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## Comparing and Evaluating Organizational Models: A Multi-Agent Programming Contest Case Study

Mariana Ramos Franco, Jaime Simão Sichman  
(mafranko@usp.br) (jaime.sichman@poli.usp.br)

Laboratório de Técnicas Inteligentes (LTI)  
Escola Politécnica (EP)  
Universidade de São Paulo (USP)

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## Agenda

- Introduction
- Multi-Agent Programming Contest
  - Agents on Mars scenario
- LTI-USP Team
  - Architecture
  - Strategies
- Experiments
- Results
- Conclusion


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## Introduction

- Recently, there has been a development toward the explicit design and use of **organizations** in MAS.
- Organization
  - Helps to better model the problem being tackled, and to **increase the system's efficiency**,
  - ... by defining the MAS structure and the rules which the agents must follow to achieve individual and system level goals.


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## Introduction

- However, how to find the organizational model (structure, constraints) that better solves the problem?


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## Introduction

- Objective
  - Compare and evaluate different organization models of a MAS.
- Scenario
  - The “Agents on Mars” scenario proposed in the Multi-Agent Programming Contest (MAPC).


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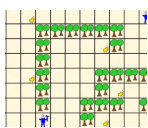
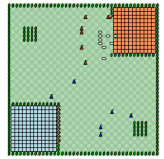
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## Multi-Agent Programming Contest

- International competition held every year since 2005 (<http://multiagentcontest.org/>).
- Objective:
  - Stimulate research in the field of programming multi-agent systems.

2006-2007: goldminers

2008-2010: cows and cowboys

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**MAPC 2011 - 2013: Agents on Mars**

water wells

team blue's zone

agents

cost for traversing from one vertex to another

team green's zone

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**MAPC 2011 - 2013: Agents on Mars**

- 2 teams, 28 agents each.
- Roles and actions:

	explorer	repairer	saboteur	sentinel	inspector
recharge	X	X	X	X	X
attack			X		
parry		X	X	X	
goto	X	X	X	X	X
probe	X				
survey	X	X	X	X	X
inspect					X
buy	X	X	X	X	X
repair		X			
skip	X	X	X	X	X

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- JaCaMo framework.
  - Jason: for programming autonomous agents.
  - CARtAgO: for programming environment artifacts.
  - Moise: for programming multi-agent organizations.
- The adopted solution is based on the centralization of coordination:
  - One agent is responsible for determining which are the best zones in the map, and then conduct the other agents to occupy these zones.

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**LTI-USP Team**

- Architecture:

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**LTI-USP Team**

- Structural Specification:

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**Experiments**

- How the number of squads in our team can impact in its overall performance?

Team Configurations.



Team	Squad	soldiers	guardians	medics	zone_explorers	Agents
TG1	1	20	1	1	1	23
	2	7	1	1	1	10
TG2	1	5	1	1	1	8
	2	5	1	1	1	8
TG3	3	4	1	1	1	7
	4	3	1	1	1	6
TG4	2	3	1	1	1	6
	3	3	1	1	1	6
TG5	4	3	0	1	1	5
	5	3	0	1	1	5

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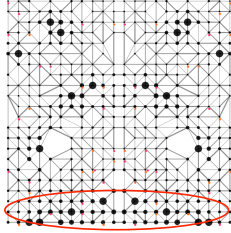
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## Experiments

- Scenarios:



**SC1**  
(1 high valued and spread zone + 8 small zones)

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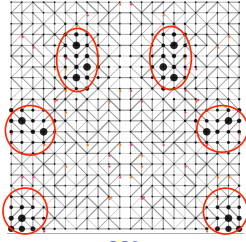
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## Experiments

- Scenarios:



**SC2**  
(6 distributed zones with almost the same value)

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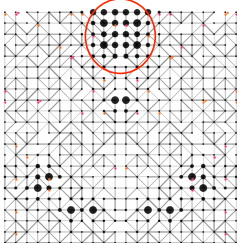
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## Experiments

- Scenarios:



**SC3**  
(1 high valued and concentrated zone + 5 small zones)

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## Results

- For each scenario, we performed 10 simulations for each of the following matches:
  - TG1 vs TG2, TG1 vs TG3, and TG1 vs TG4.

Number of wins.

	TG1 x TG2	TG1 x TG3	TG1 x TG4
<b>SC1</b>	2 x 8	4 x 6	1 x 9
<b>SC2</b>	0 x 10	0 x 10	0 x 10
<b>SC3</b>	4 x 6	1 x 9	2 x 8

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## Results

- Wilcoxon T test
  - The 10 simulations were sufficient (p-value < 0.05) or not to conclude that a team was better than other in a determined scenario?

Wilcoxon T test

	TG1 x TG2	TG1 x TG3	TG1 x TG4
<b>SC1</b>	0.02881	0.5787	0.005196
<b>SC2</b>	0.0115	0.002879	0.002057
<b>SC3</b>	0.1655	0.06301	0.02323

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## Analysis

- Scenario 1:

Number of wins.

	TG1 x TG2	TG1 x TG3	TG1 x TG4
<b>SC1</b>	2 x 8	4 x 6	1 x 9
<b>SC2</b>	0 x 10	0 x 10	0 x 10
<b>SC3</b>	4 x 6	1 x 9	2 x 8

Wilcoxon T test

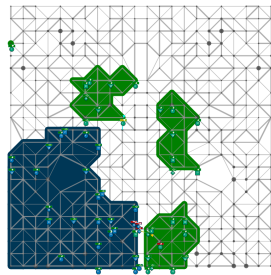
	TG1 x TG2	TG1 x TG3	TG1 x TG4
<b>SC1</b>	0.02881	0.5787	0.005196
<b>SC2</b>	0.0115	0.002879	0.002057
<b>SC3</b>	0.1655	0.06301	0.02323

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**Analysis**

• Scenario 1:



- TG1 easily conquer the best zone;  
- The score summed from the two others TG3's is not enough to defeat TG1.

Scenario 1 – TG1(blue) vs TG3(green)

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**Analysis**

• Scenario 2:

Number of wins.

	TG1 x TG2	TG1 x TG3	TG1 x TG4
SC1	2 x 8	4 x 6	1 x 9
SC2	0 x 10	0 x 10	0 x 10
SC3	4 x 6	1 x 9	2 x 8

Wilcoxon T test

	TG1 x TG2	TG1 x TG3	TG1 x TG4
SC1	0.02881	0.5787	0.005196
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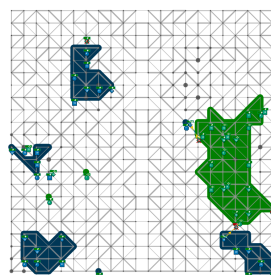
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**Analysis**

• Scenario 2:



- All best zones have almost the same value, what is good for the teams with more squads.

Scenario 2 – TG1(green) vs TG4(blue)

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**Analysis**

• Scenario 3:

Number of wins.

	TG1 x TG2	TG1 x TG3	TG1 x TG4
SC1	2 x 8	4 x 6	1 x 9
SC2	0 x 10	0 x 10	0 x 10
SC3	4 x 6	1 x 9	2 x 8

Wilcoxon T test

	TG1 x TG2	TG1 x TG3	TG1 x TG4
SC1	0.02881	0.5787	0.005196
SC2	0.0115	0.002879	0.002057
SC3	0.1655	0.06301	0.02323

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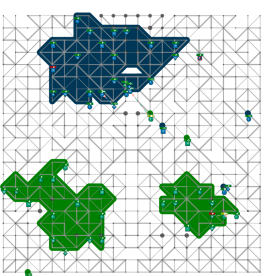
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**Analysis**

• Scenario 3:



- In some simulations, TG2 does not find the best zone in the map, since the zone is not so spread as in SC1;  
- TG1 won when it was able to find the best zone and TG2 not.

Scenario 3 – TG1(blue) vs TG2(green)

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**Conclusion**




- Determine an appropriate or best MAS organization for a given scenario is a key problem in MAS research, and empirical approaches can be very useful in this regard.
- The results are not conclusive
  - small number of scenarios;
  - the scenario can greatly impact the team's performance.

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## Conclusion

- Future work:
  - Increase the number of different tested scenarios, and also evaluate different structures and parameters of organizational models.
  - The results obtained in this study can be used to develop a team capable of reorganizing according to the characteristics of the environment.





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## THANKS FOR YOUR ATTENTION!

## QUESTIONS?

contact: [mafranko@usp.br](mailto:mafranko@usp.br) or [jaime.sichman@poli.usp.br](mailto:jaime.sichman@poli.usp.br)