Distributed Simulation with Automated Planning: Study and Support Tool for Relief Operations in Conflicted C2 Scenarios

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AGENDA

- Introduction
- Related Work
- Framework for Conflicted C2 Scenarios
- Case Study
- Conclusion and Final Remarks
Introduction

- Brazilian context
  - Natural disasters
  - Gaps in the actual C2 process
  - Military Forces engaged to support relief operations
  - NATO NEC C2 Maturity Model
    - Conflicted C2 scenario
  - Opportunity to use Decision Support Systems to improve the C2 maturity level
Introduction

Problem

- Conflicted C2 Scenario – Entities are not aware of each other's actions. No interaction between organizations. Decisions are not allocated to the collective.

Introduction

**Question**

- How to improve Situation Awareness in such scenario when the organizations are not required to collaborate or are not being operationally allocated by a central coordinator?

**Options**

- Increasing the C2 Maturity level
  - Centralizing the resource allocation
  - Improving the coordination among organizations
    - DSS
    - Simulation tools
Introduction

- **Hypothesis** — simulation increases the awareness when generating pre-planned missions, from different organizations that are not aware of each other's actions.

- **Objective** — to generate a collaborative simulation environment with 2D and 3D visualization to increase Situation Awareness during operations planning in a Conflicted C2 scenario.
Related Work

- OR/MS, HA/DR and C2 may be considered as somewhat similar research areas in terms of management focus, decision making process and logistical and operational environments.

- OR/MS and HA/DR papers that specifically focus on Disaster Operations Management (DOM) may be highlighted as related works.
Related Work

- **Disaster Operations Management** - ALTAY and GREEN, 2006; SIMPSON and HANCOCK, 2009; and GALINDO and BATTA, 2013.

- **Command and Control** – few related articles to HA/DR could be found in the aforementioned reviews – gap in the capacity of non-military agencies for managing HA/DR operations.

- **Distributed Simulation** – no related articles found.
Framework

- **COTS tools**
  - VT-MÄK VR-Forces®

- **Distributed Simulation environment**
  - HLA/DIS protocol
  - Each federate acts as a plan execution defined by an organization responsible for conduct actions in the scenario
  - Federation provides a fused view for allocated resources
Inference model to support planning

A knowledge base was structured to support task reasoning based on the effects to be reached and the available resources

- **Deterministic inference:** to identify the adequate resources to the task to be executed
- **Probabilistic inference:** to identify the probability to achieve the task based on the resource and environment

For study purpose

- To generate Conflicted C2 scenarios to understand the impact of uncoordinated actions
- Before actions being executed (operational level), and after action review (tactical level)
Knowledge Base

- Semantic approach using 5 ontologies in OWL:
  - Domain Ontology
    - Description about the domain of interest
  - Planner Ontology
    - Description about the problem solver methods and operators
  - Scenario Ontology
    - Description about the world
  - PR-OWL Ontology
    - Probabilistic description for the OWL language
  - Task Ontology
    - Description about tasks, activities and phases
Knowledge Base

- Why ontologies?
  - To support different organizations
    - Different tasks may reach the same effect
    - Different resources may execute the same task
  - Probabilistic reasoning based on the scenario description
  - Extensible
  - Planning based on the specific situation
  - Ontologies allows the description of the differences between actions, tasks, resources and situations – context based
HTN Methods

Case Study

- Real scenario occurred in Brazil (2008)
  - 8 million people were affected
  - Flooding and mudslides in the affected region
  - Itajaí River above 10m of its level
  - 80% of Itajaí city became flooded
  - Population could not flee at time and needed support

- Objective
  - To partially reproduce the situation and understand ways to improve synergy between organizations
Case Study

- Three federates
  - Federate 1 acting as the air resources allocator
  - Federate 2 acting as the land resources allocator
  - Federate 3 acting as the fluvial resources allocator

- Each plan describes the actions in the specific domain

- The federation executes all the plans at the same time
Federate 1 – Air Resources
Federate 2 – Land Resources
Federate 3 – Fluvial Resources
Federation – Fused View
Federation Execution
Path Analysis
Coordinators may have the ability to see the scenario as a whole, perceiving the misuse of resources due to the lack of communication between organizations and also the resource utilization in regions that will be affected before the mission could be accomplished.
Conclusion

- The simulation provides a better visualization of the resources’ tracks, giving to a coordination team the ability to understand the possible path conflicts and the necessity to create air corridors during the scenario evolution, which is quite hard to get by only using conventional maps and pictures.
Conclusion

- This simulation tool can be also used to reproduce the whole operation, serving as a useful after action review tool, which can improve the lessons learned process.
Future Work

- To create a more detailed mission, evolving a scenario which reproduces the previous condition of 2008, where 80% of the Itajaí City was totally flooded.
- To evolve the Task Ontology to be more general about HA/DR operations.
- To establish some measures of performance in order to quantify the improvements.
  - Ex: Number of duplicated assets per task, the total number of launched missions, and the average waiting time for rescuing people.
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Questions?