

# “Distributed Planning in a Mixed-Initiative Environment”

## Collaborative Technologies for Network Centric Operations



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Paper 035  
19 May 2008



# 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



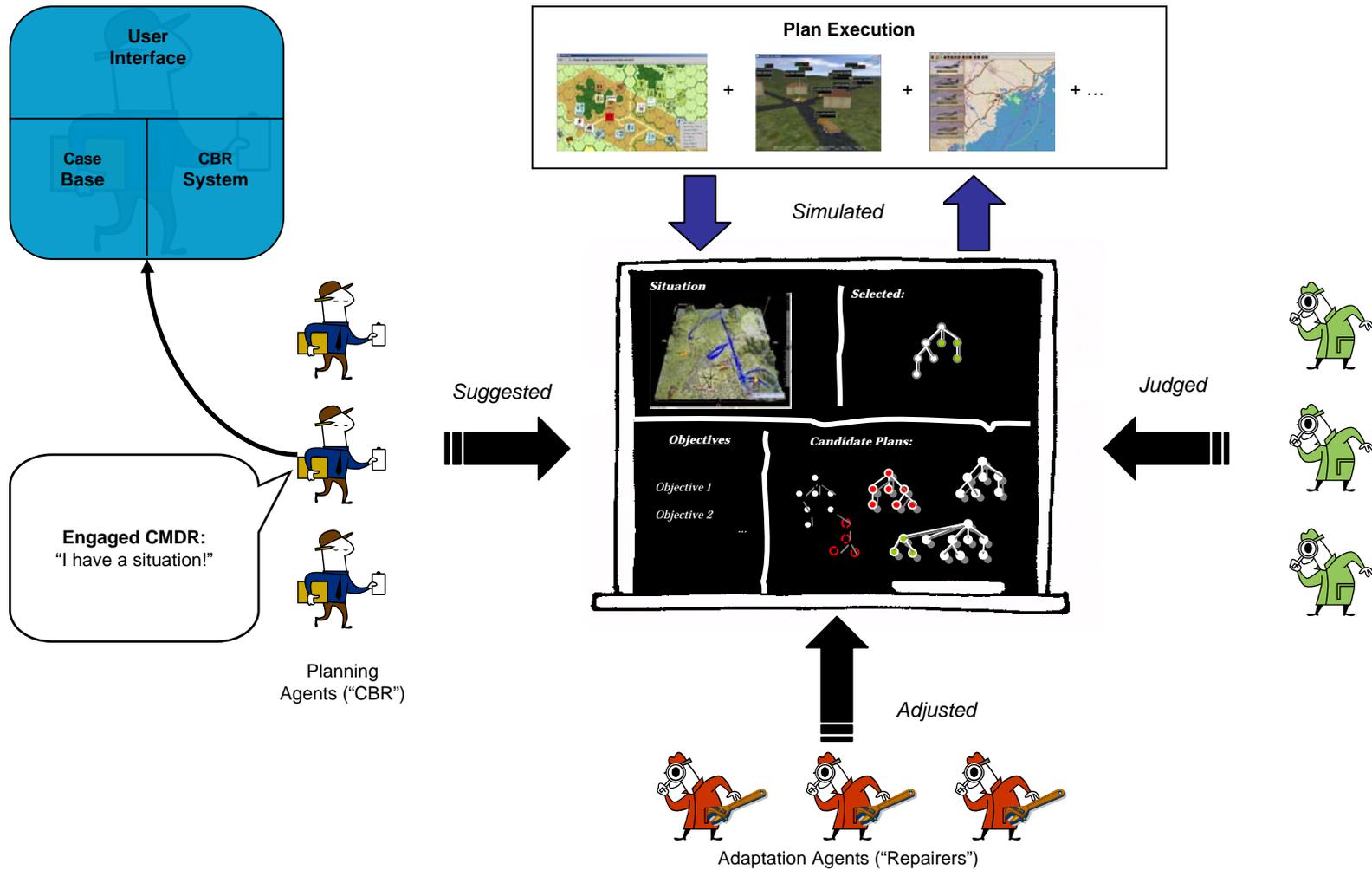
# DEEP Architecture Overview



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



# DEEP Architecture Diagram



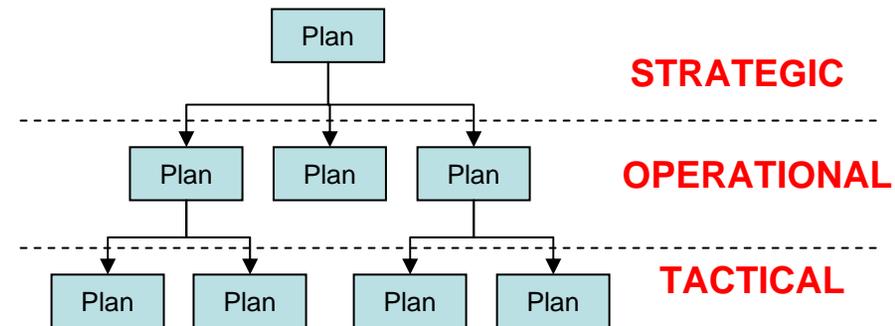
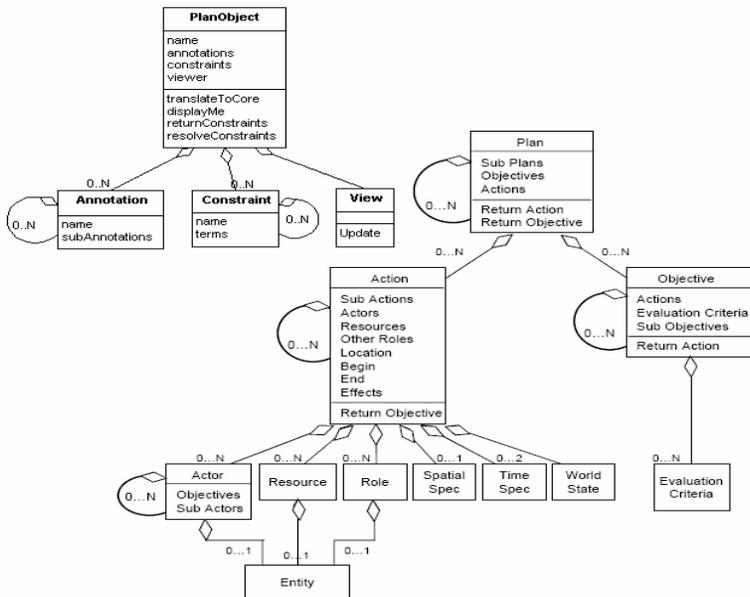


# Framework for Distributed C2



- **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



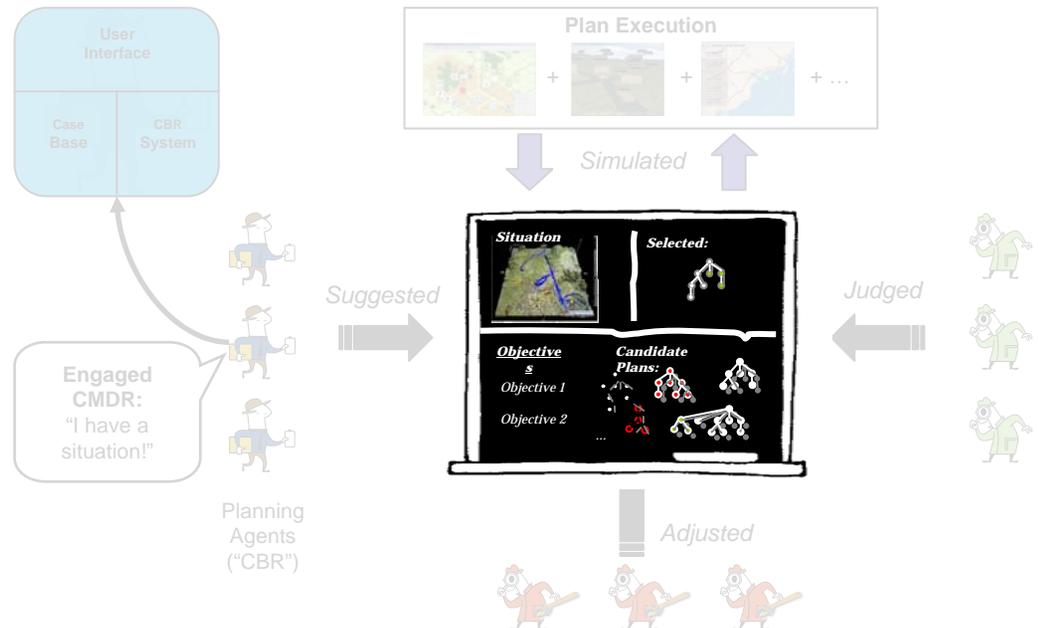
- Distributed Shared Data Structure

- Provides

- Multi-agent, non-deterministic, opportunistic reasoning
    - Persistent storage
    - System messaging

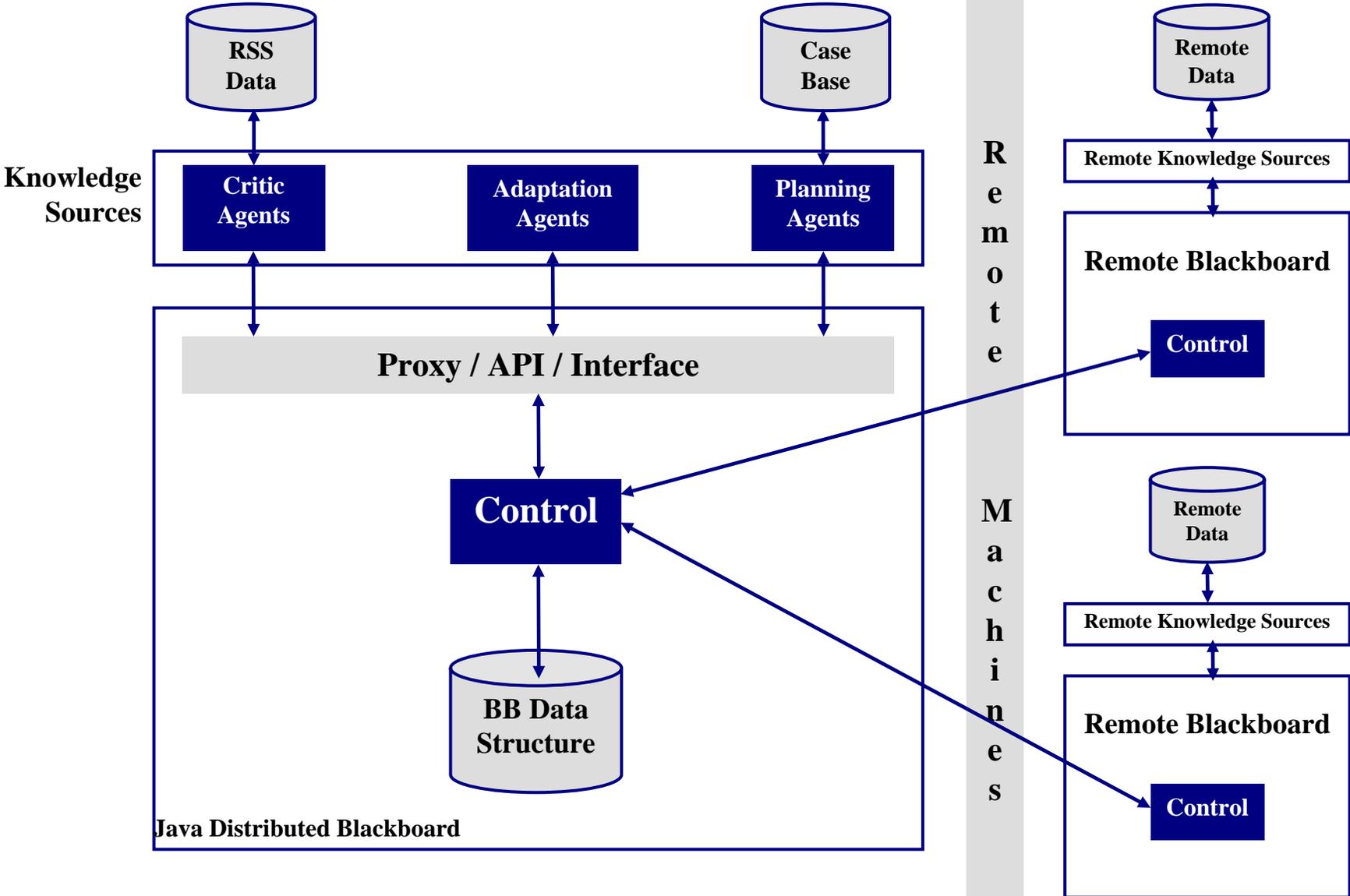
- Components

- Core Data Store
    - Knowledge Sources
    - Control



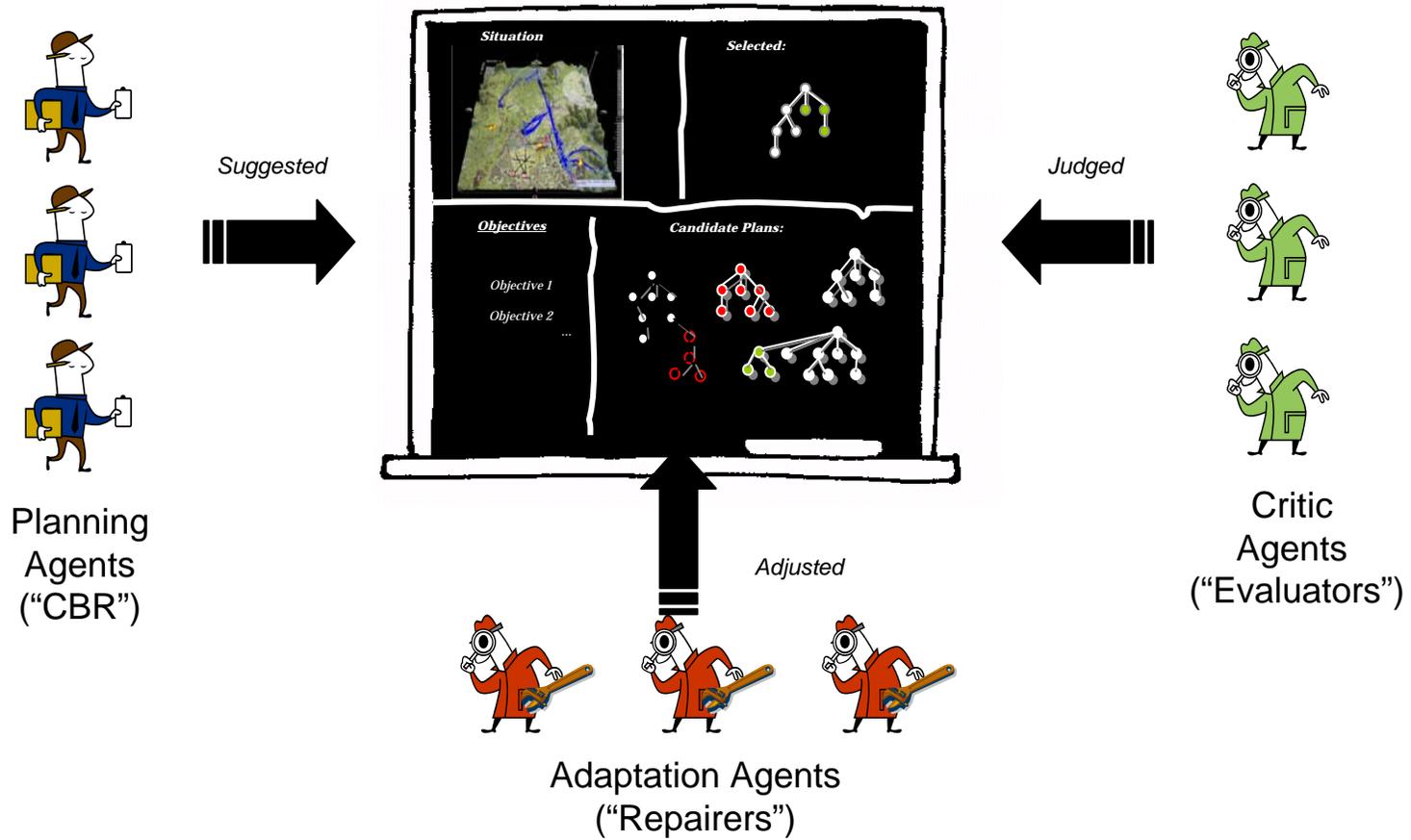


# Distributed Blackboard Architecture





# DEEP Agent Overview

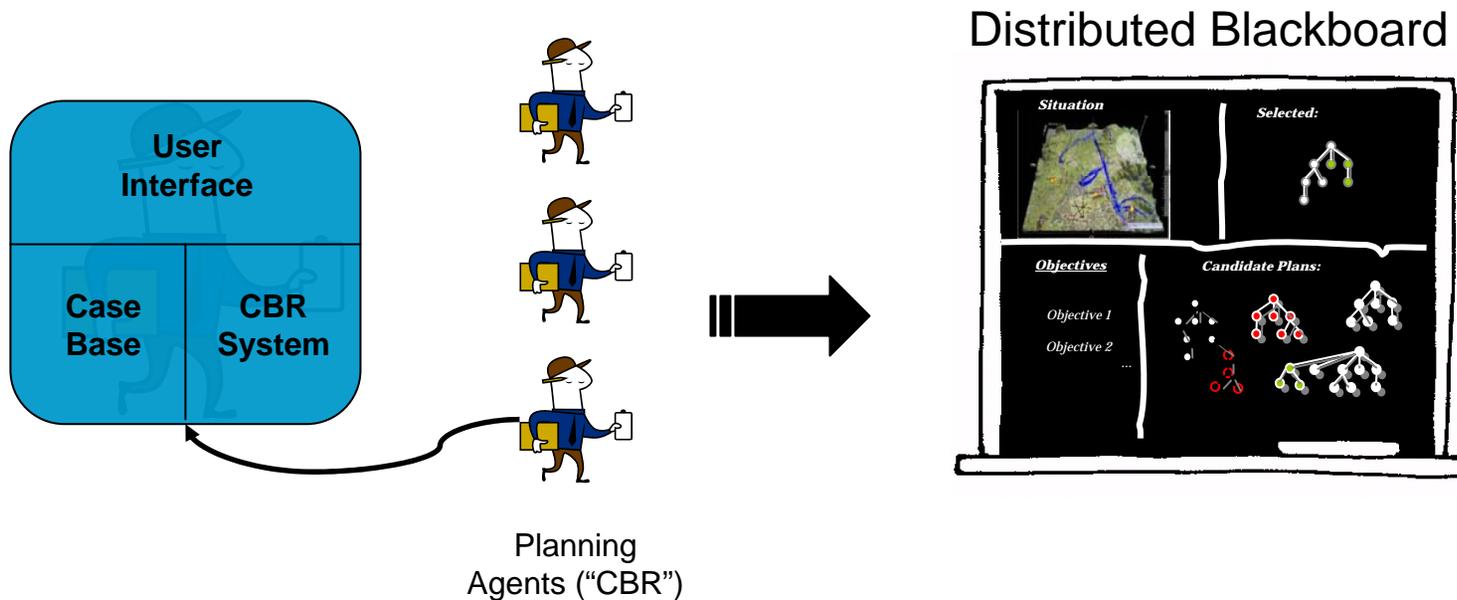




# Interface / Planning Agent



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





# 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

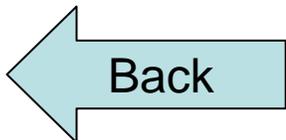




# DEEP Modeling / Redesigning



- 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

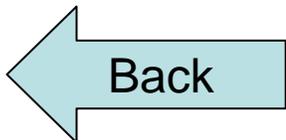




# Blackboard Extensions



- 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

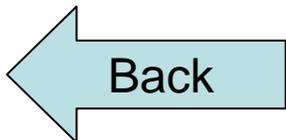




# Cyber



- Added cyber experiences
- Implementing information assurance
- Develop cyber agent (adaptation type)





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# Notes



- 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