Adaptive Defense Coordination for Multi-Agent Systems

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Overview

- Large MAS need a variety of autonomous & coordinated Defenses
  - Cougaar/UltraLog is an example of such an infrastructure & application
    - emphasis on survivability in the face of kinetic & info warfare attacks
    - 1200 agent logistics planning society
  - This will also be true of *Application Communities*
- Problem:
  - Defenses generally are myopic, so make mistakes in diagnosis
  - Even if correct diagnosis, lack “big picture” of what matters most right now
- Leads to:
  - Responses that do not work – simply wrong
  - Wasteful responses – correct, but not helpful
- Adaptive Coordinator
  - Cope with uncertainty about present & future
  - Prevent undesirable combinations of actions
  - Select actions based on high-level criteria of what matters to the application

Kinds of Defenses

- Corrective – fix a problem
  - e.g., restart a Dead agent elsewhere
- Compensatory – work around a problem
  - e.g., try alternate communications to avoid an unfixable network problem
  - e.g., encrypt to counter an eavesdropper who can't be suppressed
- Protective – keep a problem from occurring
  - e.g., persist agent state more often to avoid loss of work
- Application Tradeoffs – change the way work is done
  - e.g., produce lower fidelity logistics plans to go faster

- Some are "done & gone", while others have continuing costs

Problems Addressed

- Defense independence has advantages:
  - Ease of development
  - Reaction speed
  - Simplicity
  - Ability to work during partitions
- But:
  - Local knowledge misdiagnoses problems
    - So we do the wrong thing
  - Local knowledge insufficient to see a problem
    - So we fail to do anything
  - Two or more components decide to act
    - Overwork, both trying to solve the problem
    - Trying to solve two conflicting diagnoses of the problem
  - Local components unable to weigh importance of other survivability properties over their own priorities
- Global knowledge needed and global priorities must be considered w/o creating a bottleneck or single point of failure

Adaptive Control Goals

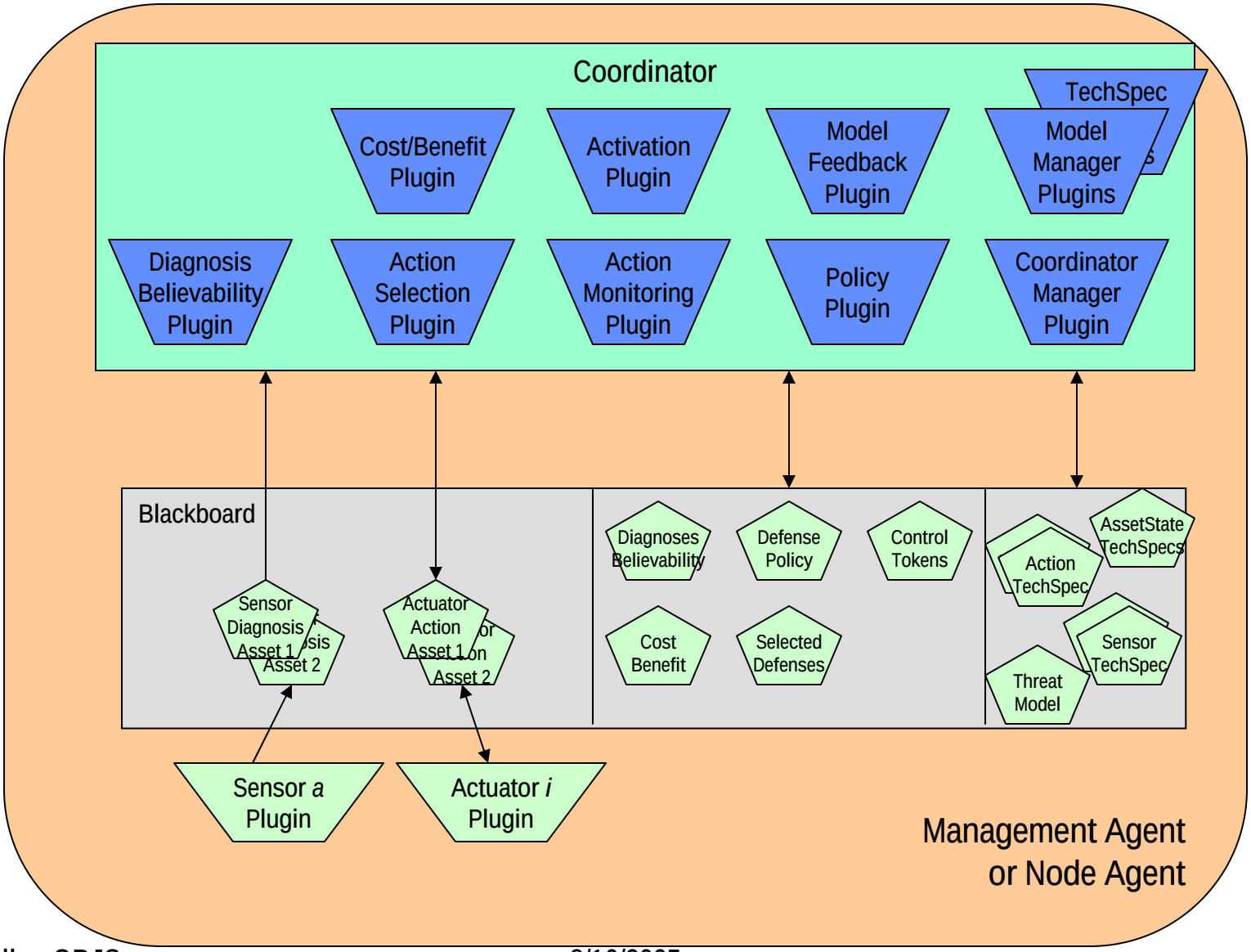
- Prevent undesirable combinations of actions
- Intelligent use of information when selecting responses
  - Current status
  - Expectations of future behavior
- Cope with uncertainty when selecting responses
  - Conflicting diagnoses
  - Missing diagnoses
  - Imprecise projections about future stress profiles
- Selection of responses is sensitive to high-level policy
- Adaptive
  - To changes in High-Level policy (changes to MAU curves)
  - To changes in perceived stress environment

- Measured by improved Survivability as seen by the application
  - W.r.t. uncoordinated baseline & to an ad hoc pairwise control baseline

Decision Logic Overview

- Estimate society state
  - In the face of uncertainty
    - Incorrect diagnoses
    - Conflicting diagnoses
    - Missing diagnoses
  - Considering expected stresses in the environment
- Policy driven action selection
  - Base benefits of society assets being in a particular state
  - Policy changeable valuation of different system properties
  - Choice of objective functions when computing action benefits
- Feedback loop to determine if an enabled action had the desired result
- Highly “plugIn-ized” Coordinator internal architecture
  - Each basic capability can be accomplished in many different ways at varying degrees of complexity, accuracy, development effort, etc.
  - Heavy internal decomposition allows putting effort where the payoff is

Coordinator Internal Architecture



Status & Issues

- Freely available
  - Cougaar Open Source
- Portable
  - Architecture is independent of
    - Specific sensors & defenses
    - Underlying agent framework
- Model Fidelity
  - How accurate can the models be?
  - How accurate do the models need to be? (sensitivity experiments required)
  - What is the correct level of abstraction for modeling?
- *Application Communities* will require a capability like this