Southwest Research Institute®

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AnyLogic Conference 2016

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AGENT-BASED EXPLORATION OF SYSTEM NEGOTIATION AND REDISTRIBUTION OF GOALS

Roadmap

- Intro
  - Southwest Research Institute
- Research Topic
- AnyLogic to the rescue
- Application and Model
- Conclusion
  - Q&A

About Southwest Research Institute®

10 Operating Technical Divisions

- Applied Physics
- Applied Power
- Mechanical Engineering
- Engines, Emissions, and Vehicle Research
- Fluids and Lubricants Research
- Defense and Intelligence Services
- Intelligent Systems
- Space Science and Engineering
- Geosciences and Engineering
- Chemistry and Chemical Engineering

Organizational Characteristics

- Independent and nonprofit [501(c)(3)]
- Revenue provided by R&D contracts
- Broad technological and scientific capabilities
- Decentralized organization
- Internal research encouraged
- Unique Client-Oriented intellectual property policy

SwRI Statistics

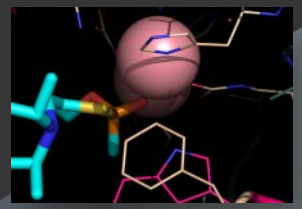
- ESTABLISHED: 1947
- STAFF: >2700
- GROSS REVENUE FY2015: >$592M
- FY15 Projects: >6,300
- CAMPUS: ~4.86 km2 (1200 Acres) in San Antonio, TX
- LABS/OFFICES: > 204,400 m^2 (2.2M ft^2)
- Over 1,235 Patents; 41 R&D 100 Awards
- FY15 IR&D: $7.2M, 194 projects

Deep Sea to Deep Space

And Everything Between

Deep Sea – Alvin

Pharmaceuticals & Bioengineering



Water and Geological Engineering

Lubricants Testing

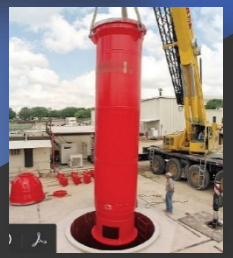
Robotics, Automation, and Simulations

Engine Design and Optimization

Energy

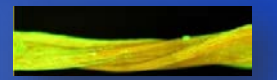
Infrastructure Communications

Materials & Engineering

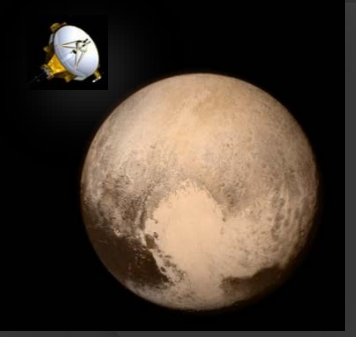


Spacecraft & Planetary Sciences

Regenerative Medicine



Deep Space - New Horizons



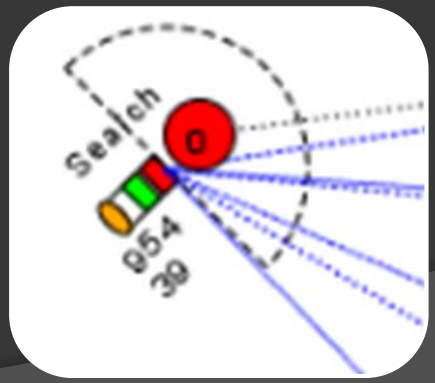
Autonomous Vehicles at the Institute

Big Red
Class VIII Freightliner

MARTI Ford Explorer

1165 Military HMMWV

UAVs: Tri, Quad and Hex rotors



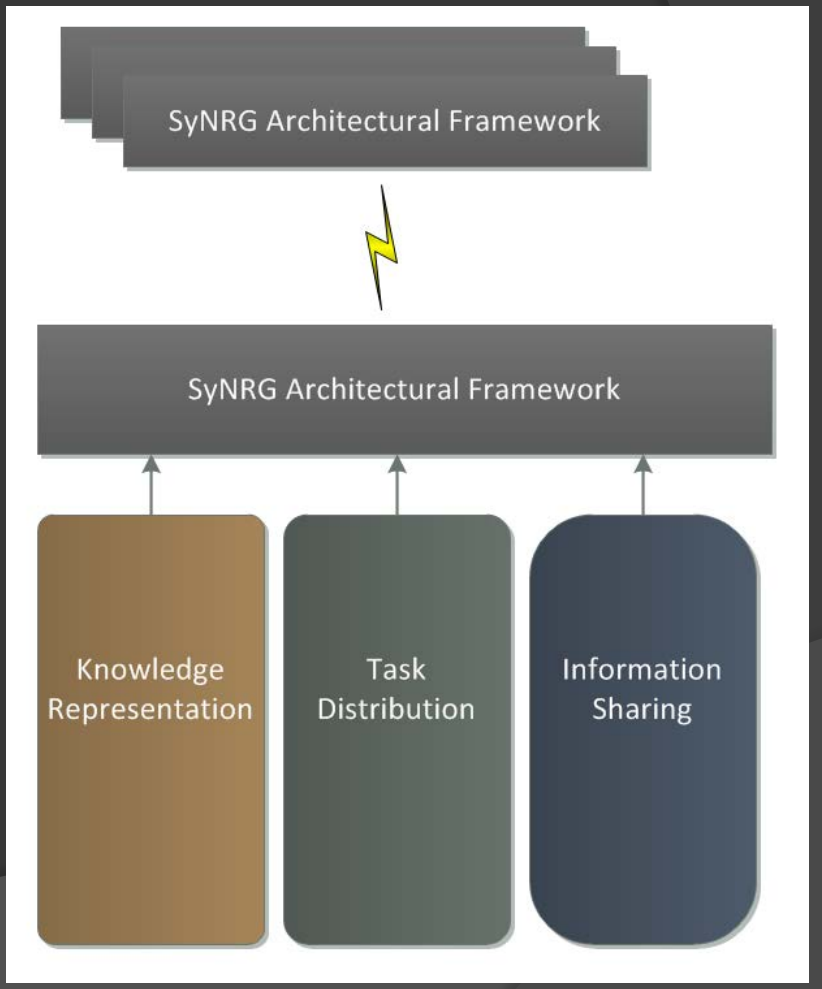
Simulated Vehicles

Executive Summary of Research Topic "Making awesome things more awesome!"

- Each autonomous vehicle is different, with unique characteristics that fit their purpose.
- Working together, there are advantages that each could bring that would further a purpose beyond the limited capability of one vehicle or one type of vehicle (synergy).
- Challenge - Create a team of autonomous vehicles that communicate with each other in a decentralized manner and solve a large system goal through dynamically allocating tasks to each vehicle according to their capabilities and location.

SyNRG – System Negotiation and Redistribution of Goals

- Software Architectural Framework
  - Allows intelligent agents to represent and share knowledge
  - Form teams based on capabilities that contribute to the system goal
  - Coordinates task completion dynamically
  - Distributed amongst teamed agents



Example

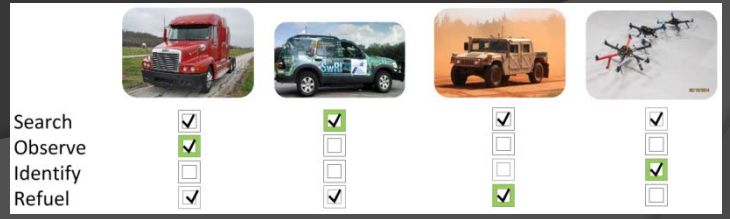
- Example Mission: Blended Search & Rescue with Refueling
- Includes autonomous ground, air and simulated vehicles with a variety of capabilities
- Environment includes an unknown number of capsules that are in unknown locations and may need refueling. The vehicles have a variety of capabilities and speeds, not all vehicles can refuel the capsules and not all can identify the fuel level of known capsules.
- Goal: Find all of the capsules and refuel them

Capabilities

Capabilities

Goal – Search, Observe, Identify and Refuel								
Tasks	Capabilities					Priority	Trigger
	1	2	3	4	5		
Search	✓					36	A
Observe		✓				29	B
Identify					✓	67	C
Refuel				✓		82	D

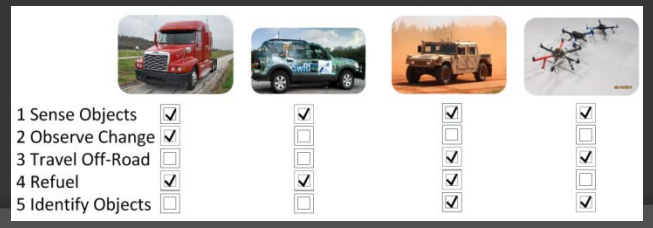
Goal Definition



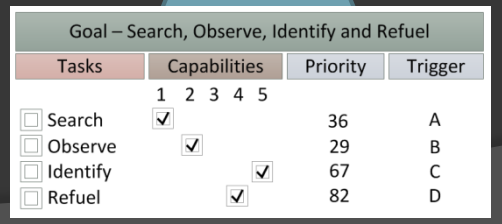
Establish a Team

Goal Definition

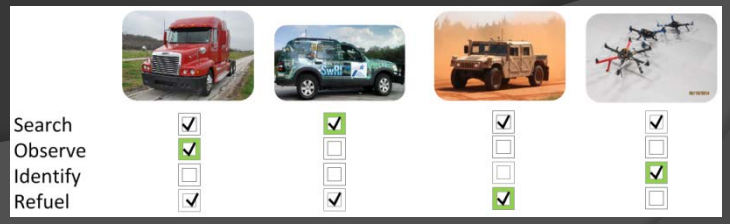
Goal – Search, Observe, Identify and Refuel			
Tasks	**Capabilities**	**Priority**	**Trigger**
	1 2 3 4 5		
☐ Search	☑	36	A
☐ Observe	☑	29	B
☐ Identify	☑	67	C
☐ Refuel	☑	82	D



Capabilities

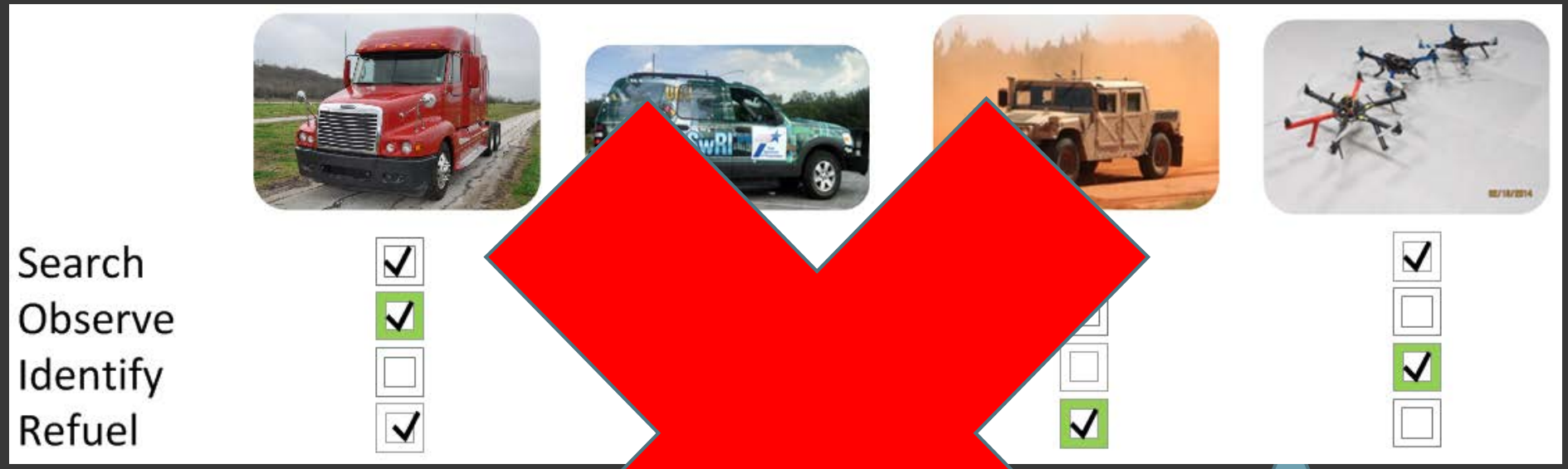


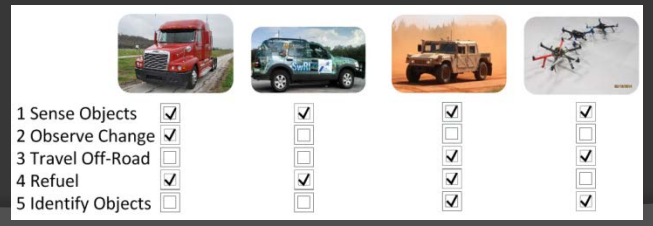
Goal Definition



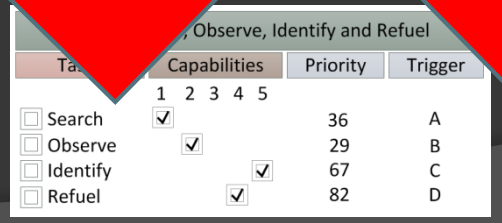
Establish a Team

Establish a Team

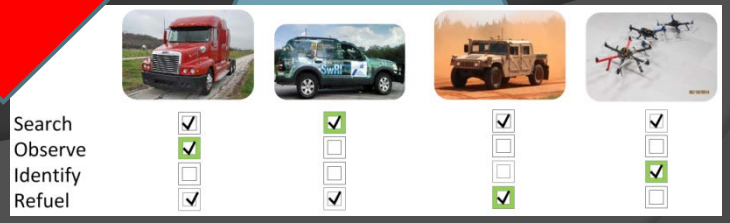




Capabilities



Goal Definition

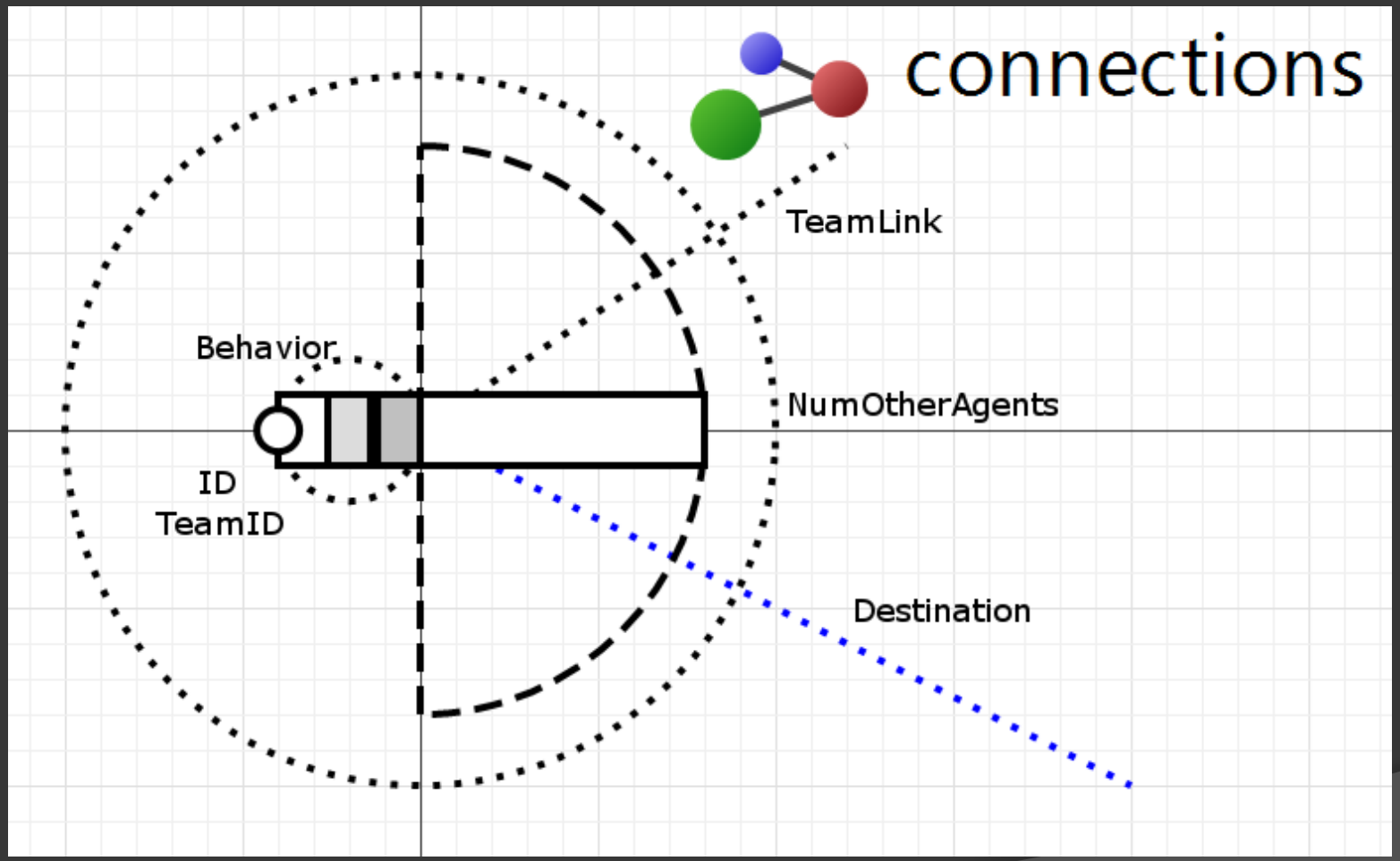


Establish a Team

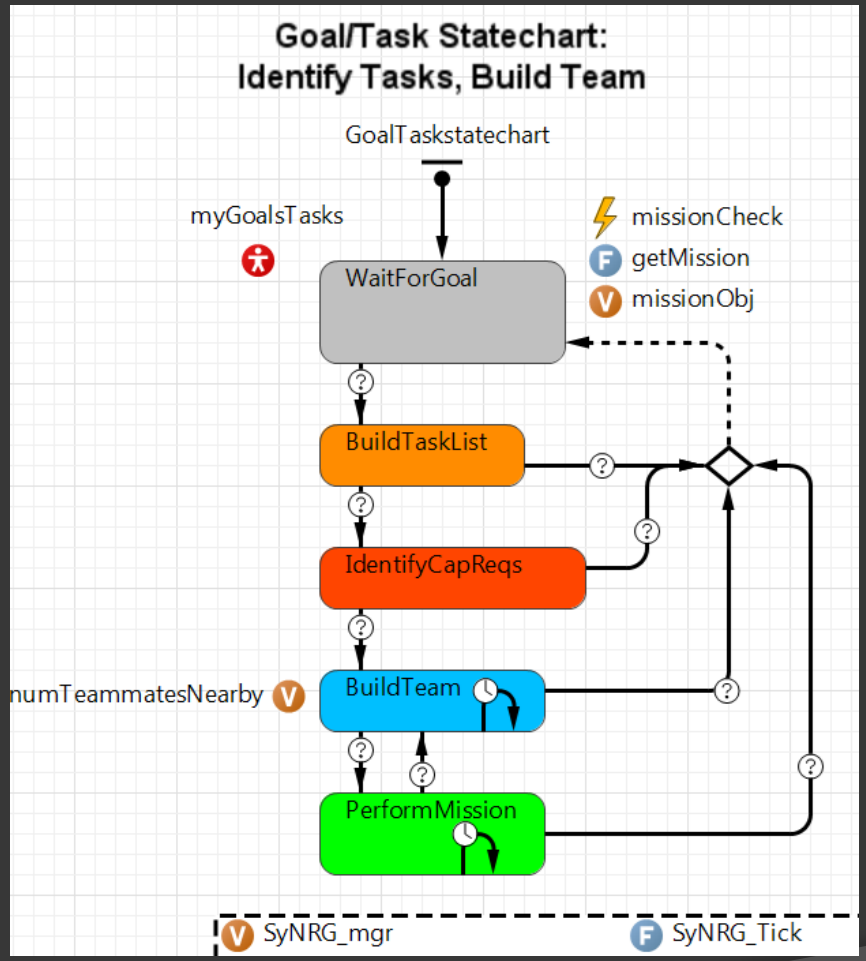
AnyLogic to the rescue

- Expensive to execute on physical vehicles
  - Simulation environment needed
  - Traffic simulation software would not be appropriate
  - Physics simulations are incredibly feature-rich but complicated
- Investigated AnyLogic, quickly able to provide proof-of-concept
- Intelligent agents were modeled in AnyLogic representing various capabilities
- World environment where the agents can interact
- Logic and interactions between agents could be simulated and quantified

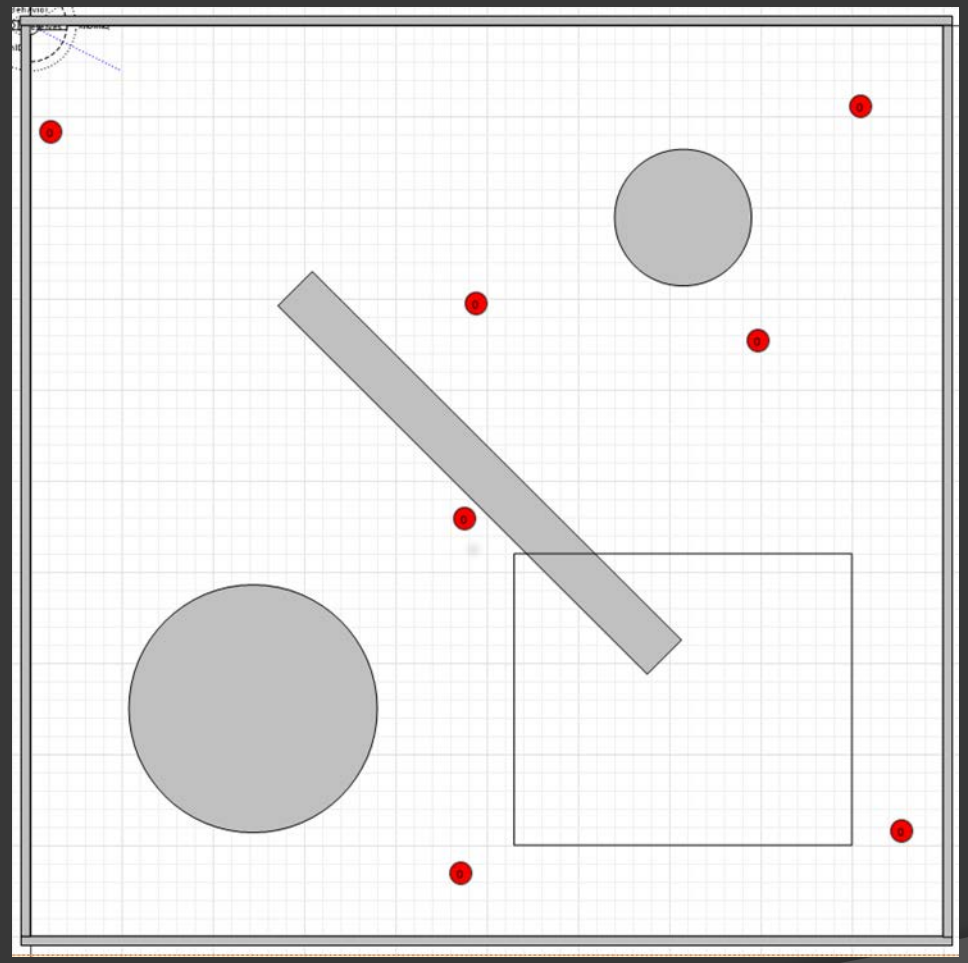
Agent Model


connections
TeamLink
Behavior
NumOtherAgents
ID
TeamID
Destination

Statemachine

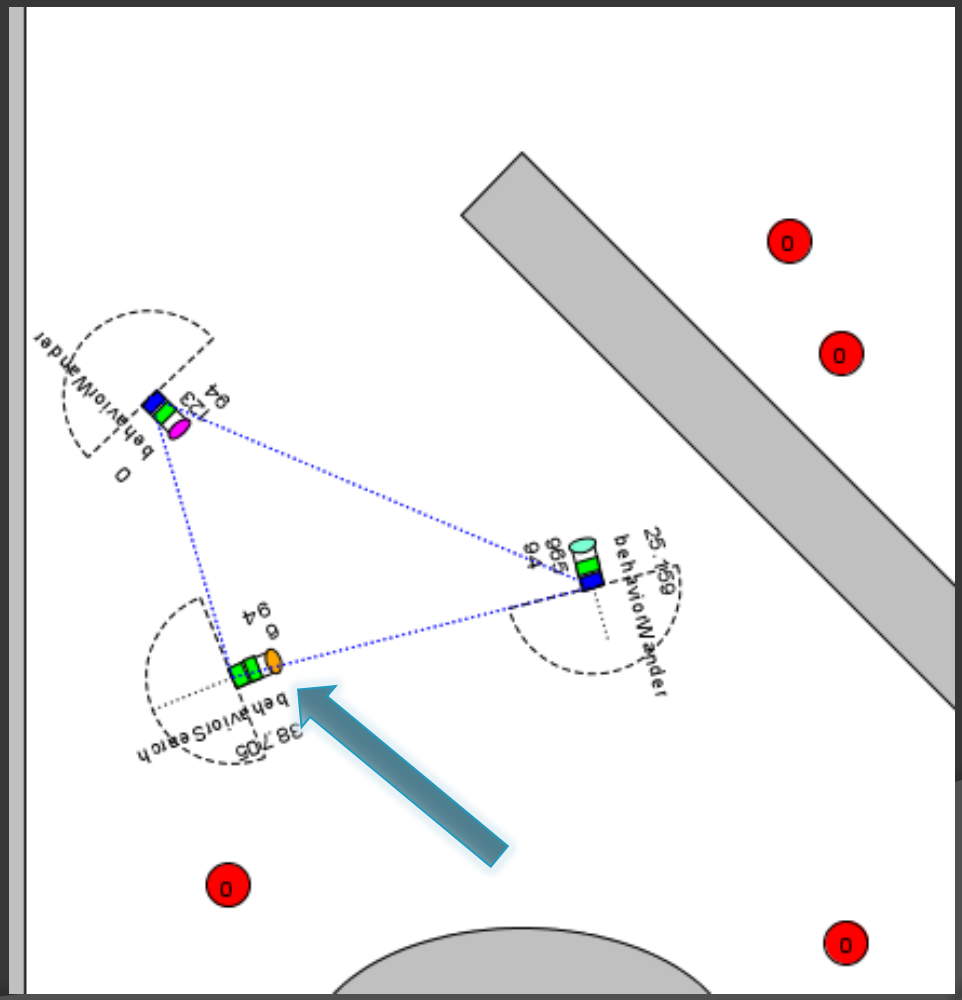


Environment



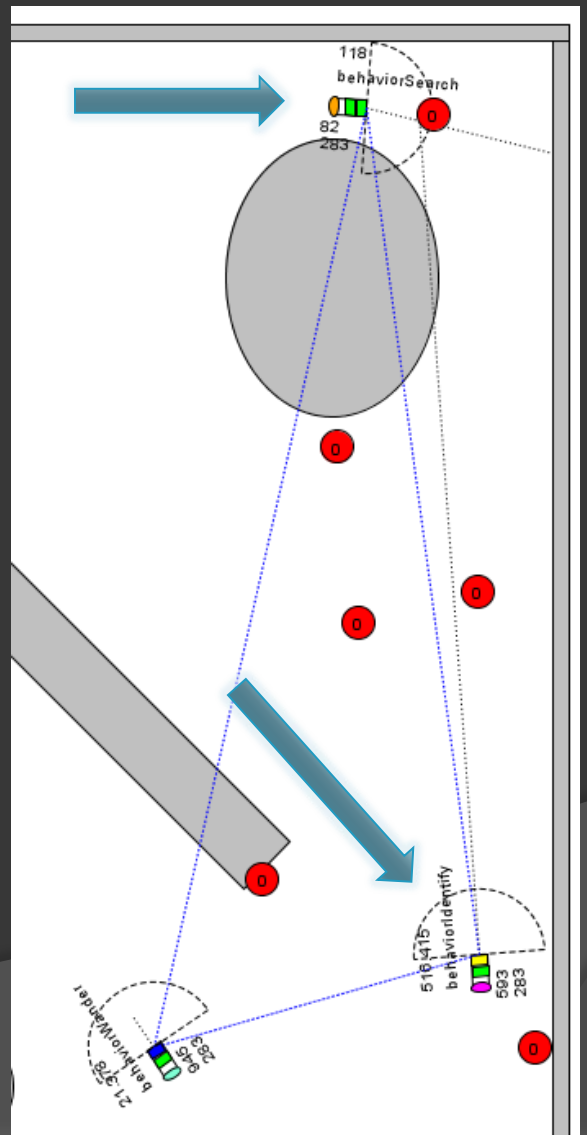
Executing Tasks

- Searcher is exploring
- Sharing knowledge of encountered objects
- Other vehicles are waiting for a task trigger

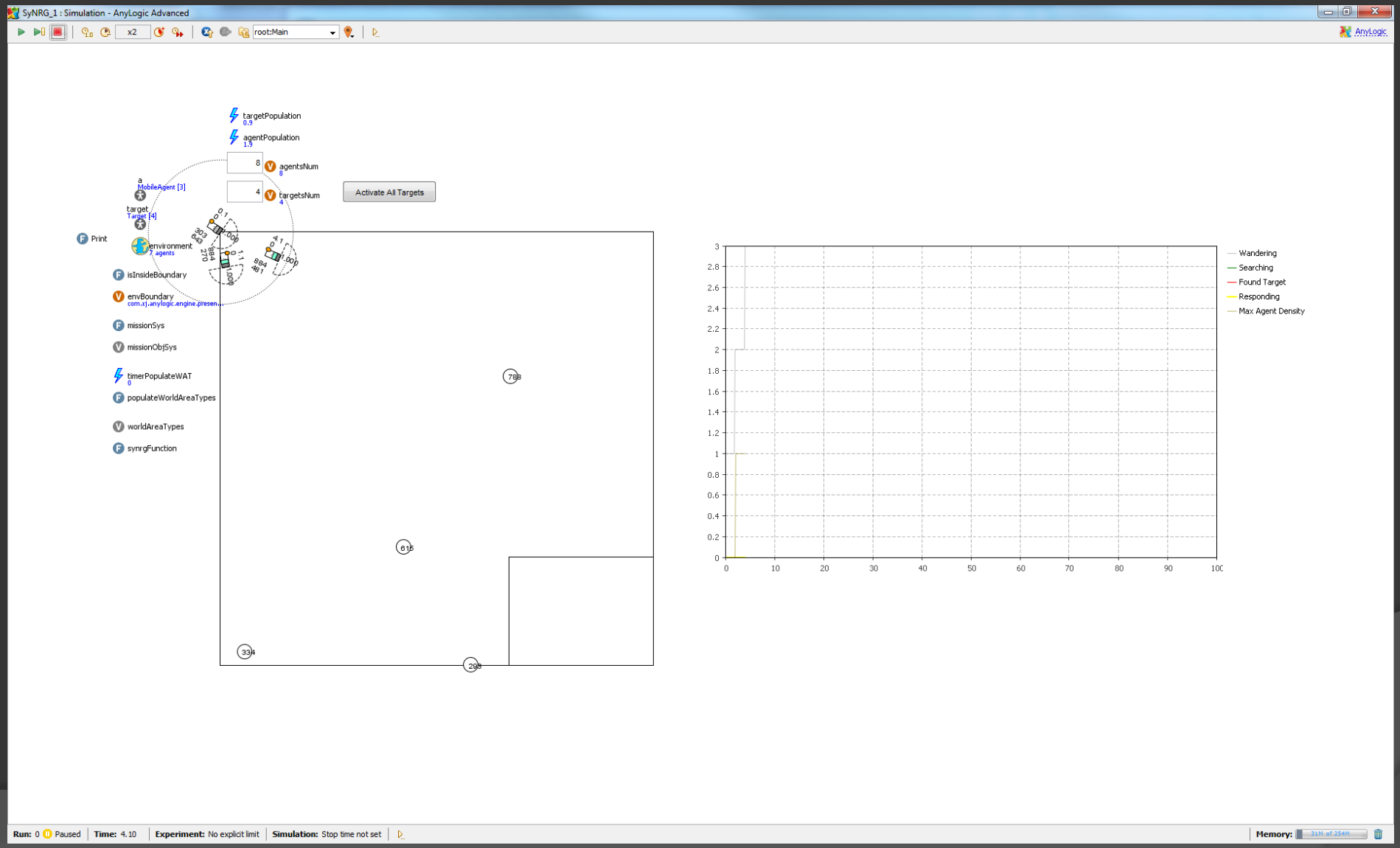


Example of Task Distribution

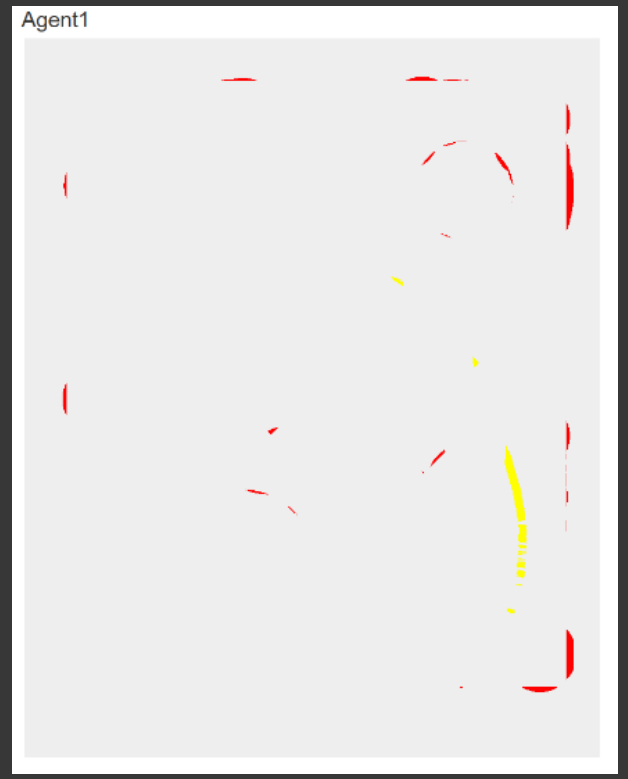
- Task trigger occurs
  - Object of interest has been found
  - Trigger sent to teammates – Needs Identification
- Vehicle with Identify capability responds by planning a path to the object

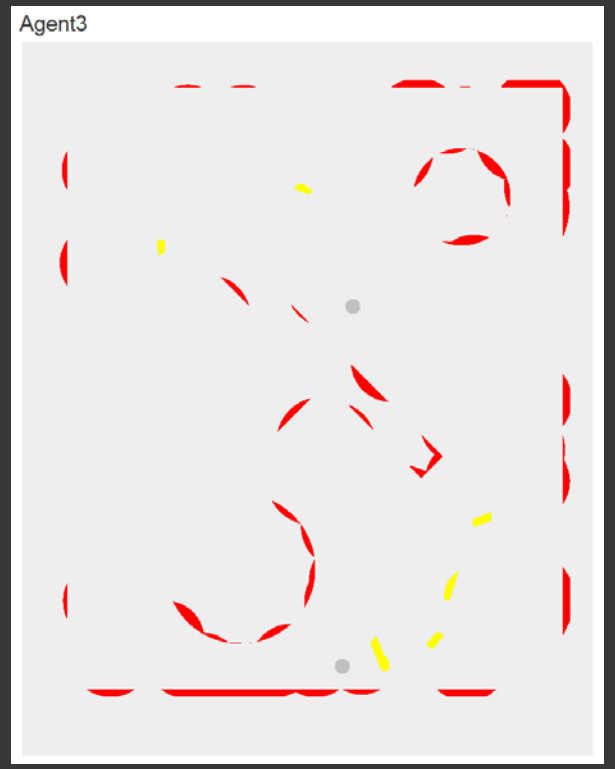


Model in operation

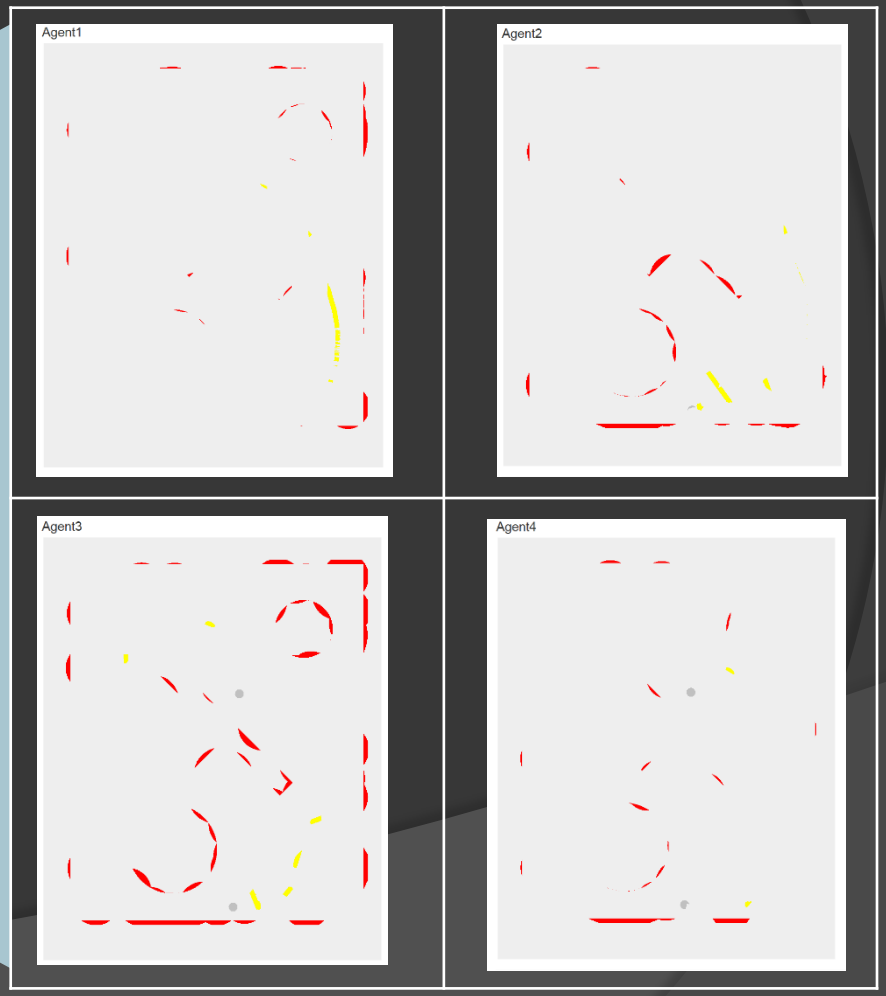


Discovering the world one agent at a time

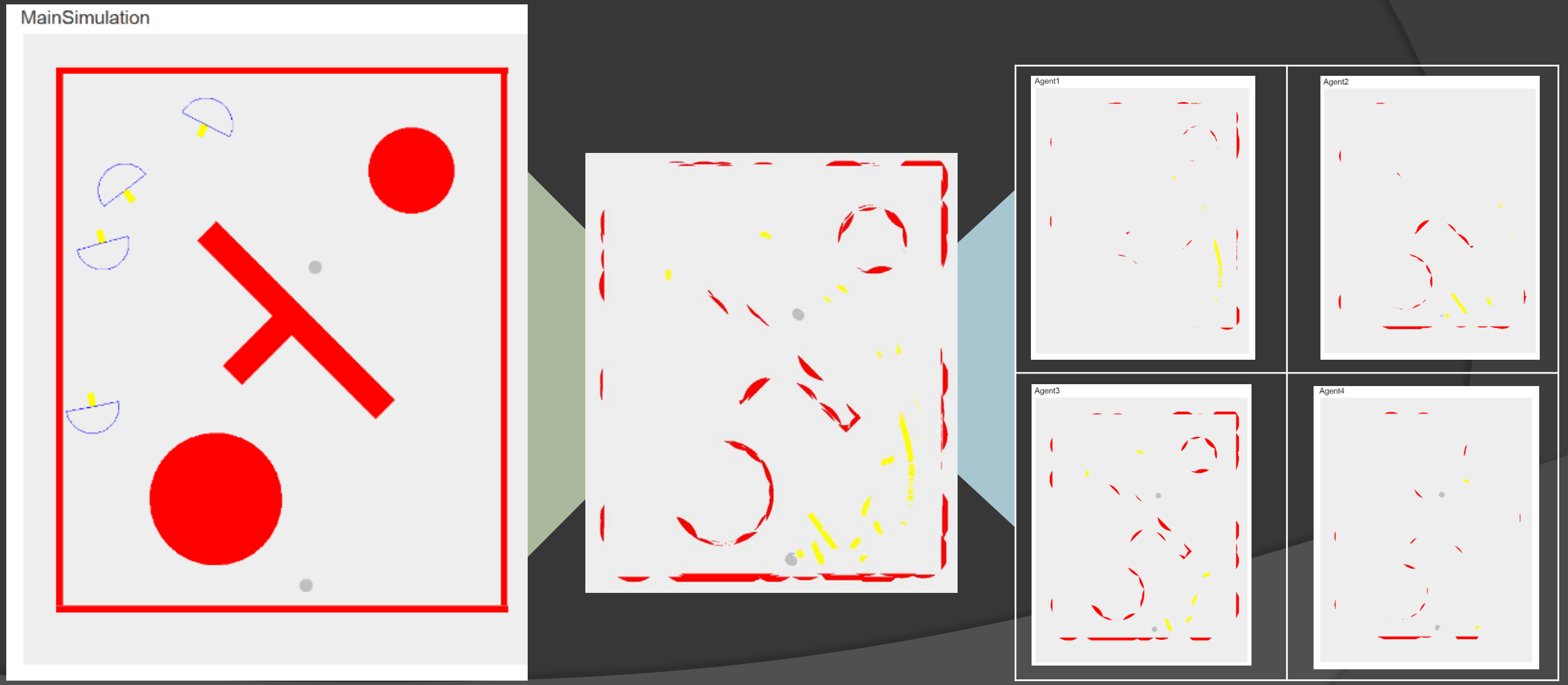




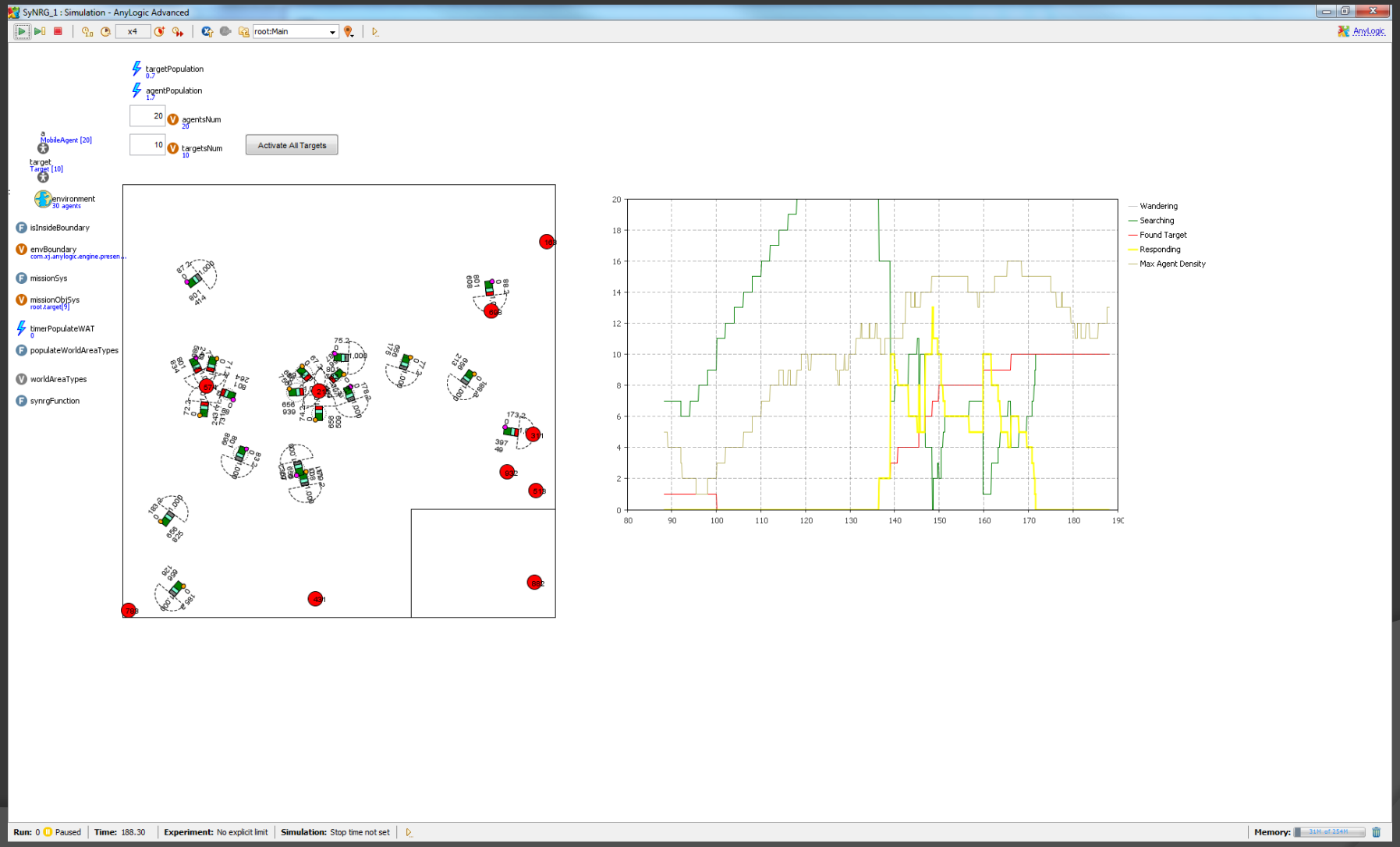
Sharing knowledge of the world



Collaborative view



Running multiple agents and graphing progress



Results

- Multiple (up to 45) agents running simultaneously in an AnyLogic model
- Enabled algorithm execution and development
  - Optimization of task distribution
  - Goal achievement with given resources
- Capability to address many limitations
- Years (3 likely) ahead of implementation

Conclusion

- Successful demonstration of team negotiation and dynamic task allocation
- Enabled through AnyLogic agent-based modeling

Questions?