“Mission Assurance in a Distributed Environment”

14th ICCRTS – C2 and Agility

Track 8 - C2 Assessment Tools and Metrics

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Overview

- Problem
- Objective
- Defining Mission Assurance (MA)
- DEEP Description
- Applying MA to DEEP
- Future Work
  - Metrics and Experimentation
- Summary

Problem

- Shift from individual hackers to sophisticated teams operating at will in complete stealth
  - Website defacement, Denial of Service (DoS) attacks, identify theft are overt, and nearly immediate to detect
  - Persistent access designed to influence in subtle or perhaps violent ways is becoming the new threat
- Continued shift to network-centric C2 with information processing distributed over computer networks at geographically dispersed locations presents technical challenges
  - The biggest threat is to our core mission planning and processing systems, examples:
    - Target coordinate, inventory decrement manipulation

Objective

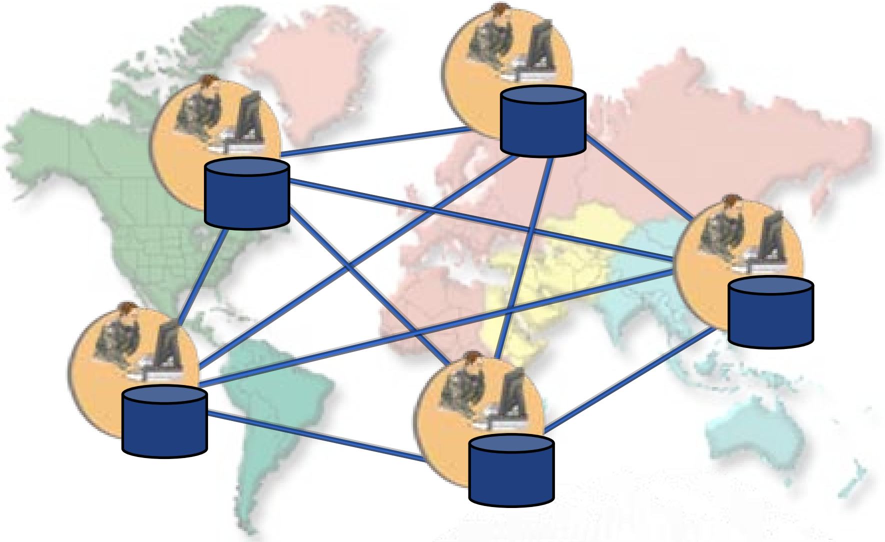
- Define and illustrate mission assurance concepts within a distributed application operating in a notionally contested environment
  - Use the Distributed Episodic Exploratory Planning (DEEP) as an exemplary planning environment
  - Identify DEEP components that can be enhanced to maintain operations under duress
    - Initial “fight-through” capability
  - Formulate a test environment to conduct experimentation and determine metrics

Defining Mission Assurance

- Use standard information assurance (IA) tenets as a baseline
  - Attribution - holding a user accountable for their actions
  - Authentication – ensuring only privileged users access appropriate information
  - Availability - ensuring information and services are available when required
  - Confidentiality – ensuring information destined for an individual or group is exclusive
  - Integrity – information is kept unmodified by unintended sources
- IA Extensions
  - Availability a function of prioritized mission tasks mapped to network capabilities
    - So degraded states can be specified and measured
  - Trust must be built on top of attribution, authentication, confidentiality and integrity
    - So that contributors to mission success will be given increased responsibility
  - Mission workflow must be formally specified as business processes
- Exploring Trust
  - Trust is integral regarding either human or machine interaction
  - DEEP does not address trust formally yet (trust is assumed)

DEEP Objective

Current AOC Planning



BOGSAT

- **Bunch of Guys/Gals Sitting Around a Table**

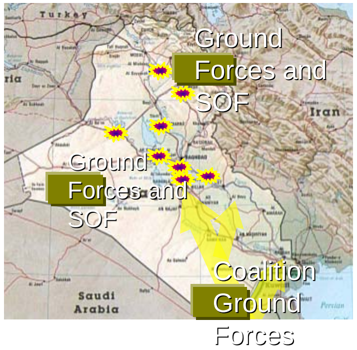
Constrains planning

- **Quality**
  - **Finite experience**
- **Speed**
  - **Limited automation**
- **Creativity**
  - **Finite diversity**

Improve planning quality, speed, and creativity

- **Experienced-based**
  - **Orient and decide faster than adversaries with better plans**
- **Mixed-initiative**
  - **Syntheses of the strengths of both human and machine**
- **Net-centric**
  - **Expert team formation with greater diversity and creativity**

DEEP Example



Scenario/Situation

$A_1\ S_1\ C_1\ I_1\ L_1\ M_1$

$A_2\ S_2\ C_2\ I_2\ L_2\ M_2$

……………………

……………………

……………………

$A_N\ S_N\ C_N\ I_N\ L_N\ M_N$

Distributed Experience Bases

A = air **S = space**

C = cyber **I = integrated**

L = land **M = maritime**

1

Multi-Case Agents

Initial Plan

$A_{51}+L_{32}+M_{451}$

Experience-Based Planner

2

Critic/Advisor Agents

Refined Plan

P_1

Plan Advising & Critiquing Agents

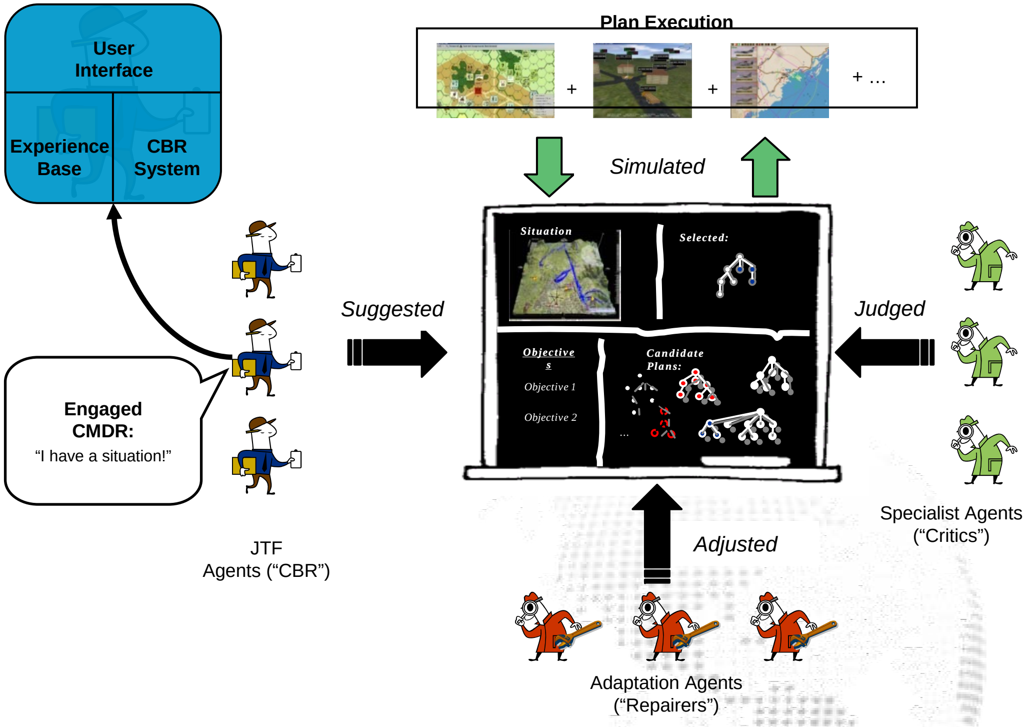
3

Plan Explorer

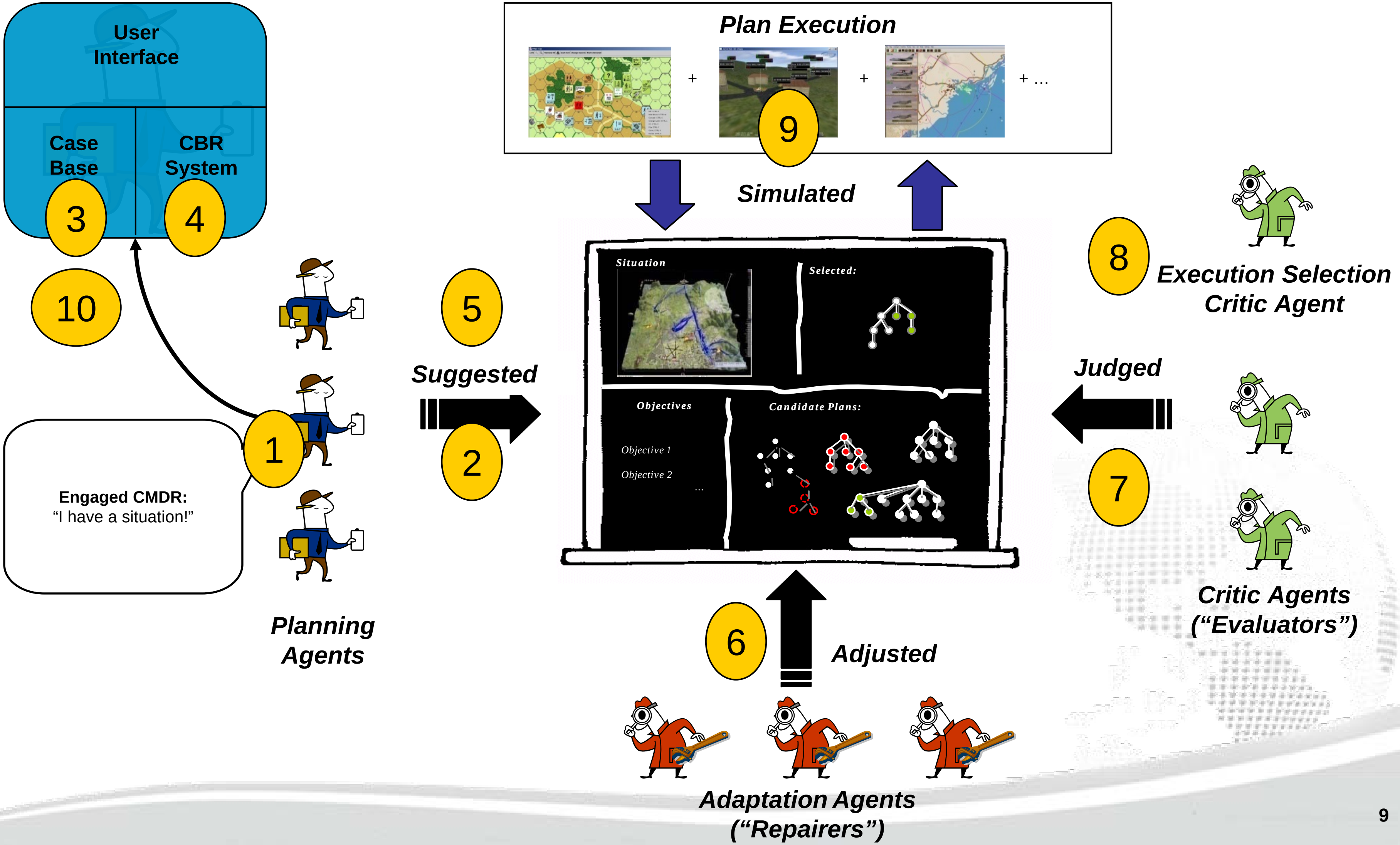
(M&S)

DEEP Approach

- Specifically
  - **Distributed AI Blackboard** for multi-agent, non-deterministic, opportunistic reasoning **“at the edge”**
  - **Experience-Based Reasoning** to capture experiences (successes and/or failures)
  - **Episodic Memory** for powerful analogical reasoning
  - **Multi-Agent System** for mixed-initiative planning
  - **ARPI Core Plan Representation** for human-to-machine dialog
  - **Constructive Simulation** for exploration of plausible future states



DEEP Approach



User Interface

Case Base

CBR System

Plan Execution

Simulated

Engaged CMDR:
"I have a situation!"

Planning Agents

Suggested

Judged

Adjusted

Execution Selection Critic Agent

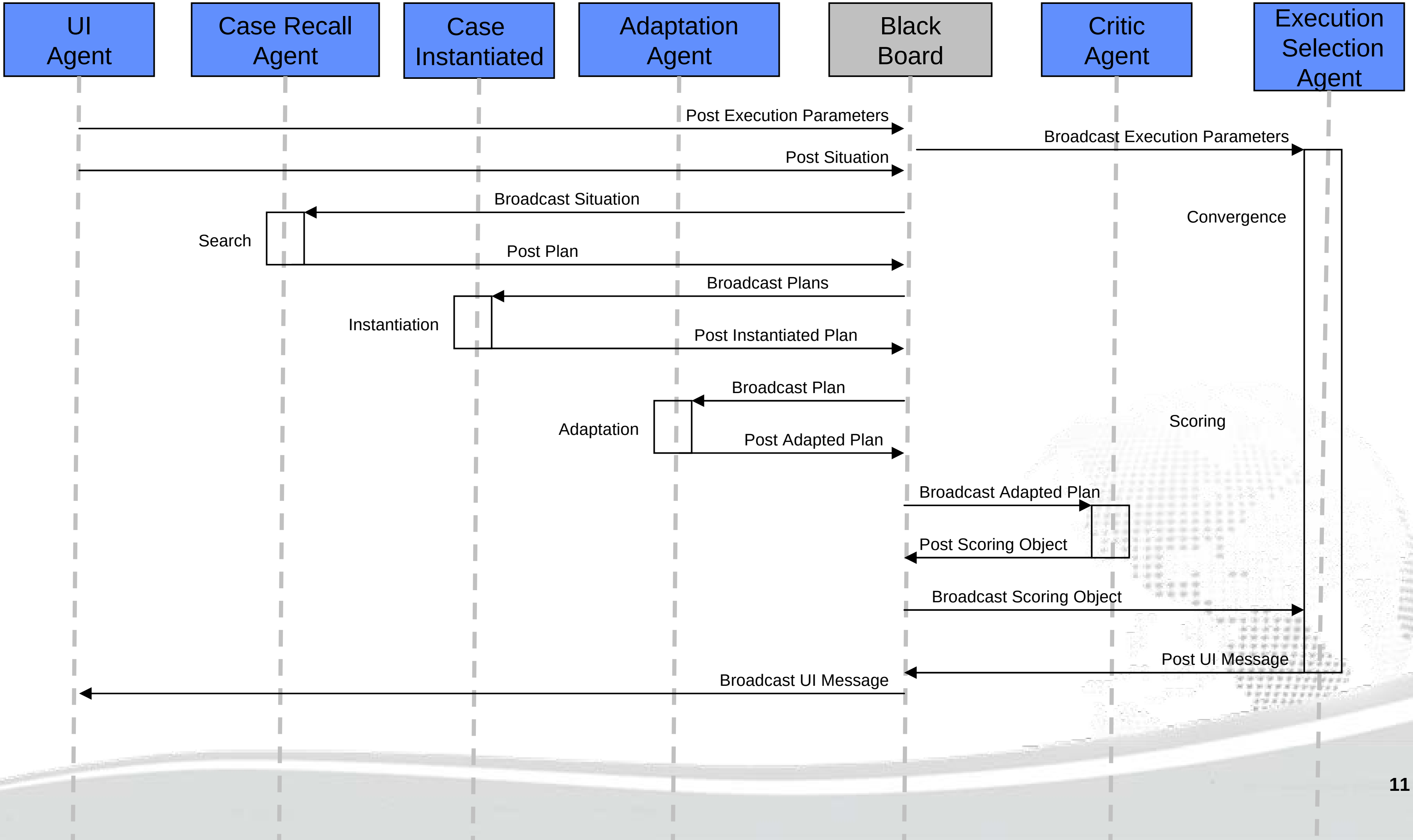
Critic Agents ("Evaluators")

Adaptation Agents ("Repairers")

Applying MA: Modeling the Process

- Protecting internal and external applications requires a model of the overall business process
- In DEEP, the business process is modeled at the application level and we can determine:
  - The sequence of prioritized events/activities
  - Event dependencies
  - Events that are not as important to the core business as others
- Knowing this information allows us to make decisions on redundancy, contingency plans, resource management for IA, and the impacts of resource losses
- In some cases, DEEP handles intrusions intrinsically
  - Plans have to survive a critical review process that would eliminate plans that were not fit for the objective
  - Critic agents do not have authority to modify plans

DEEP Process



Fight-Through : Agents

- Agent Control Center (ACC)
  - Agents are an integral part of DEEP, so proper synchronization and control is important
  - The ACC automatically and manually controls agents and monitors the system and network, it should:
    - Monitor traffic, move agents, shutdown agents, restart agents, ping agents, conduct behavior analysis based on connection patterns, and assess agent interaction as a foundation for determining trust
      - Some of these functions are provided by the Java Agent Development Framework (JADE) used to develop the DEEP agents
    - Detect network issues like congestion and attempt to automate system restart on an operable network

Fight-Through : Information

- Data concerns
  - Modification (both minute and large)
  - Deletion
  - Theft
- Solutions
  - Encryption
    - All traffic should be encrypted
    - Data repositories should be encrypted
  - Hold data integrity using signature techniques to ensure data has not been modified
  - ACC could monitor traffic and alert based on irregular data movement
  - Redundant stores of data and rollback capability to ensure steady recover in the event of intrusion
  - Authentication to data repositories (limit access to a need to know basis – blackboard has panes / layers concept)

Fight-Through : Human

- The human in the loop can pose problems for the mission as well
  - Classic “insider threat”
  - Insiders may have access to critical data and knowledge of how to use it
    - Very tough problem to solve
  - Solutions
    - Enable authentication procedures
    - User privileges – blackboard using authentication and proper registration to specific zones of information

Fight-Through : Network

- Networks that applications operate on also provide an attack vector
  - Examples of issues include limited bandwidth, loss of bandwidth (DoS, kinetic attack)
  - Solutions
    - Control center and network examining tools should detect loss of communication and attempt to regain functionality.
      - Software component movement or restart with state
    - Use of another mode of communication

Future Work

- Better establishment of metrics / experimentation
  - Experimentation
    - Emulation of rogue agent behavior sending out messages it shouldn’t
    - Conducting a DoS attack at critical pressure points
    - Emulation of component loss
    - Data modification – Can DEEP intrinsically handle data changes during the process?
  - Metrics (area of interest)
    - Must be able to achieve the above issues
    - Rollback must be faster than full restart

Future Work

- Establish a generic framework to apply to other programs
- Integration of AFRL IA in-house technology
- Multi-agent control
- Trust (can we employ wisdom of the crowds voting mechanic or control procedures to ensure trust?)

Summary

- **Providing mission assurance is not an option, but a requirement for surviving in a contested network environment**
- **Emphasize building applications and systems that are reliable, self-sustainable and trustworthy**
- **Applying mission assurance using DEEP allows for experimentation as well as the creation of a generic model of mission assurance**

Thank You and Questions

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Backups

Process Modeling

- Business Process Execution Language (BPEL)
  - Web service standard for specifying interactions
  - Model executable and abstract processes
- Business Process Modeling Notation (BPMN)
  - Graphical representation of business processes in a workflow
- Unified Modeling Language (UML)
  - Use standard UML diagrams to model the system
  - Component, sequence, activity diagrams