“Distributed Planning in a Mixed-Initiative Environment”

Collaborative Technologies for Network Centric Operations

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Overview

• DEEP Objectives
• Problem Statement
• C2 Vision
• Conceptual Architecture Design
• Current Work
• Future Work / Research Areas
• Conclusion
DEEP Objectives

- Provide a mixed-initiative planning environment
  - Human expertise is captured and developed
  - Expertise is adapted and provided by a machine to augment human intuition and creativity

- Support distributed planners in multiple cooperating command centers to conduct distributed and collaborative planning
C2 Problem

• Problem Statement
  – Modern warfare capabilities met with unconventional tactics due to their superiority
  – Future C2 process should
    • Adapt to any level of conflict
    • Handle full-spectrum joint warfighting capability
    • Rapidly handle complexity and uncertainty
C2 Vision

- Future C2 Requirements
  - Distributed/Reachback planning
  - Redundant/Backup planning
  - Continuous planning
  - Flexible, scalable, tailorable C2

- Information Age C2 Solutions
  - Network Centric Operations (NCO) requires:
    - Information sharing
    - Shared situational awareness
    - Knowledge of commander’s intent
DEEP Architecture Overview

• DEEP components:
  – Distributed Blackboard
  – Case Based Reasoning System
  – Episodic Memory
  – Multi-Agent System
  – ARPI Core Plan Representation
  – Simulation Capability
DEEP Architecture Diagram

User Interface

Case Base
CBR System

Engaged CMDR: "I have a situation!"

Planning Agents ("CBR")

Plan Execution

Simulated

Suggested

Situation
Selected:

Objectives
Objective 1
Objective 2

Candidate Plans:

Adjusted

Suggest
Judge

Adjusted

Adaptation Agents ("Repairers")
Framework for Distributed C2

- Core Plan Representation (CPR)
  - Object-oriented plan framework developed under ARPI
  - Motivation: Interoperability
  - Extended for DEEP (effects, outcome, costs,..)

- Provides
  - Human-machine dialog (mixed-initiative)
  - Recursive (multi-level)
  - Plan fragments (dist. C2)
  - Interoperable C2 (both integrated and joint)
Distributed Blackboard

- Distributed Shared Data Structure
  - Provides
    - Multi-agent, non-deterministic, opportunistic reasoning
    - Persistent storage
    - System messaging
  - Components
    - Core Data Store
    - Knowledge Sources
    - Control
Distributed Blackboard Architecture

Knowledge Sources

- Critic Agents
- Adaptation Agents
- Planning Agents

Proxy / API / Interface

Control

BB Data Structure

Remote Machines

- Remote Blackboard
  - Control
  - Remote Data
  - Remote Knowledge Sources

Remote Knowledge Sources

Java Distributed Blackboard
DEEP Agent Overview

Planning Agents ("CBR")

Candidate Plans:
- Objective 1
- Objective 2

Objectives

Situation

Selected:

Suggested

Adjusted

Adaptation Agents ("Repairers")

Judged

Critic Agents ("Evaluators")
Interface / Planning Agent

- Interact with case-base reasoning system
- Interface allowing mixed-initiative interaction

Distributed Blackboard

User Interface

Case Base

CBR System

Planning Agents ("CBR")
Critic Agents

• Adaptation Critic Agents
  – Plan repair
    • Example – Capabilities Agent checks actor roles and makes sure the present actors are capable of performing their assigned roles

• Scoring Critic Agents
  – Plan evaluation
    • Example – Weather Agent uses weather knowledge and data to evaluate plan actions

• Execution Selection Critic Agents
  – Determines top rated plans
  – Mixed-initiative decision point
Current work

- DEEP Modeling / Redesigning
- Blackboard extensions
- Simulations
- Multi-case reconciliation & planning *
- Trust
- Cyber
- Semantic Interoperability *
- Logistics Critic Agent
Future Tasks/Research

- Formalized Messaging Structure
- Multi-Case Distributed Planning
- Simulation Technologies
- Mixed-initiative Interaction
Presentation Summary

• DEEP will:
  – Provide mixed-initiative, experience-based anticipatory planning in a distributed environment where commanders can orient and decide faster than their adversaries.
  – Meet the needs of Integrated C2 by addressing each level in any domain.

• By applying the following technologies:
  – Experience-based Reasoning
  – Multi-Agent Systems
  – Distributed Blackboards
  – Exploratory Simulation
Questions?

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Backup Slides
DEEP Modeling / Redesigning

• Formal UML documentation of current software architecture

• Apply the Rational Unified Process to DEEP
  – Formal documentation of requirements
  – Development of use cases
  – Redesign of DEEP software architecture in UML
Blackboard Extensions

- Finishing spiral 2 of 3 of the blackboard development cycle
- Spiral 1 – Implement java blackboard addressing the immediate needs of DEEP
- Spiral 2 – Replace blackboard persistence component with an Oracle database
- Spiral 3 – Leverage Oracle distributed database technologies
• Added cyber experiences
• Implementing information assurance
• Develop cyber agent (adaptation type)
References

- Bellifemine, Fabio. “JADE ADMINISTRATOR’S GUIDE.” November 10, 2006. JADE 3.4.1
- Bellifemine, Fabio. “JADE PROGRAMMER’S GUIDE.” August 21, 2006. JADE 3.4
- Caire, Giovanni. “JADE TUTORIAL JADE PROGRAMMING FOR BEGINNERS.” December 4, 2003. JADE 3.1
• Alberts and Hayes (2007)
  – Taxonomy for planning and plans;
  – Quality metrics for planning and plans;
  – Factors that influence planning quality;
  – Factors that influence plan quality;
  – Impact of planning and plan quality on operations;
  – Methods and tools for planning; and
  – Plan visualization