

# ***Autonomy of Decision-Makers in Coalitions***

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# Autonomy – General Intuition

- **Freedom from human intervention, oversight, or control.** (Beale and Wood, 1994; Brown et al., 1998; Etzioni and Weld, 1995; Evans et al., 1992; Wooldridge and Jennings, 1995)
- **Freedom from intervention, oversight, or control by any other agent, including, but not limited to, a human.** (Luck and D'Inverno, 1995; Martin et al., 1996)



# Goal-Directed Behavior

**Autonomous agents are goal-directed.** (Etzioni and Weld, 1995; Foner, 1993; Luck and D'Inverno, 1995)

**Autonomy becomes ...**

- **Freedom from intervention, oversight, or control by any other agent, *with respect to some goal.***



# Pro-Active Behavior

**Autonomous agents are pro-active.** (Beale and Wood, 1994; Etzioni and Weld, 1995; Foner, 1993)

**Autonomy becomes ...**

- **An agent's active use of its capabilities to pursue some goal without intervention, oversight, or control by any other agent.**



# Dimensions of Autonomy

- **Environmental Isolation...**  
Manipulating the environment in which the agent operates
- **Incredulity** (autonomy in beliefs) ...  
Exchanging information/data with the agent
- **Self-Determination** ... Exerting control over how the agent carries out its goal  
(i.e. manipulating the decision-making process the agent uses to determine how to carry out its goal)



# Definition of Autonomy

**Autonomy is ...**

**an agent's active use of its capabilities to pursue  
some goal**

**without intervention by any other agent**

**in the decision-making process used to  
determine how that goal should be pursued.**



# Degree of Agent Autonomy

**An agent's degree of autonomy,**

**with respect to some goal that it actively uses its capabilities to pursue,**

**is the degree to which**

**the decision-making process**

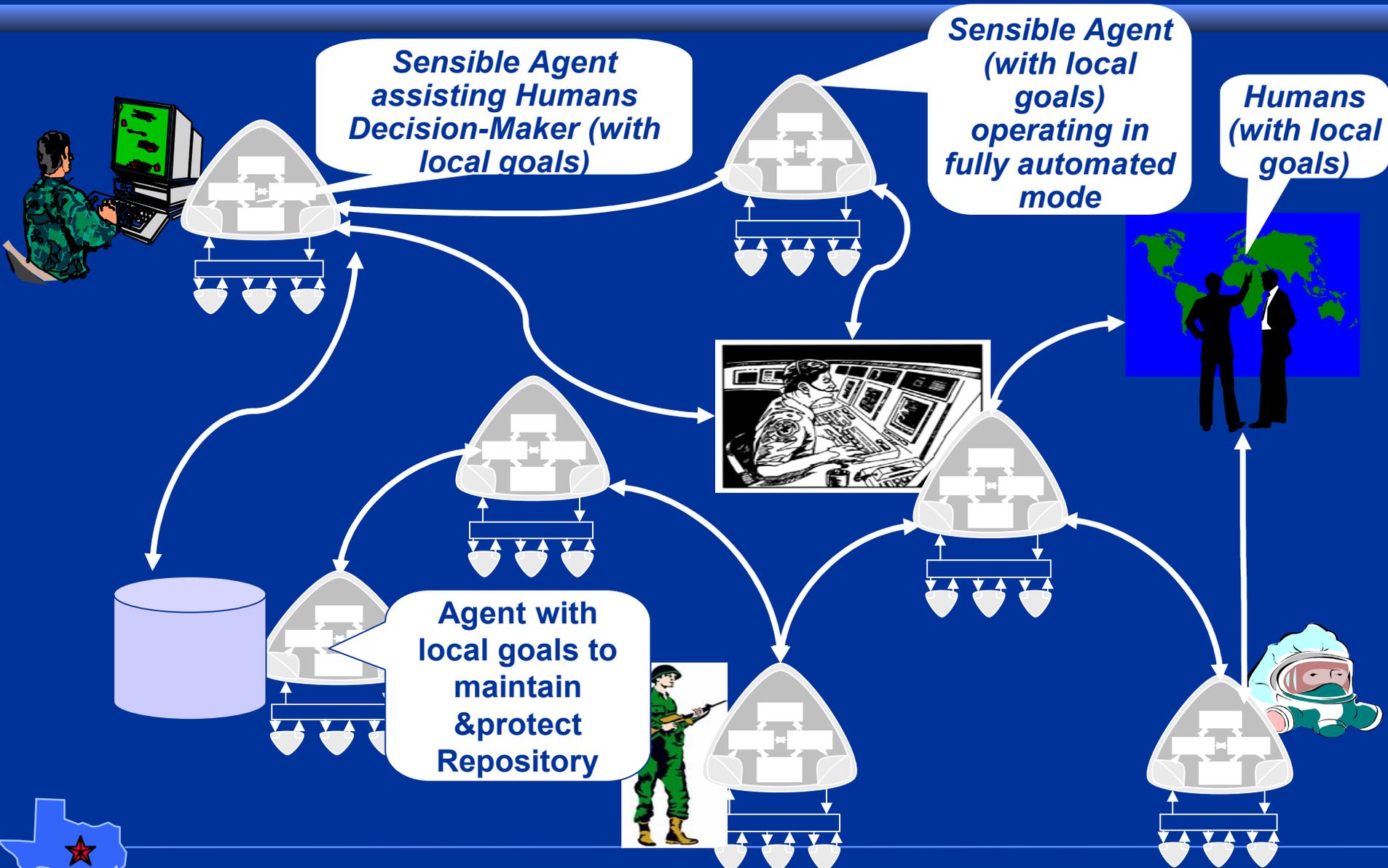
**used to determine how the goal should be pursued**

**is free from intervention by any other agent.**

**Autonomy >> Control Over Decision-Making and Execution Process**



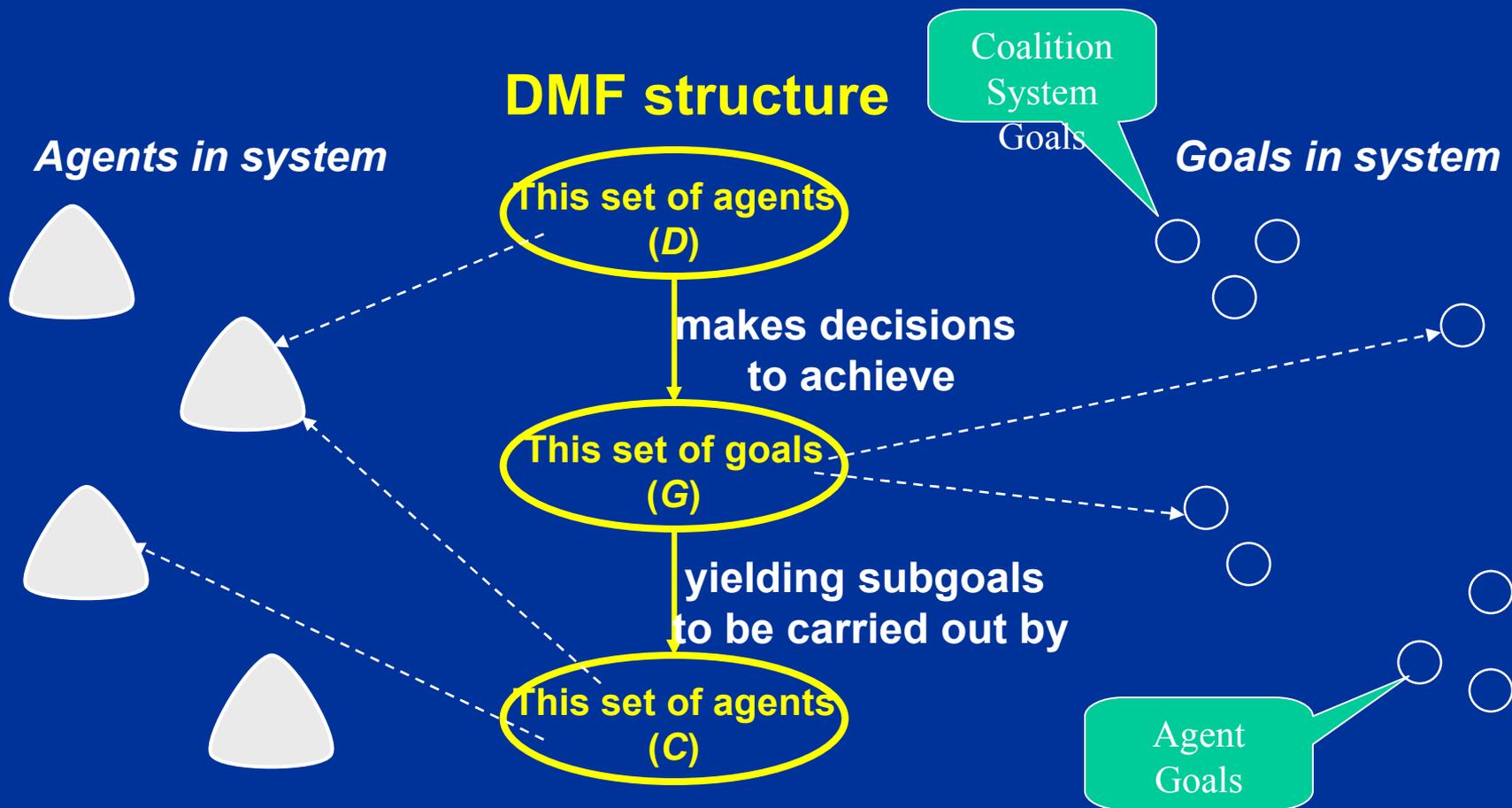
# Network of Decision-Makers (Human, Semi-Automated, Automated)



# **Network of Decision-Makers (Human, Semi-Automated, Automated)**

**The Coalition  
(defines the System Goals)**

# DMF Representation ( $D, G, C$ )



# Best Decision-Making Framework?

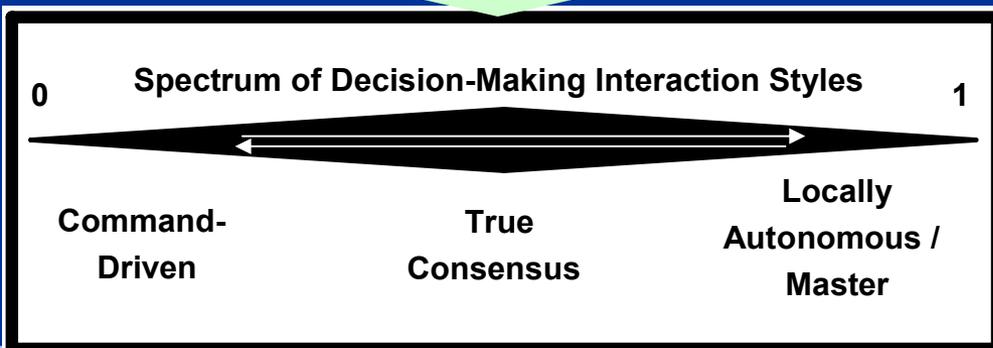
Decision-makers (agents) select  
*degrees of decision-making control*  
corresponding to different  
Decision-Making Interaction Styles

within a

## Decision-Making Framework

(e.g. Peer Consensus, Master/Command-Driven, Self-Interested)

For every problem (Goal)  
And  
Current Situational Picture

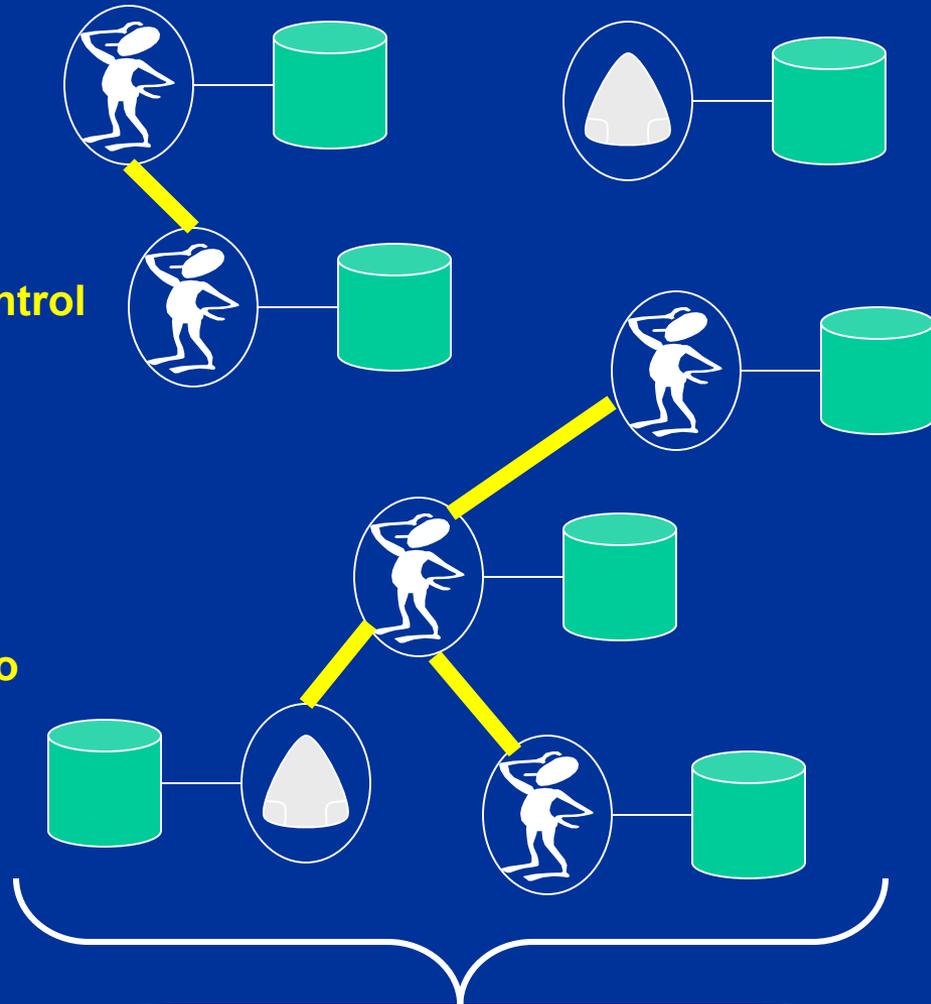


- Locally Autonomous / Master - Agent plans alone; may or may not give orders to other agents.
- Command-Driven - Agent does not make decisions; obeys Master.
- True Consensus - Each Agent is a team member, sharing decision-making tasks with other agents.

# Reconfiguration of Decision-Control among Players to insure Player (Agent) and Coalition Goals are Met

## Decision-maker organizations reconfigure based on PERTURBATIONS

- System Perturbations:
  - Load balancing of decision-making control (coalition policies violated)
  - System goals not met
  - Agent or Human dies or another factor degrades system performance
- Environment Perturbations:
  - Environmental conditions changing too fast (e.g., too many targets)
- Human or Agent Perturbations:
  - Agent recognizes it is unable to meet local goals
  - Agent runs short of resources or time
  - Agent not performing to agreements

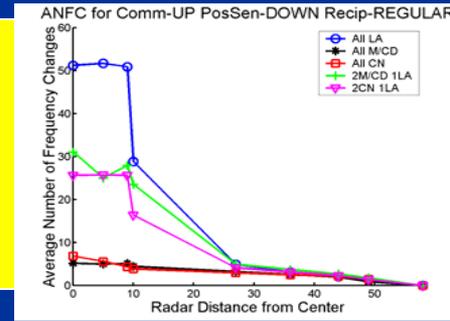
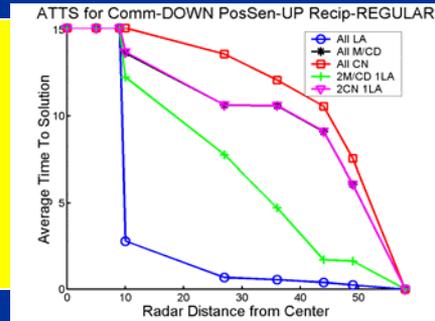


**Network of decision-makers,  
including agents and humans**

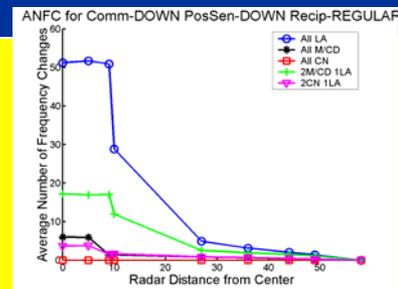
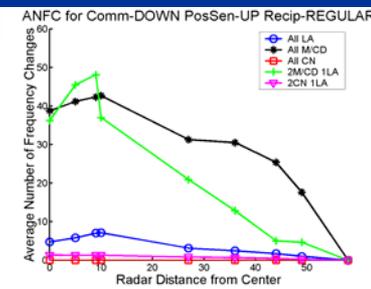
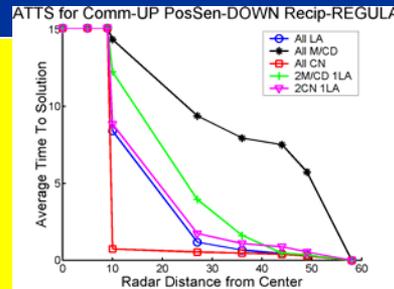


# Situation-Sensitive Measurement of Organizational (DMF) Performance

Time to Solution measurements for different DMFs



Average # Solutions Attempted measurements for different DMFs



# Organizational Restructuring

*Previous Work Focusing on Changes In These Parts of the Structure. . .*

- **Communication Links and Resources:** “Organizational Self Design” (OSD) Low-level modifications of connectivity in a network of agents for load-balancing objectives. Change occurs through composition and decomposition of agents. [Ishida et al., 1992]
- **Distribution of Tasks and Payoffs:** “Coalition Formation” Agents join and leave task-centered groups within a system adding their own capabilities and resources to the group. Agents attempt to maximize their payoff or to maximize the payoff to all groups. [Sandholm and Lesser, 1997; Shehory and Kraus, 1998; others]
- **Any or All:** Goal of “Role Re-definition.” Preliminary supporting representations developed by [Fox et al., 1998; So and Durfee, 1998]. Roles are application specific.



# ADMF as Organizational Restructuring

An organization's structure defines the pattern of information, control, and communication relationships among agents as well as the distribution of tasks, resources, and capabilities.

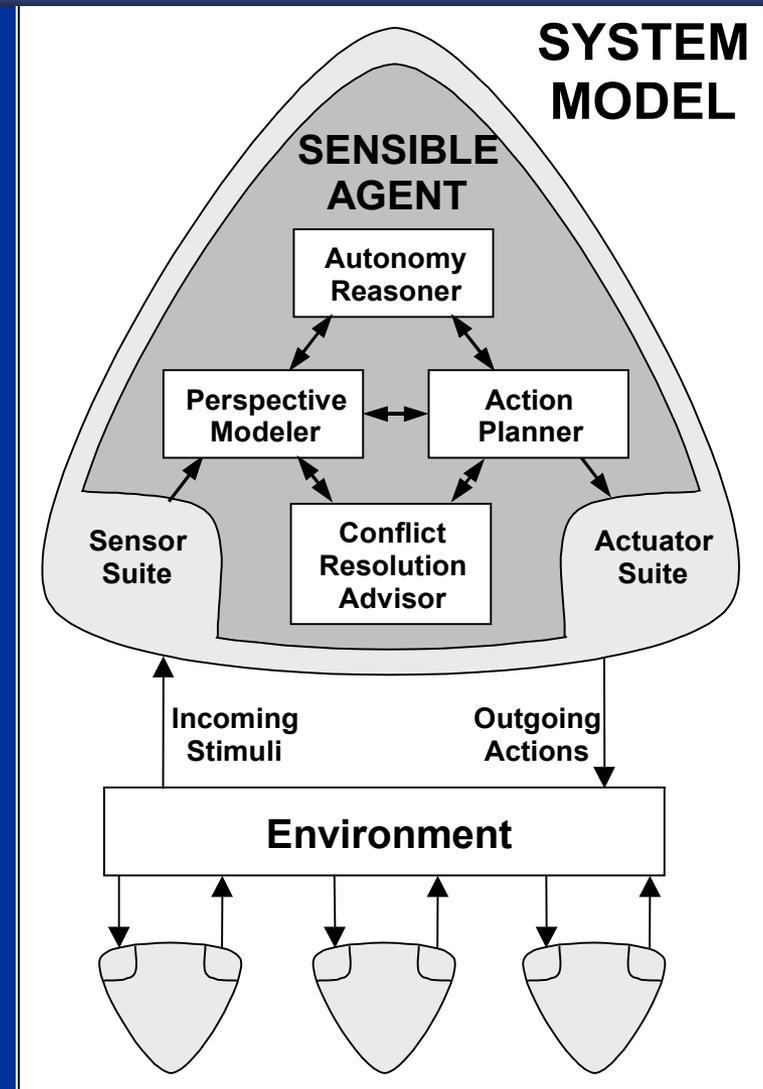
[Fox et al., 1998; So and Durfee, 1998; Sycara, 1998b]

- The set of all DMFs that exist in a system specifies the distribution of decision-making control and control relationships in a system [Barber and Martin 2001; Barber and Martin 1999a].
- **ADMF differs from previous work because previous work does not explicitly reason about and adapt decision-making control relationships in a multi-agent system as an application-independent concept.**
- However, previous work has shown that the distribution of decision-making control can be a differentiating factor in system performance [Briggs and Cook, 1995; Daft and Marcic, 1998; Mertens et al., 1994; others].



# Sensible Agent Architecture

- Generates the Agent's Plans or Reactions (Core Planner inside Action Planner)
- Coordinates Planning & Execution with Others -- Action Planner
- Selects "Best" Organization to Plan and Execute to Achieve Goals – Autonomy Reasoner
- Performs Situation Assessment; Modeling and Evaluating Certainty of Incoming Data and Reputation of Information Sources – Perspective Modeler
- Identifies Conflicts and Suggests Resolution Strategies – Conflict Resolution Advisor



# Capabilities Summary

- **Adaptive Decision-Making Frameworks (ADMF) delivers “best” problem solving organization given the situation:**
  - Certainty and completeness of information about other agents (benevolent, neutral, or threat) and the environment,
  - Communication constraints,
  - Domain-specific resource accessibility,
  - Goal deadlines and goal priorities, and
  - Goal, plan, or belief conflicts
- **Trust Evaluations based on Information Certainty and Information Source Reliability**
- **Coordinated Planning about Distributed Players with varying problem-solving preferences**
- **Formally Specified Testbed**
  - Rapid Integration, Rapid Prototyping
  - Repeatable Experimentation
  - Operation Visualization
  - 3<sup>rd</sup> Party Accessibility

