Command and Control Modeling in Soar

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Project Goals

- Develop autonomous command forces
  - Act autonomously for days at a time
    - Reduce load on human operators
  - Behave in human-like manner
    - Produce realistic training environment
  - Perform Command and Control (C2) functions
    - Reduce the number of human operators
    - Create realistic organizational interactions
C2 Modeling Hypotheses

- **Continuous Planning**
  - Understand evolving situations
  - Achieve goals despite unplanned events

- **Collaborative Planning***
  - Understand behavior of other groups
  - Understand organizational constraints

* See Gratch’s workshop talk on Rude Planner
C2 Modeling Hypotheses

**Situation Awareness**

- Identify information requirements
- Focus intelligence collection efforts
- Model intelligence constraints on planning
- Fuse and assess sensor reports*

* See Zhang’s workshop talk on clustering
Mission Capabilities

- Army Aviation Deep Attack
  - Battalion command agent
  - Company command agents
  - CSS command agent
  - AH64 Apache Rotary Wing Aircraft
Soar-CFOR Planning Architecture

- **Support for continuous planning**
  - Integrates planning, execution and repair
  - Requires enhanced situation awareness

- **Support for collaborative planning**
  - Reasons about plans of multiple groups
  - Plan sharing among entities
  - Explicit plan management activities
C2 Architecture

Operations Order (plan)

Battalion Commander

Company A Commander

Company X Commander

Company A

Company X

ModSAF

Pilot

Helicopter

Pilot

Helicopter

Pilot

Helicopter

Pilot

Helicopter

Pilot

Helicopter

Pilot

Helicopter

Pilot

Helicopter

Situation Report (understanding)

Operations Order (plan)

Situation Report (understanding)

Situation Report (understanding)

Percepts

Actions

Percepts

Actions
Continuous Planning

Plan generation
- Sketch basic structure via decomposition
- Fill in details with causal-link planning

Plan execution
- Explicitly initiate and terminate tasks
- Initiate tasks whose preconditions unify with the current world
- Terminate tasks whose effects unify with the current world

Plan Repair
- Recognize situation interrupt
- Repair plan by adding, retracting tasks
Company A plan

Company B plan

OPFOR Plan

Company A plan

Battalion Tactical Plans

Company B plan

Co Deep Attack

CSS plan

Consolidate

Move

Move

Engage

Return

Move

Move

Engage

Return

Move

Move

Move

Move

FARP Operations

16tn-204_DA_16tn_16co (F328)

16tn-204_DA_16tn_16bo (B329)

6tn-204_DA_16en_16cs (N930)

Deep Attack

FARP Operations

Company A plan

Company B plan

OPFOR Plan

Consolidate
Situation Interrupts Happen!

Current World

Start of OP

Active(A)

At(A, FARP)  At(Enemy, EA)

Move(A, BP)

At(A, BP)

ATTACK(A, Enemy)

At(A, BP)

Engage(A, Enemy)

At(A, FARP)

Active(A)

At(A, BP)

ADA

Attack

Destroyed(Enemy)
Reacting to Situation Interrupt

- **Situations evolve unexpectedly**
  - Goals change, actions fail, intelligence incorrect

- **Determine whether plan affected**
  - Invalidate assumptions?
  - Violate dependency constraints?

- **Repair plan as needed**
  - Retract tasks invalidated by change
  - Add new tasks
  - Re-compute dependencies
Collaborative Planning

- **Represent plans of others**
  - Extend plan network to include others’ plans

- **Detect interactions among plans**
  - Same as with “normal” plan monitoring

- **Apply planning modulators:**
  - Organizational roles
  - What others need to know
  - Phase of the planning
  - Stance of the planner wrt phase and role
Situation Awareness

- **Current situation: consolidated picture**
  - Use summary from higher headquarters
  - Fuse sensor reports
  - Apply clustering and classification algorithms (Zhang)
  - Make inferences about behavior and intentions

- **Future situation: knowledge goals**
  - What will I need to know for this plan to work?
  - Establish Priority Intelligence Requirements (PIR)
    - What commander needs to know about opposing force
    - Drives the placement of sensors and observation posts
  - Constrains the pace of plan execution
Automating PIR

- **Identify PIR in my own plans**
  - Find preconditions, assumptions, and triggering conditions that are dependent on OPFOR behavior

- **Extract PIR from higher echelon orders**
  - Specialize as appropriate for my areas of operation

- **Derive tasks for satisfying PIR**
  - Sensor placement

- **Ensure consistency of augmented plans**
Summary

Nuggets

- Continuous planning paradigm appears to work well for C2 behavior in the joint synthetic battlespaces domain
  - Handles situation interrupts in test cases
- Enabled collaboration with a few extensions to planner
- After playing with planners, Gratch appreciates Soar a lot more

Coal

- Planning in Soar still EXPENSIVE c.f. workshop
- More evaluation needed!
  - Scalability, robustness, efficiency, …