Scalable Autonomous Teams for Disaster Management

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Stanford University
MSL
Max Planck Institute for Intelligent Systems


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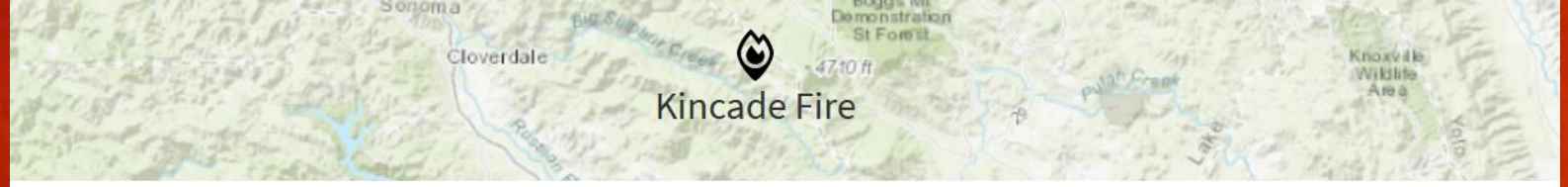
Paradise, CA


ROTO
AID



Kincade Fire

Overview | Maps | News | Contacts

54,298 Acres
Vegetation

Active
Active for 3 days

5%

Contained
Estimated 2,715 acres contained

1 County
Sonoma

Last Updated	10/27/19 7:10 PM
Date Started	10/23/19 9:27 PM
Location Information	John Kincade Road and Burned Mountain Road, northeast of Geyserville
Lat/Long	[38.792458, -122.780053]
Administrative Unit	CAL FIRE Sonoma-Lake-Napa Unit
Cause	Under Investigation

Damages and Losses

Confirmed Damage to Property, Injuries, and Fatalities

17 Structures Damaged
Residential, Commercial and Other

94 Structures Destroyed
Residential, Commercial and Other

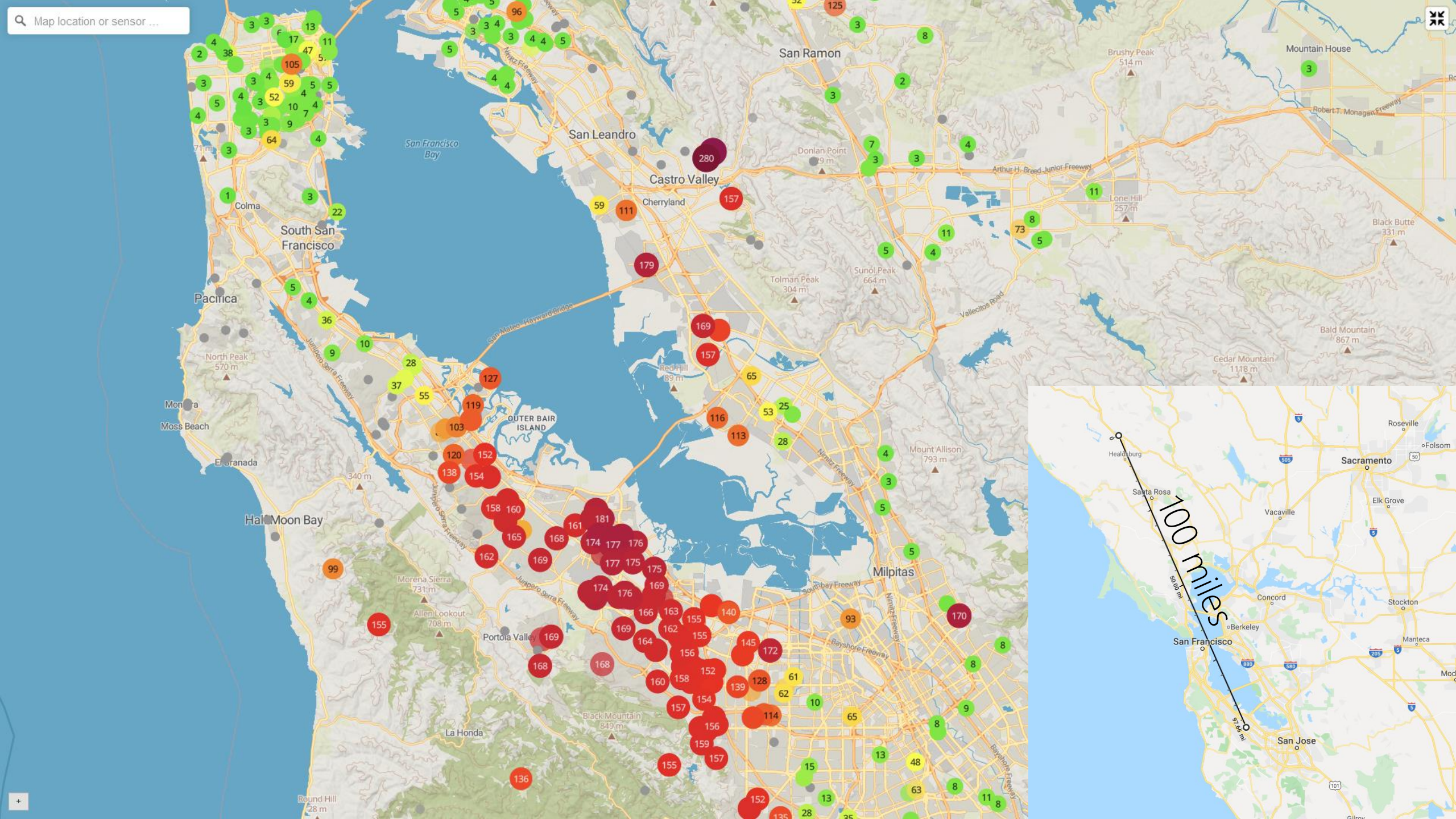
Cooperators & Personnel

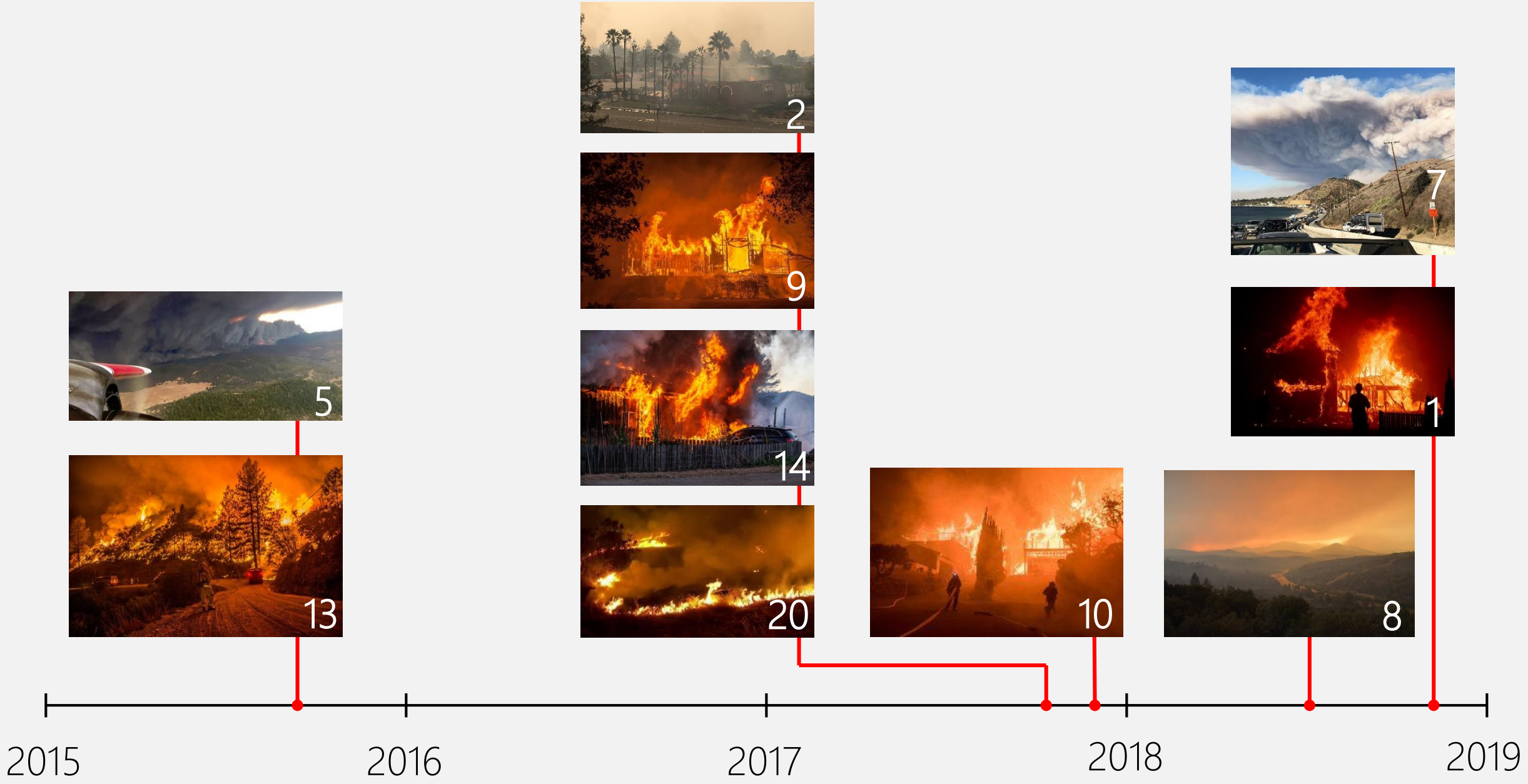
CAL FIRE often partners with other agencies during extended emergency incidents.

1 Agency
Partner Federal, State and Local Agencies

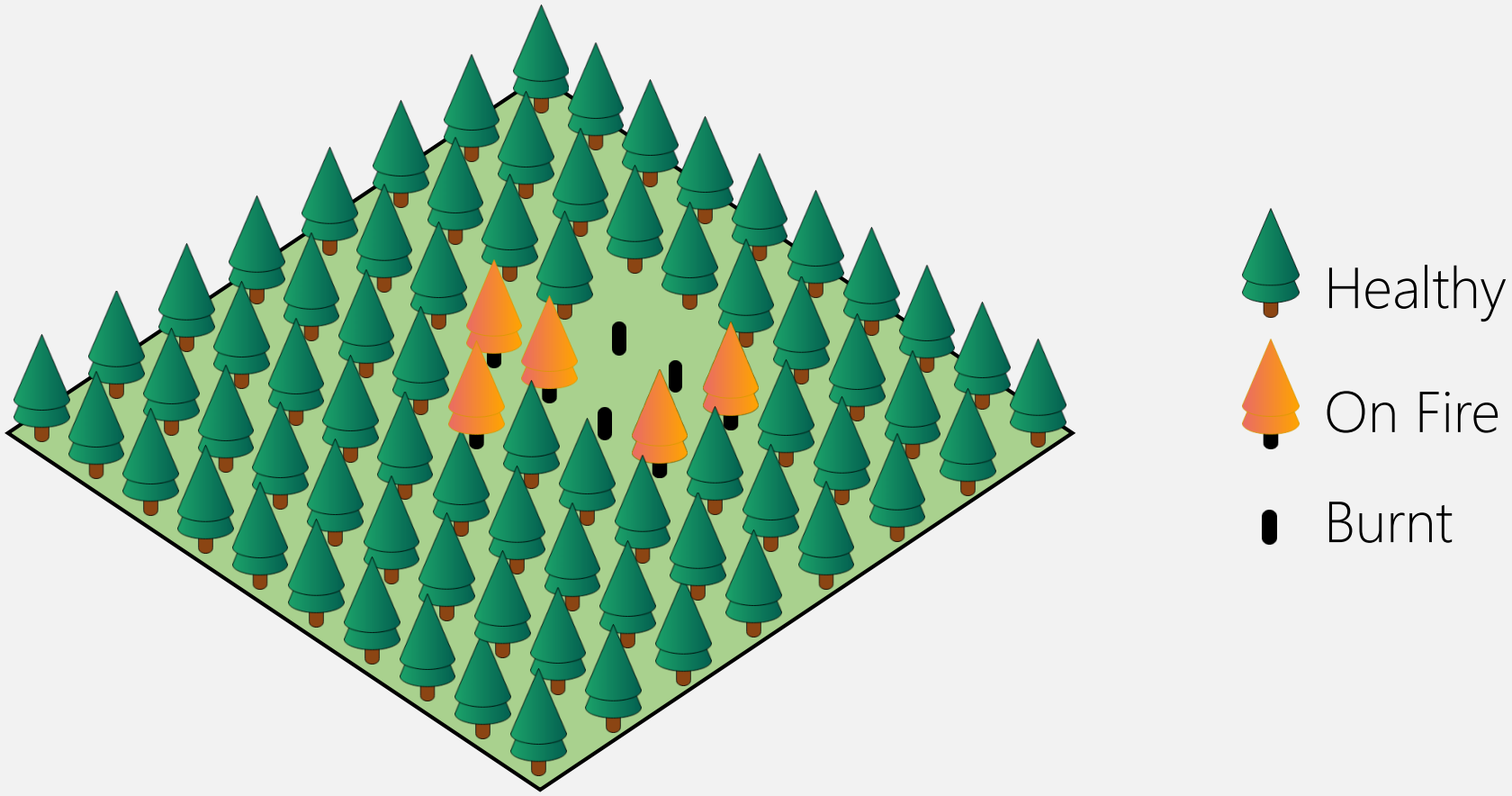
3,441 Personnels
Total Fire Personnel Assigned

76 Crews
Number of Crews Assigned


Map location or sensor ...
San Ramon
Mountain House
San Leandro
Castro Valley
Cherryland
South San Francisco
Colma
Pacifica
Moss Beach
Half Moon Bay
OUTER BAIR ISLAND
Milpitas
Portola Valley
La Honda
San Francisco Bay
Nimitz Freeway
Junipero Serra Freeway
Arthur H. Breed Junior Freeway
Robert T. Monagan Freeway
Vallecitos Road
Bayshore Freeway
Southbay Freeway
San Mateo - Hayward Bridge
Brushy Peak 514 m
Donlan Point 9 m
Lone Hill 257 m
Black Butte 331 m
Tolman Peak 304 m
Sunol Peak 664 m
Bald Mountain 867 m
Cedar Mountain 1118 m
Red Hill 89 m
Mount Allison 793 m
North Peak 570 m
Morena Sierra 731 m
Allen Lookout 708 m
Black Mountain 849 m
Round Hill 28 m
Healdsburg
Santa Rosa
Sacramento
Roseville
Folsom
Vacaville
Elk Grove
Concord
Berkeley
San Francisco
Stockton
Manteca
San Jose
100 miles
50.00 mi
97.56 mi

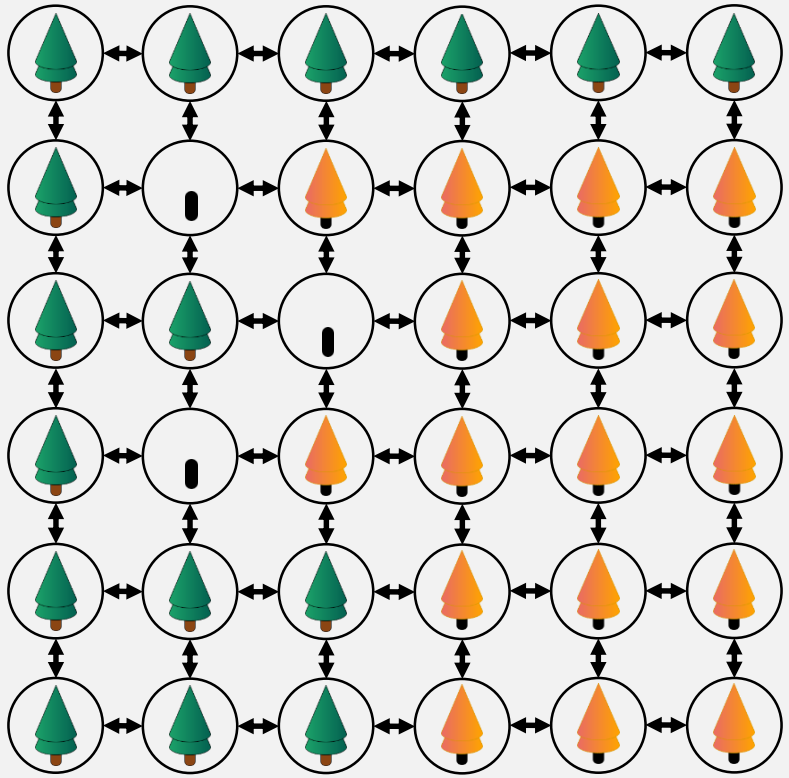

2
9
14
20
7
1
5
13
10
8
2015
2016
2017
2018
2019

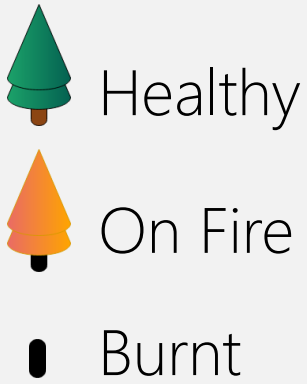
Modeling



Modeling

Graph-based Markov model





Our Work

Markov model

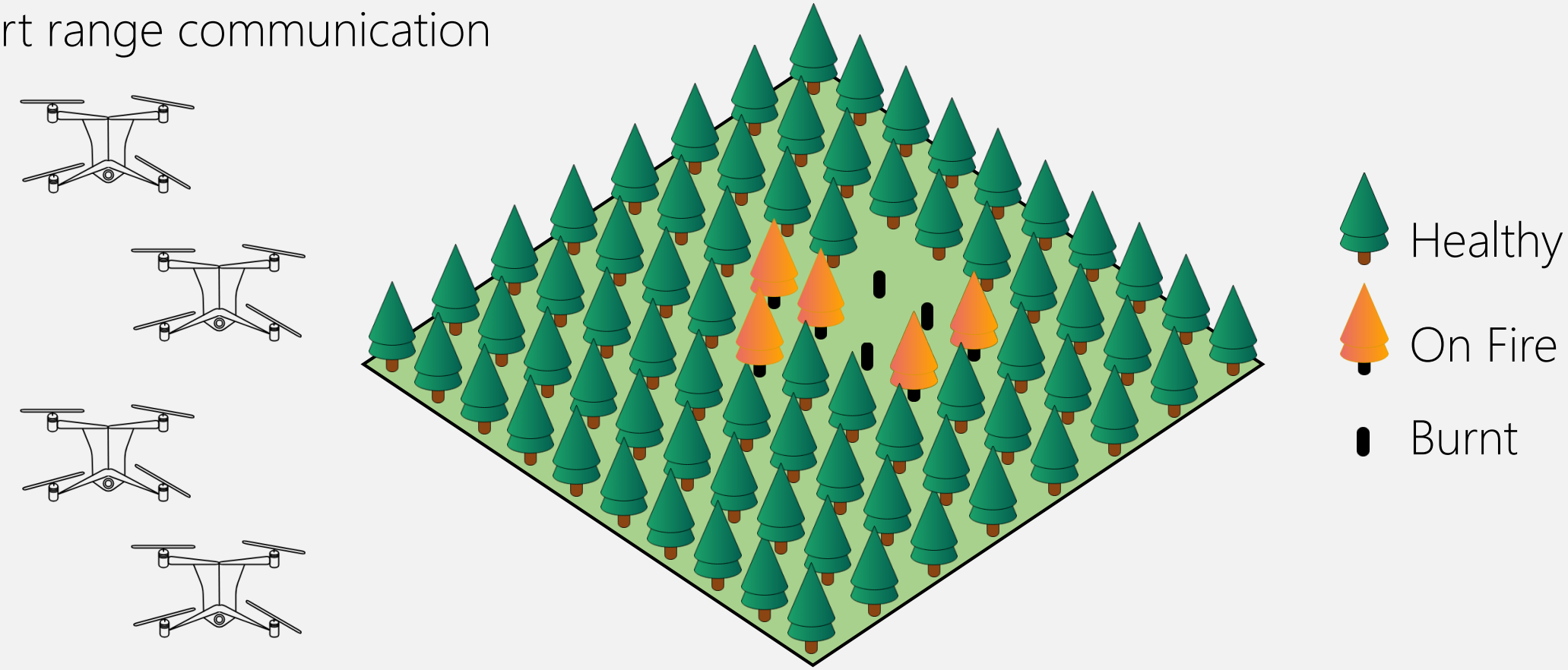
- Constrained resource allocation
- Fast online filtering

Markov model + aerial vehicles

- Wildfire suppression
- Persistent monitoring

Persistent Monitoring

Downward facing IR Cameras
Short range communication



Challenges

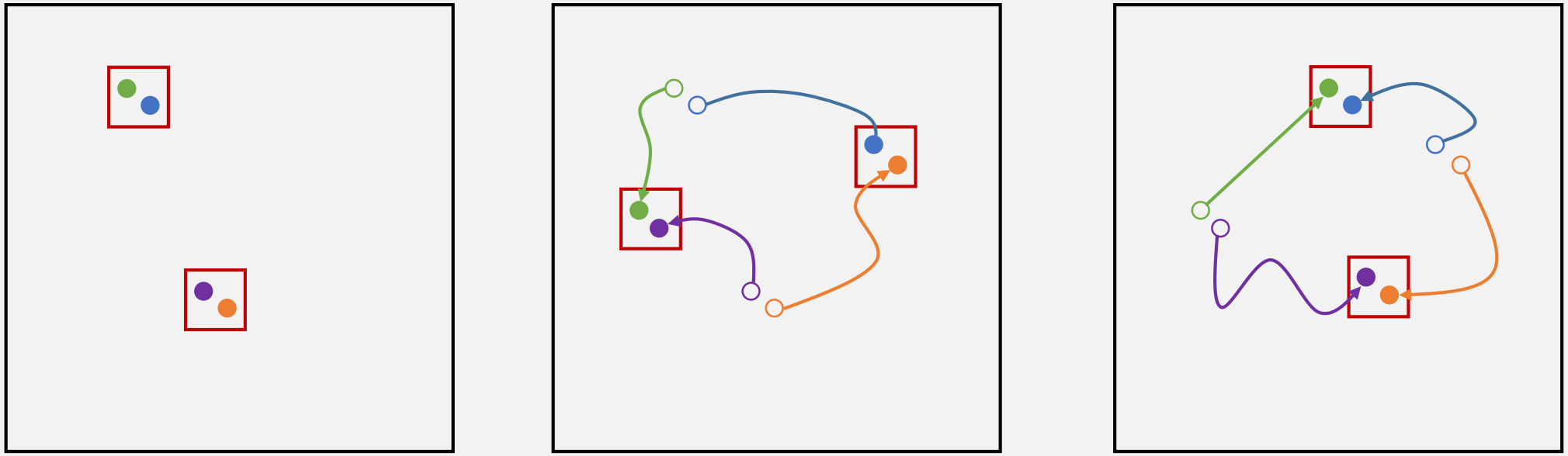
Robust communication networks are not typically available
Forest wildfires occur over very large areas and spread quickly
Large trajectory planning problem with partial observability

We build a scalable framework to coordinate a team of aerial vehicles

Main Idea

Robots schedule meetings to ensure information is shared

A meeting is a { **group**, time, location }



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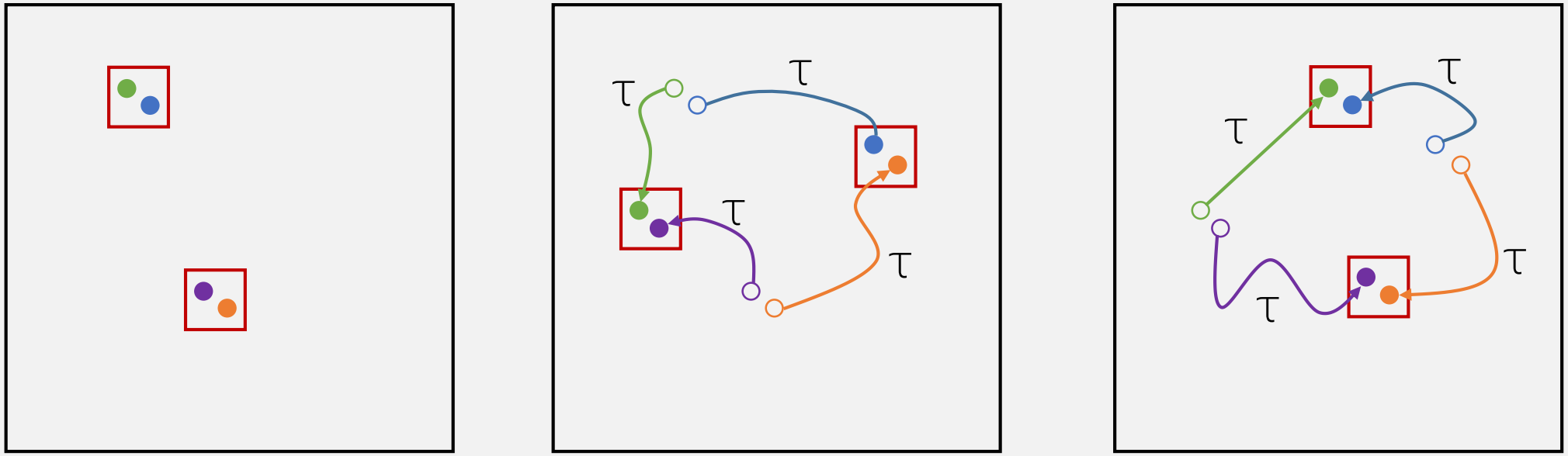

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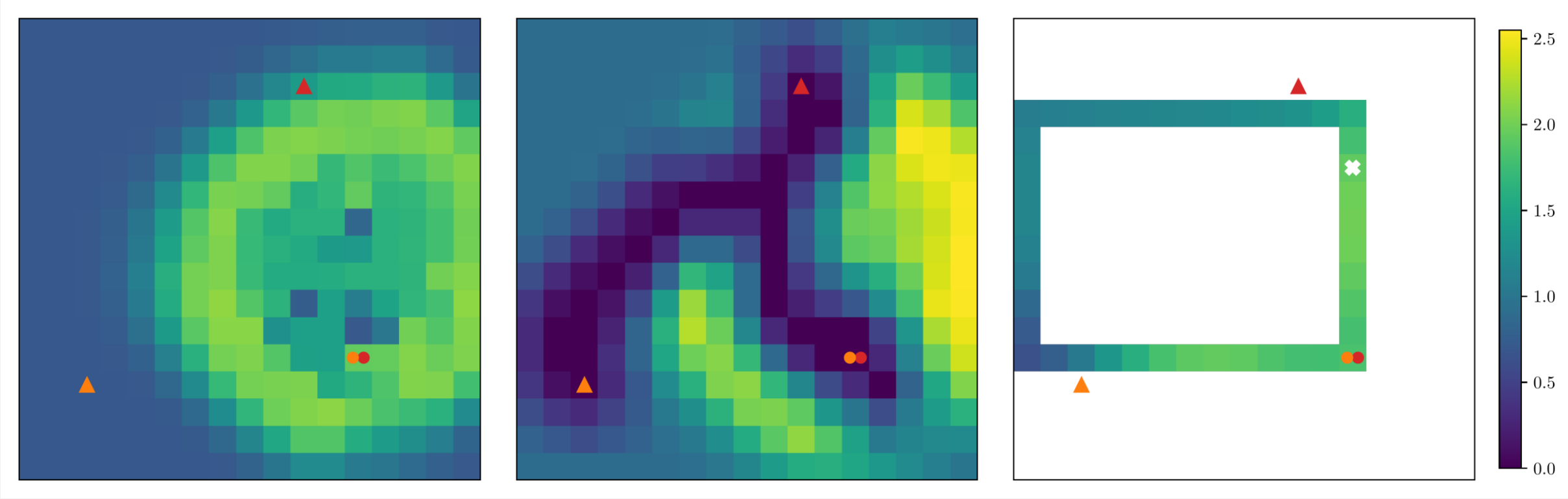
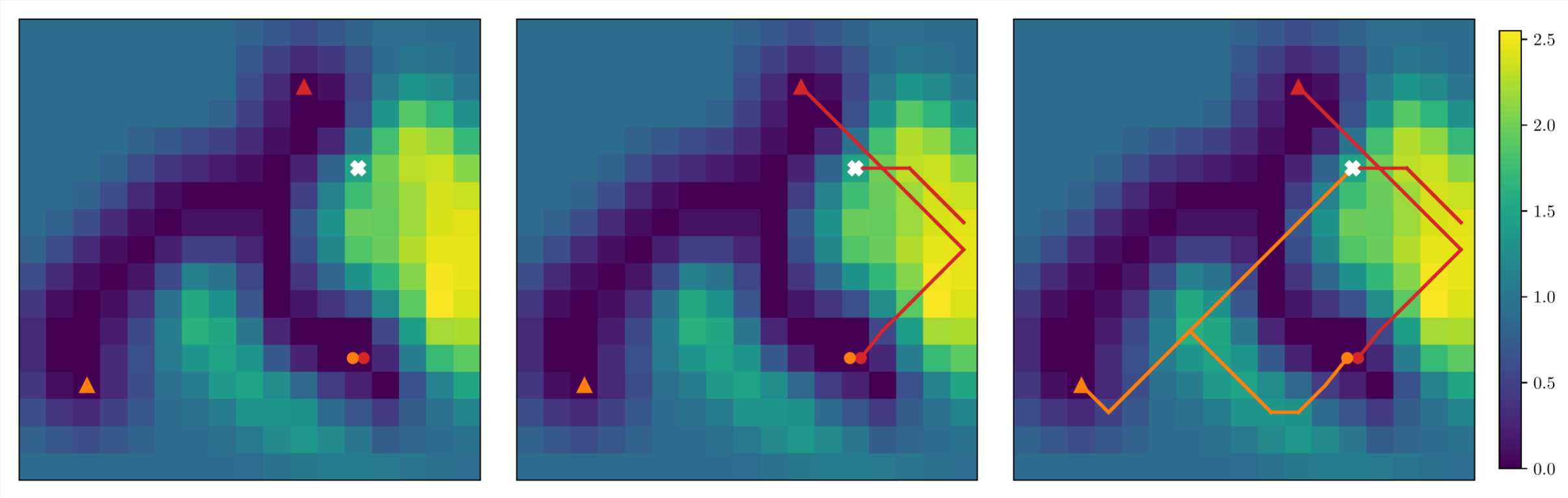


Main Idea

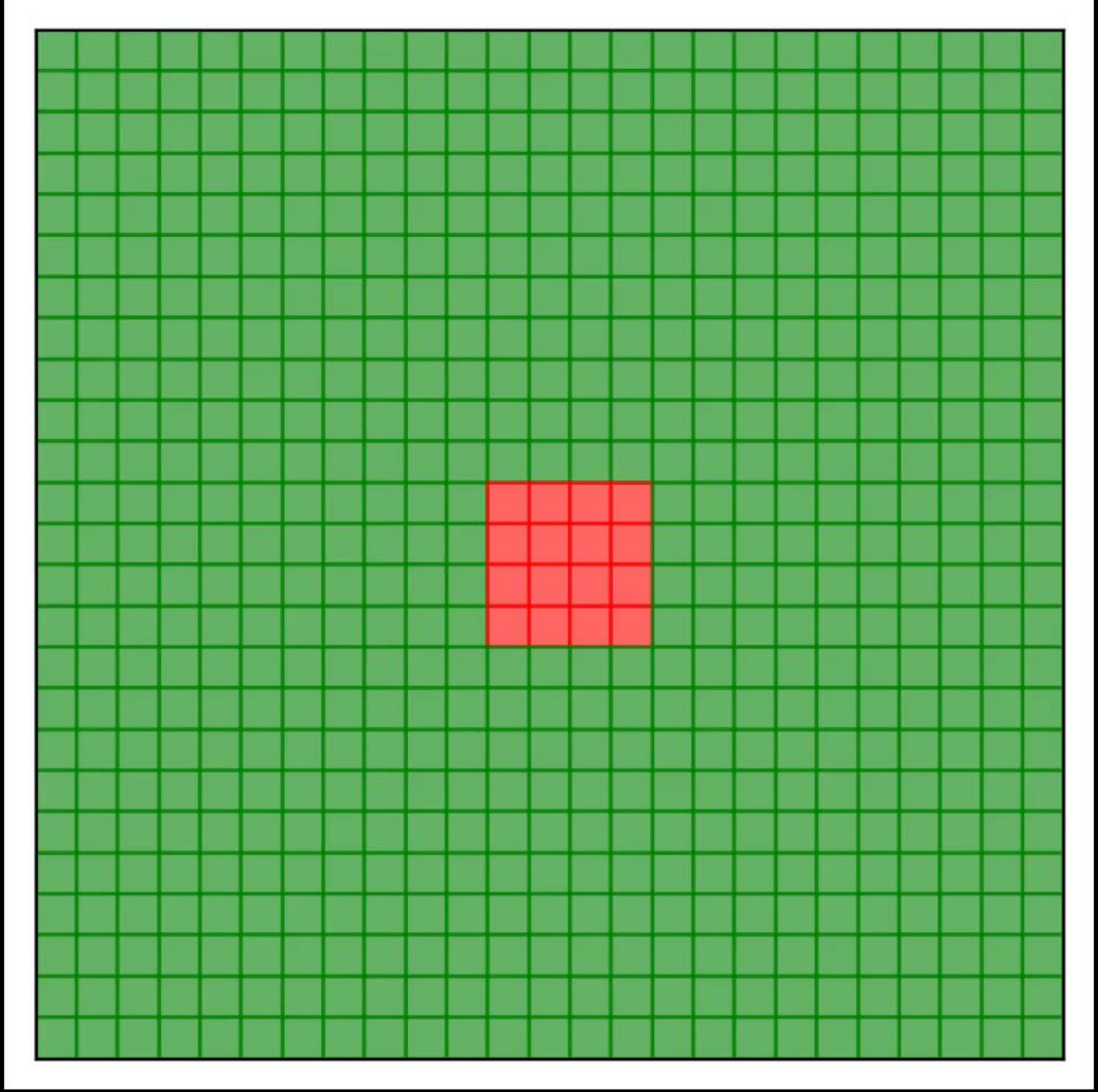
Planning - Pair of robots in a meeting

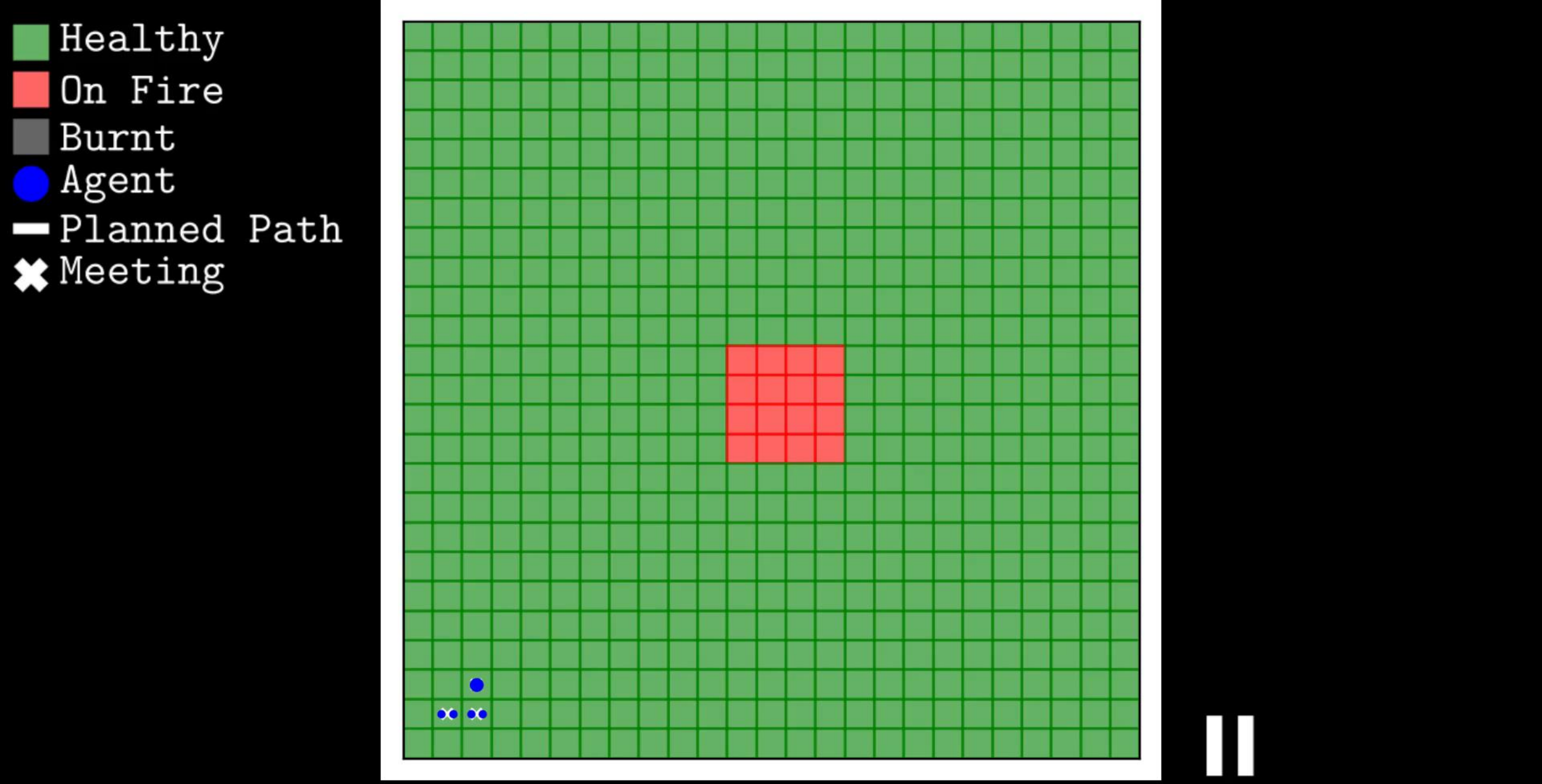


Algorithm

```
Deploy robots
for each time step do
    if a meeting occurs then
        Merge robots' beliefs
        Schedule next meeting
        Perform joint path planning and save paths
    for each robot do
        Move to first location of planned path
        Take image and update belief
    Update wildfire process every ρ time steps
```

Healthy
On Fire
Burnt

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Meeting

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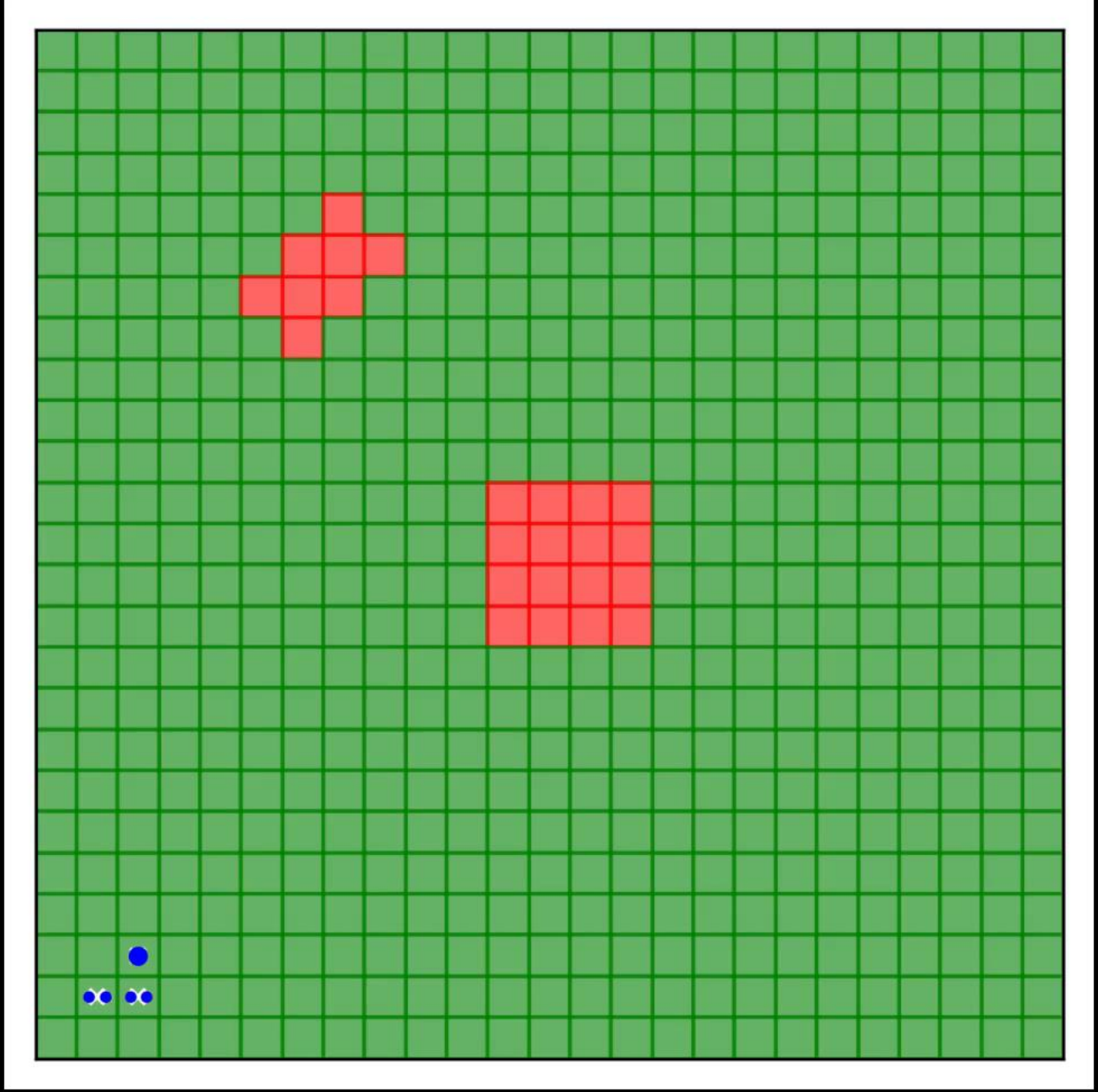

Future Directions

Dynamic groups and meeting times

Combined tracking and control

Other physical models