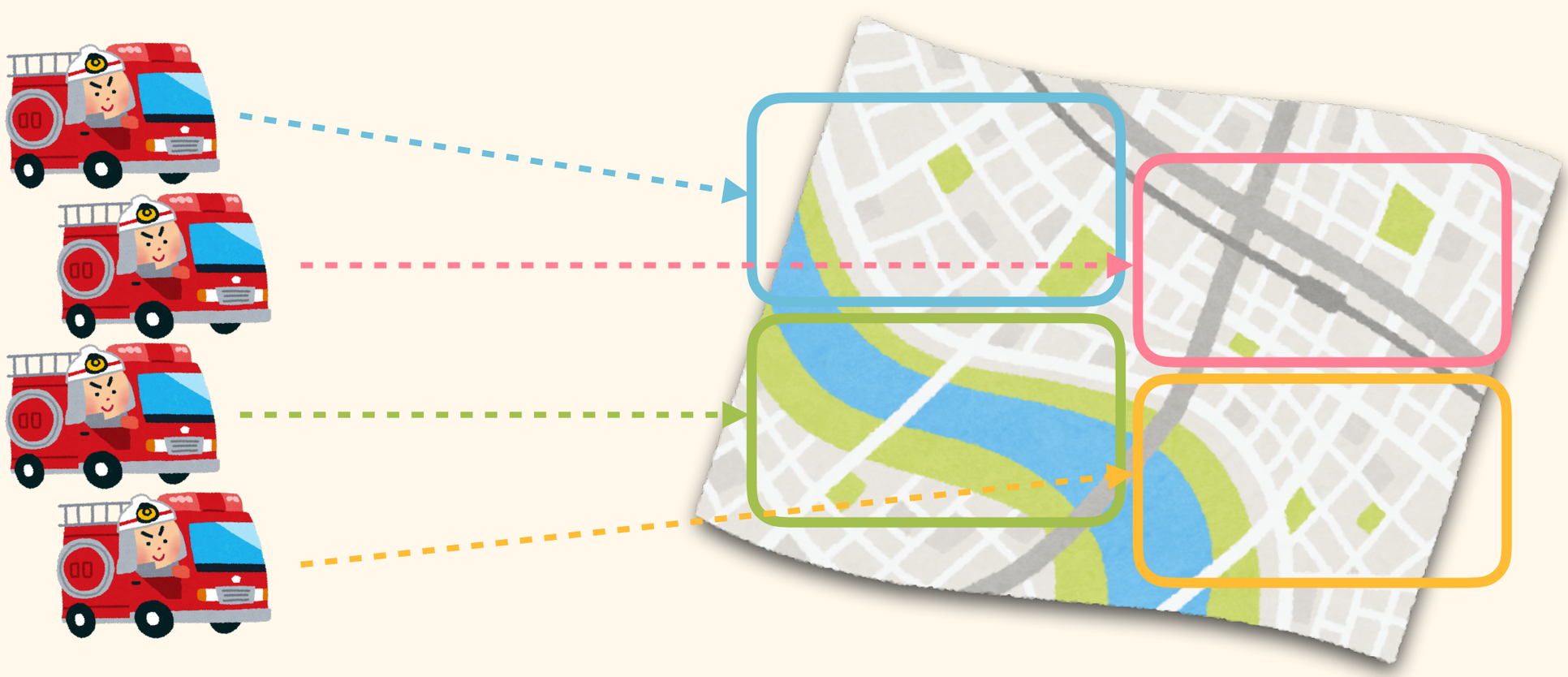
→ **Minimizing values based on all costs & all penalties**

* we explained them in TDP more detail

Modules

Clustering for the working areas

- The module divides a map into working areas to which each agent assigned.

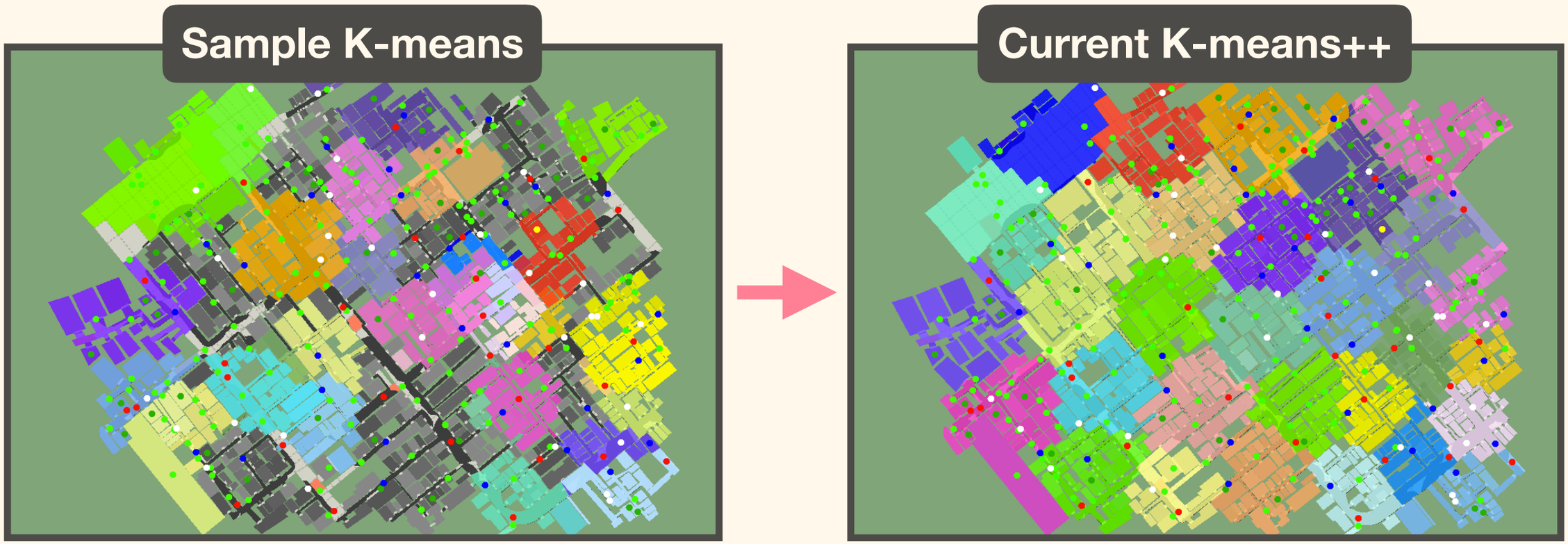


Clustering for the working areas

Improvements (from the sample)

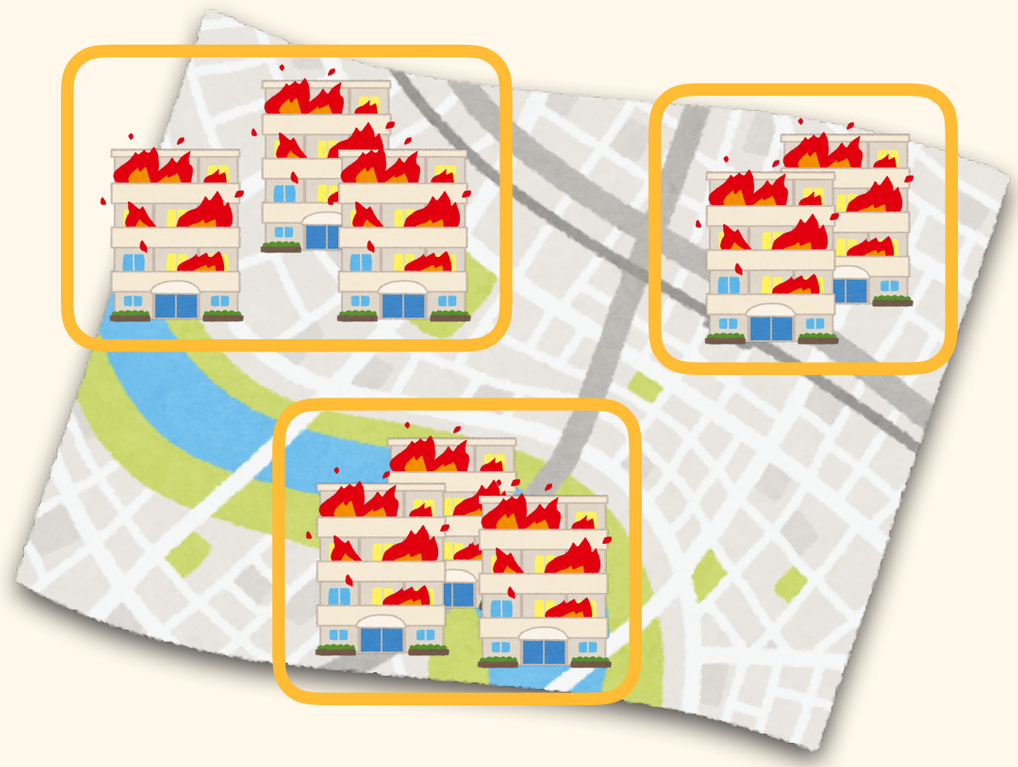
- Fixed the problem of some clusters overlapping each other
- Implemented the **k-means++** to address the initial-value dependence

A characteristic of clustering



Clustering for the buildings on fire

- The module groups some buildings on fire.
- We use this module to create **convex hulls** in ordering when extinguish buildings on the cluster edges.

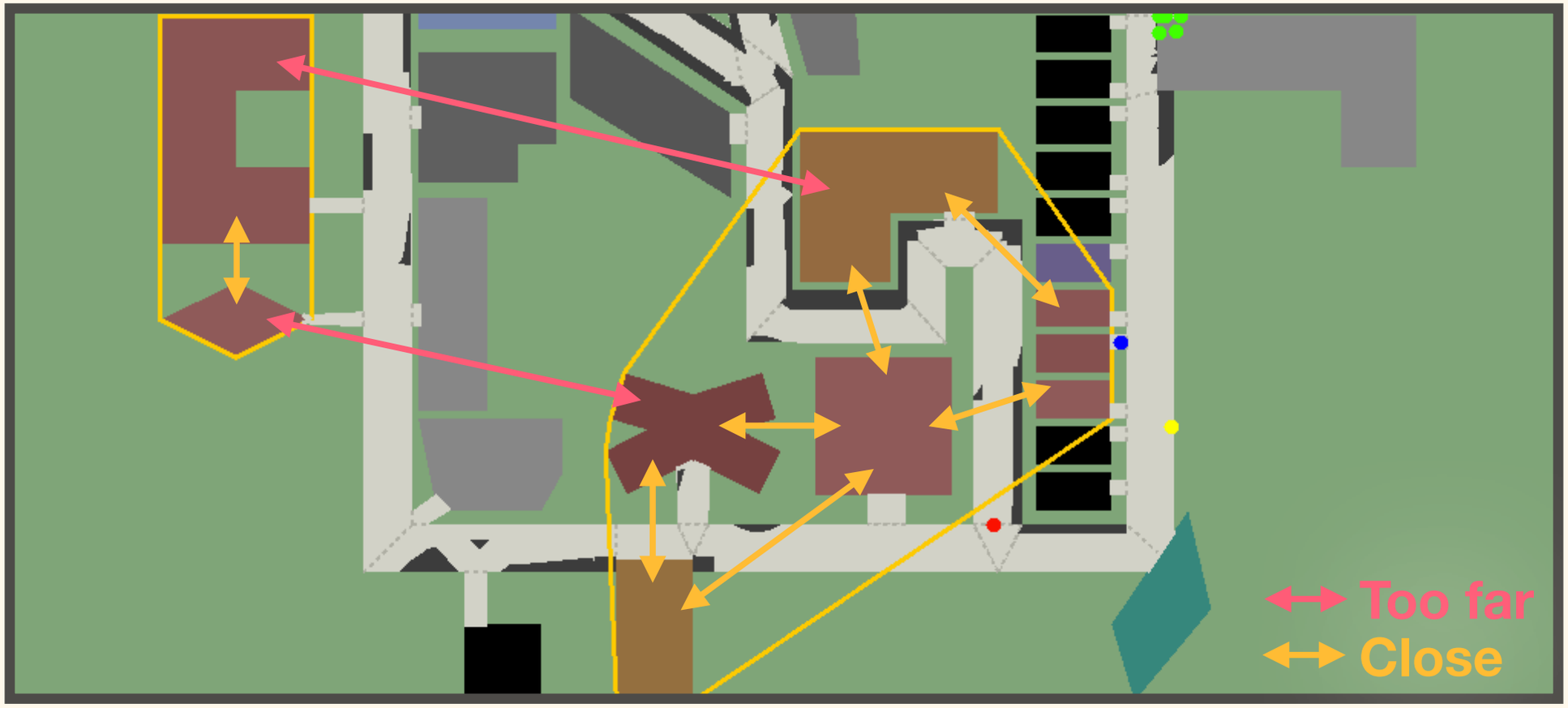


Clustering for the buildings on fire

Implementation

- Implemented a **hierarchical clustering** that merges any two clusters if they are within the set distance from the criterion

  e.g. The average distance between all buildings

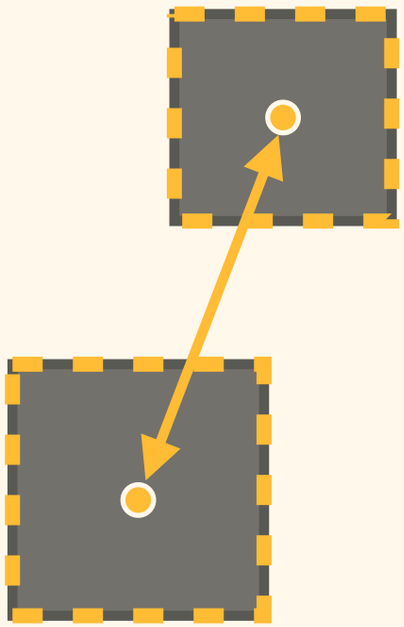


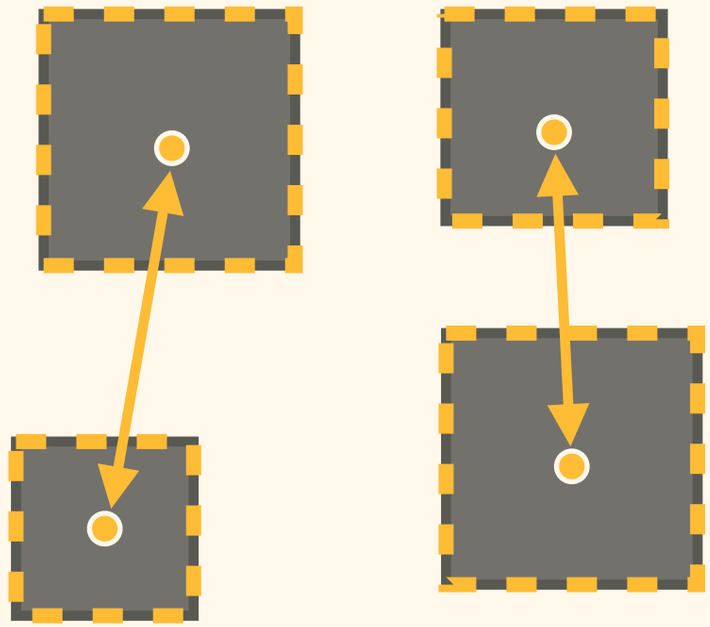
Clustering for the buildings on fire

Flow

Step 1:

Each building is set as a cluster.



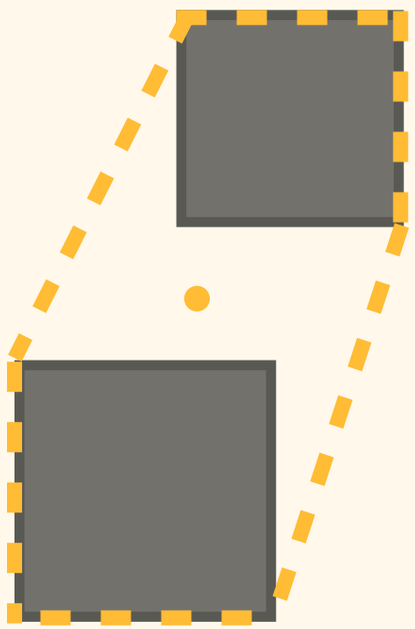


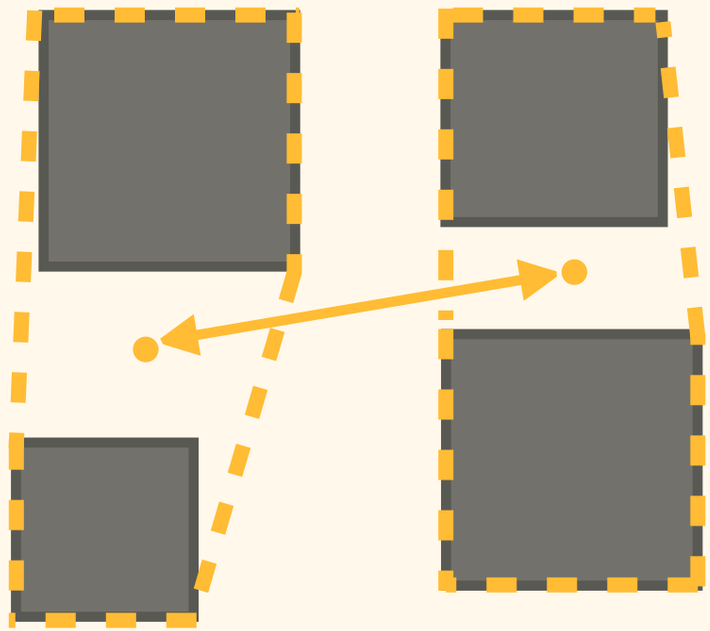
Clustering for the buildings on fire

Flow

Step 2:

Any two of the clusters if they are within the set distance from the criterion





Clustering for the buildings on fire

Flow

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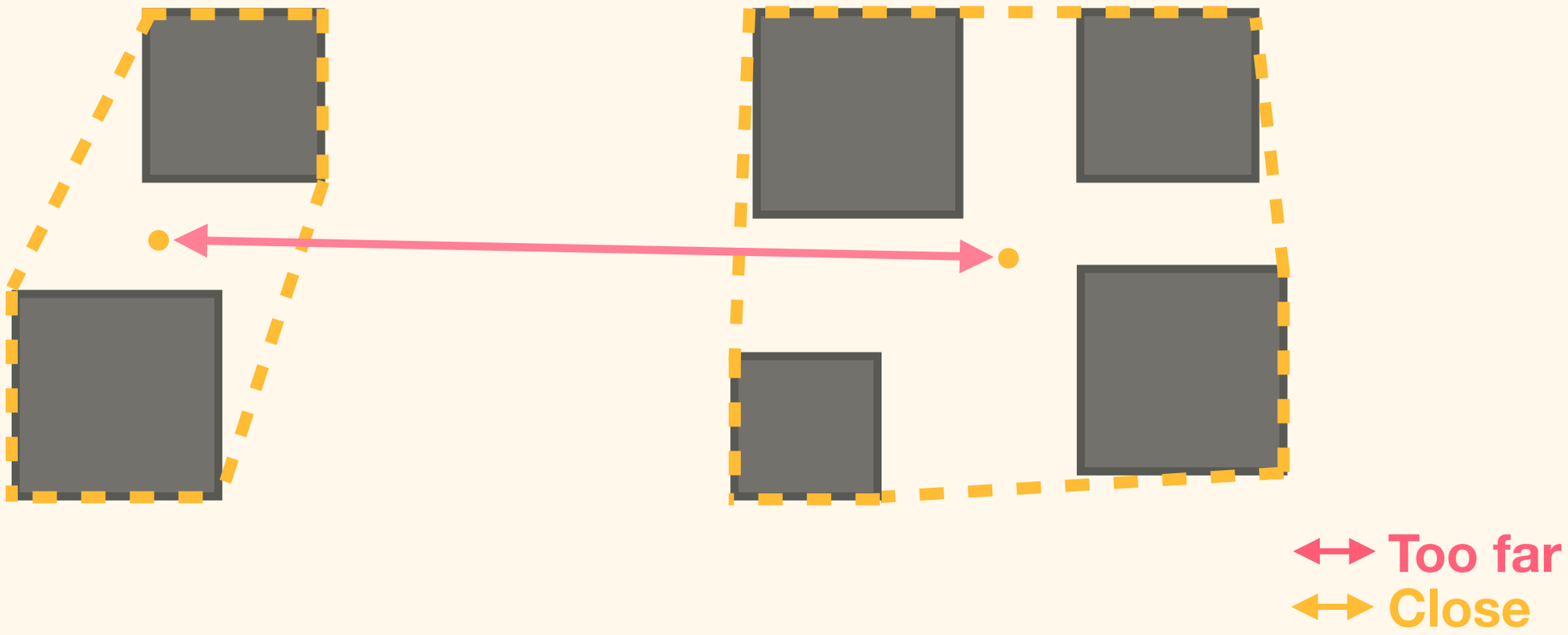
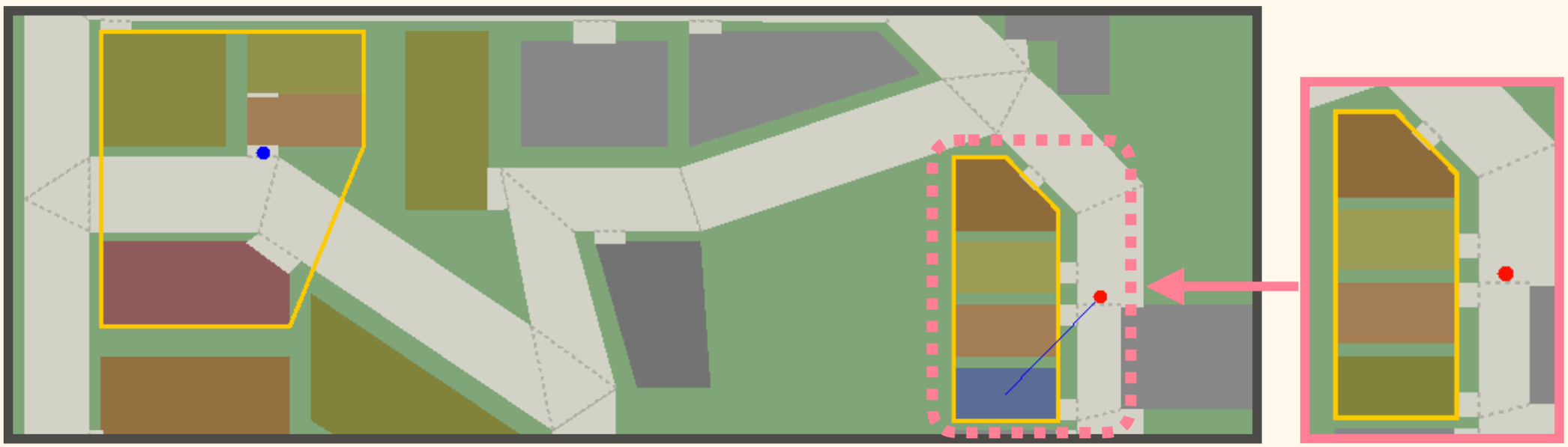


Strategies

FireBrigade : *BuildingDetctor*

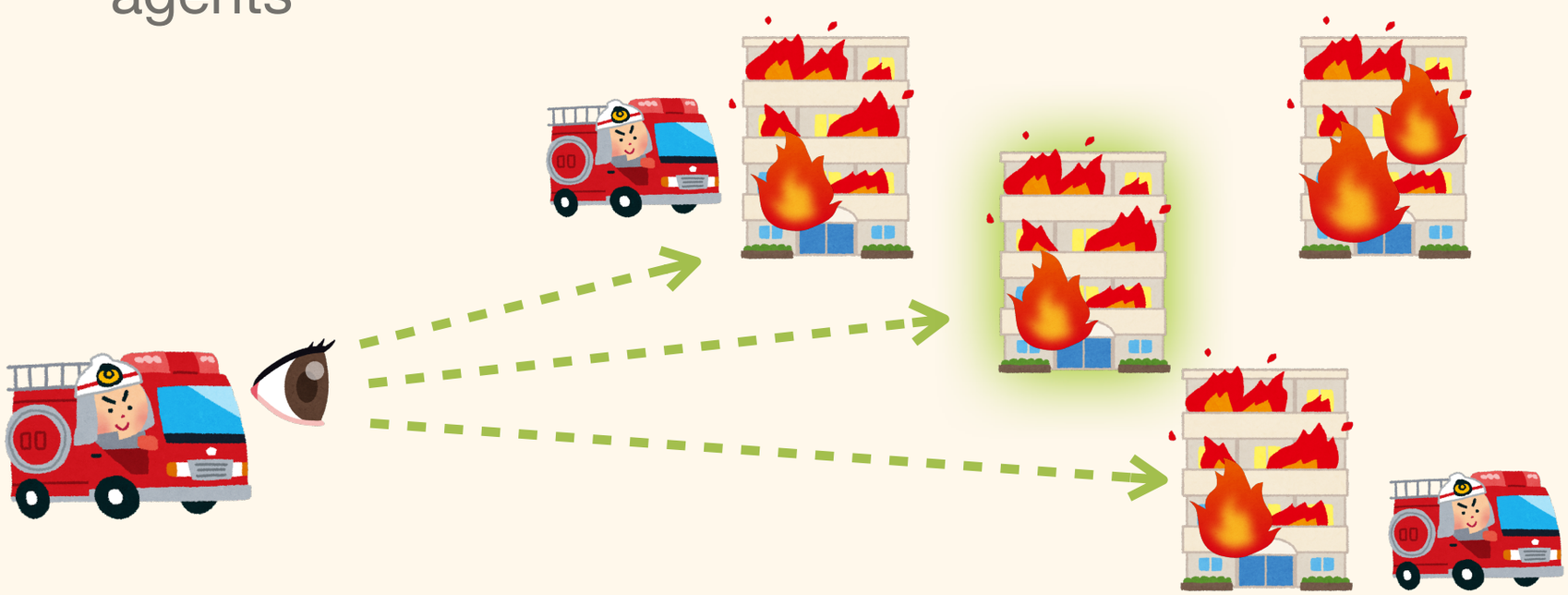
- A fire brigade typically selects a target as follows:
  - When dealing with buildings on the edge of **the convex hull** closest to the agent
    - Within the set of the buildings that have a lowest possible fieriness
      - ✓ **The target is the building** that is closer to the agent than any other agents



FireBrigade : *BuildingDetctor*

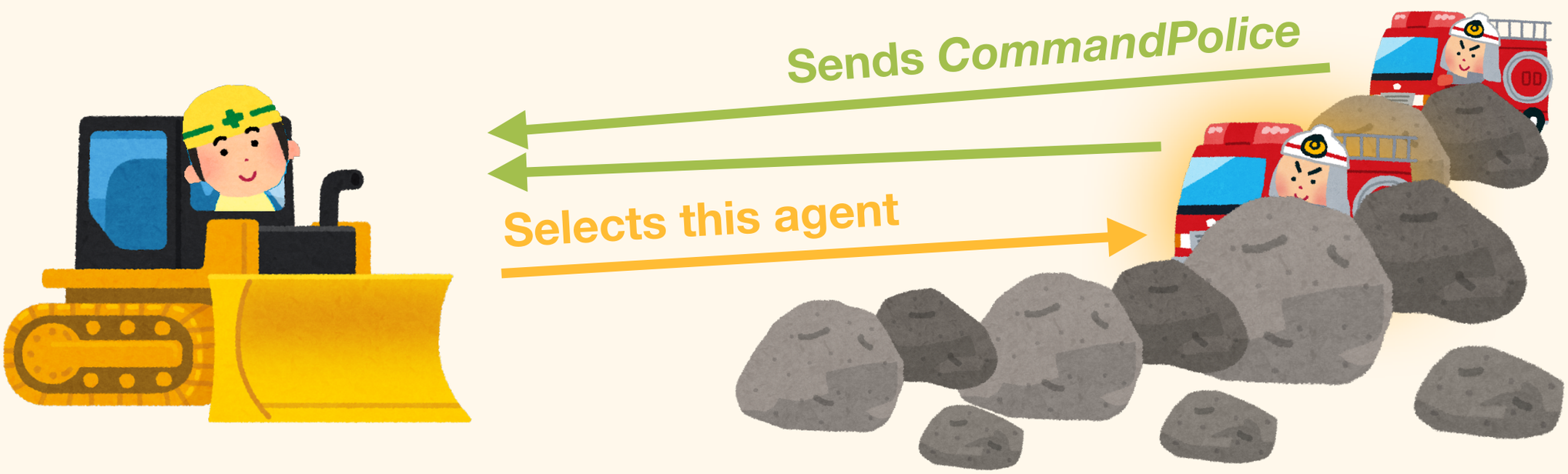
- If there are no candidate buildings, the fire brigade selects a target as follows:
  - When dealing with buildings in **the agent's perception at the step**
    - In the set of the buildings having the fieriness as low as possible

✓ **The target is the building** that is nearer to the agent than other agents



PoliceForce : *RoadDetctor*

- A police force basically selects a target as follows:
  - Regarding other agents from which the police force has received *CommandPolice* messages
    - ✓**The road** where the nearest agent to the police force is in

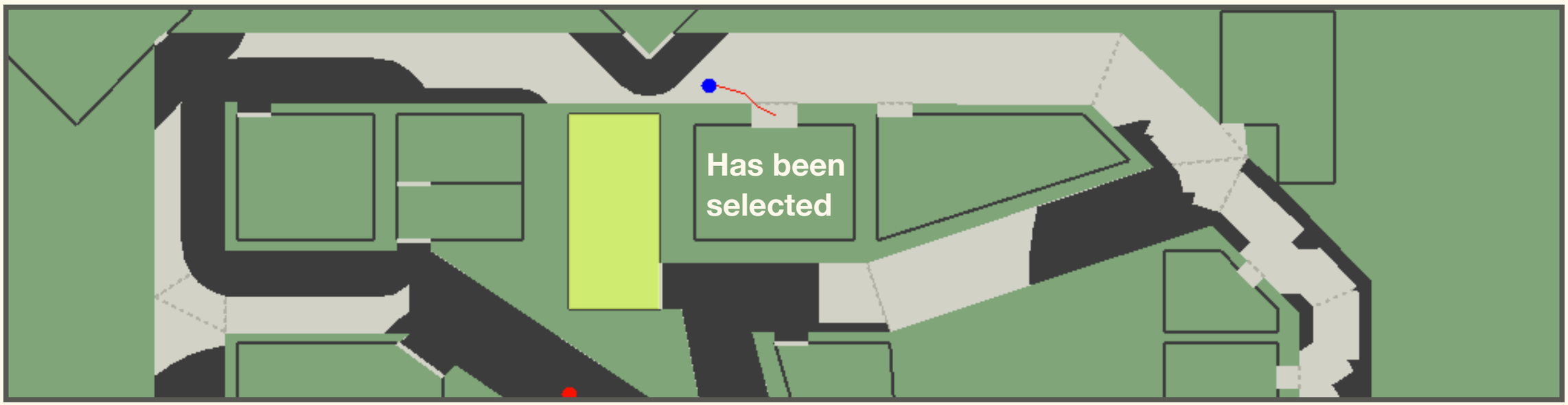


PoliceForce : *RoadDetctor*

- If there is no candidate, the police force selects a target as follows:
  - Regarding buildings in **the cluster to which the agent is assigned**
    - ✓**The target is the building** that is the nearest to the agent

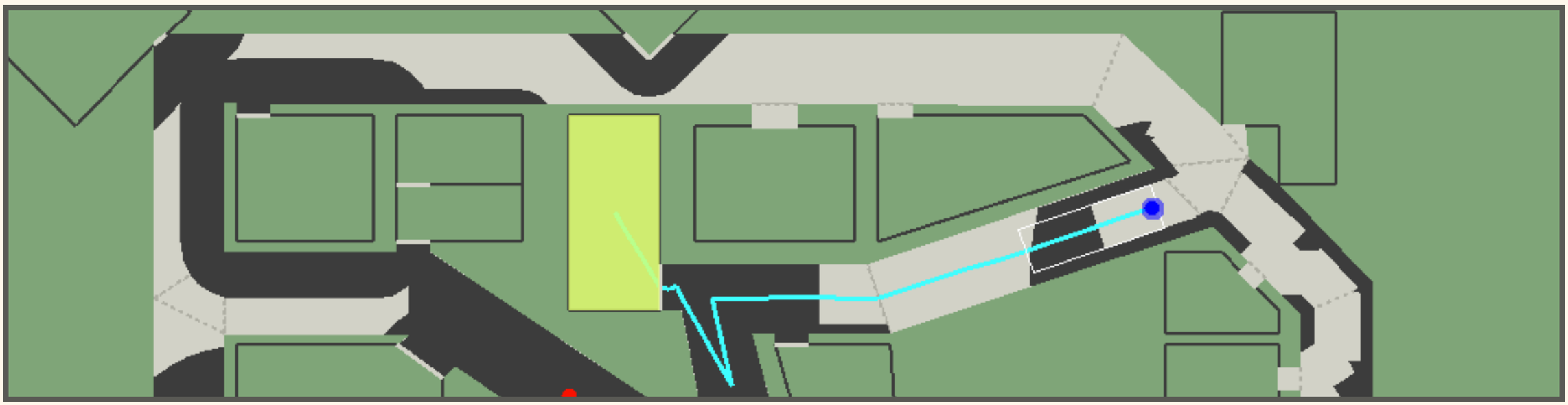
↓ If there is no candidate …

- ✓**The road** that the agent will take is decided randomly



PoliceForce : *ExtActionClear*

- A police force basically clears its way to a target as follows:
  - In the set of blockades on the way from the agent to the target
    - ✓ **The centerline blockade** of *Road*s the agent has to travel on to reach the target.



Evaluations

Results

- Our team results in 2019 are better than the others.

Agent	Scenario		
	Eindhoven2	Paris1	Sakae1
AIT-Rescue 2019	**66.83** ↑	**15.07** ↑	**9.99** ↑
AIT-Rescue 2018	64.46	9.98	9.75
Sample	64.43	11.40	9.74

  - Run 20 simulations for each result.
  - Extended Communication bandwidths of all scenarios maximize.
  - Disabled noises of all scenarios.

Conclusions

- AIT-Rescue implemented the following in 2019:
  - The task assignment by the center agent
  - K-means++
  - Hierarchical clustering
  - Task detection by fire brigades and police forces
  - Police force clearing action
- AIT-Rescue 2019 is better than last year's version.
- But, we need to implement a decentralized approach for the Max-Sum algorithm.

Thank you for your attentions!