

## Adjustable Autonomy Using Teams

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## Adjustable Autonomy

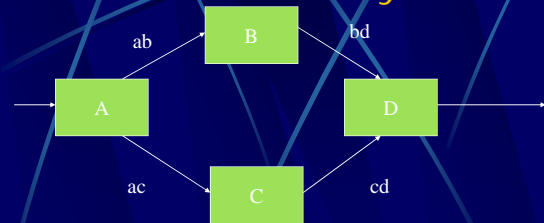
- Domain
  - Training, testing, experimentation using intelligent agents
    - Air-combat simulation, RoboCup
- Adjustable autonomy required for
  - Changing behavior on line to create training scenarios
  - Ad hoc testing
  - Creating new / interesting scenarios online

## Adjustable Autonomy Challenge

- Flexible changes to behavior
- Ad hoc changes to behavior
- Agent specification unknown in advance

➔ Behavior must remain reasonable while user is manipulating agent

## Conventional Systems



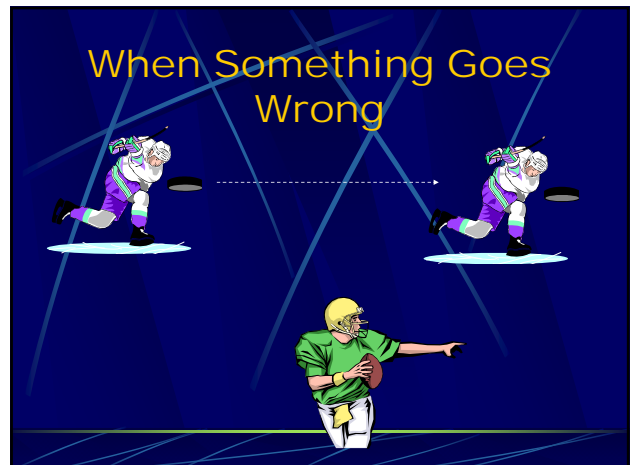
An ad hoc substitution of B' for B may cause the system to break Or act in another undesirable manner.

Because : Inflexible links between components

## An Ideal Team



## When Something Goes Wrong



## An Ideal Team

- Flexible to changes in individual members
- Robust to a single point of failure
- Reconfigure automatically around change in a single member
- Flexible links between team members



## Idea

Leverage team properties to implement flexible AA

## Implementing AA

- Behavior of the actor implemented by a team of agents
- AA mechanism allows a user (or other actors) to change a single member of the team
- Rest of team adjusts around the changed team member
  - When change occurs normal team conventions are adhered to

## Result

- Ad hoc changes possible
- Reasonable behavior under variety of changes
  - Behavior of actor does not fail completely when an ad hoc change is made

## EASE

- Agent development system with AA
  - Uses "team for AA" idea
- Implemented and tested in "simple" scenarios
  - Air-combat simulation, RoboCup
- Serious testing about to begin

## EASE "Team Model"

- Organization style
  - Hierarchical
  - Contracts between agents
- Notification of success or failure
- Negotiation at bottom of hierarchies manages inter-agent conflicts
- Fairly simple

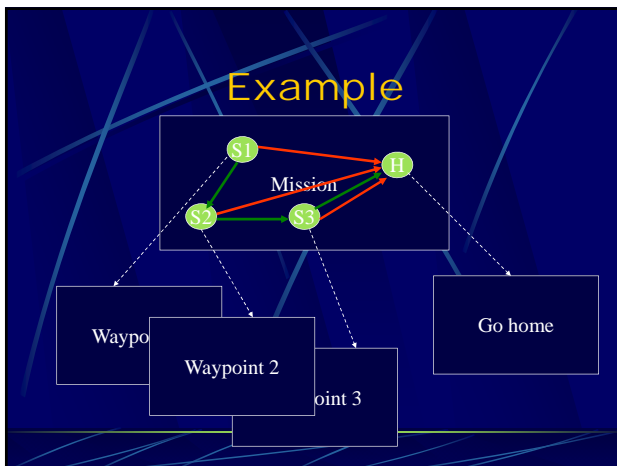
## EASE "Social Conventions"

- Inform contractor when finishing work on a contract
  - Indicate success or failure
- Priority system in force amongst agents, higher priority agents given more say in negotiations

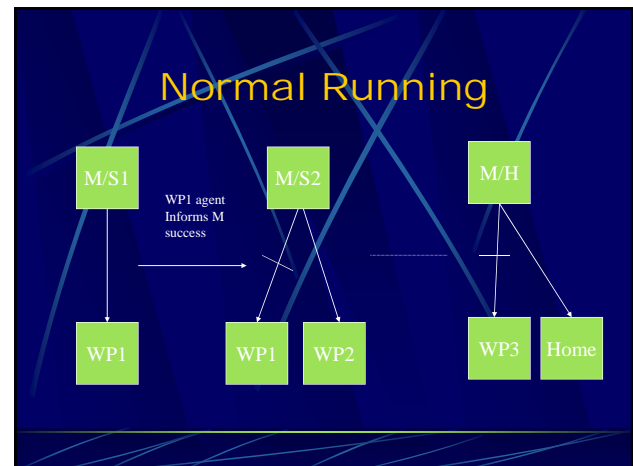
## Implementation

- User (or other agents) can terminate, pause or start new agents
- When user takes such an action normal team procedures/social conventions are followed
  - Contractor notified
  - Negotiations left/entered gracefully
  - Team adjusts to new configuration

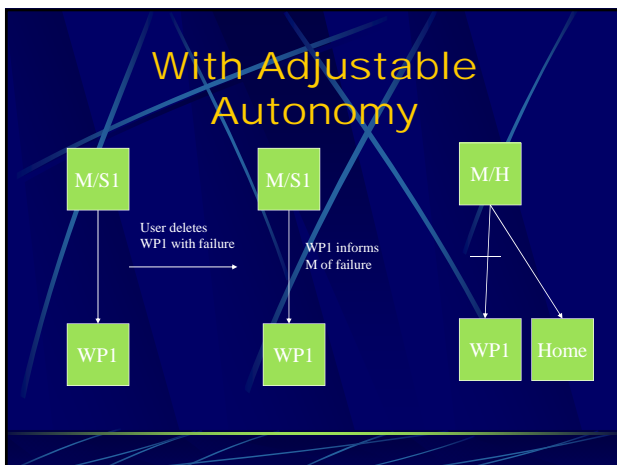
## Example



## Normal Running



## With Adjustable Autonomy



## Side Effects of Team AA

- Reasonable view of behavior
  - Good decomposition enforced
  - Fairly easy to understand why actor is doing what it is
  - Handles complexity reasonably well

## However . . .

- Flexible teamwork need not imply good behavior
- Good specification should lead to good behavior when AA is used
  - Appropriately placed success and failure transitions
  - Well designed structure of agents
  - Careful decomposition
- If specification is not well done unexpected/undesirable things may happen when user makes ad hoc changes
  - Open problem

## Future Directions

- Improve teamwork model
  - More flexible contracts
  - Higher level understanding of team goals
- Improved actor – human interface
  - Show user what is going on and why
  - Show user the effect of different actions



## Conclusions

- Team behavior leveraged to implement AA
- Flexibility of interactions between team members the key to approach
- Allows wide variety of ad hoc behavior changes at runtime