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.
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.
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)

- Sensible Agent assisting Humans
  Decision-Maker (with local goals)
- Humans (with local goals)
- Sensible Agent
  (with local goals)
  operating in fully automated mode
- Agent with local goals to maintain & protect Repository
The Coalition
(defines the System Goals)
DMF Representation \((D, G, C)\)

**Agents in system**

- This set of agents \((D)\)
- Makes decisions to achieve
- This set of goals \((G)\)
- Yielding subgoals to be carried out by
- This set of agents \((C)\)

**Goals in system**

- Coalition System Goals

- Agent Goals
Best Decision-Making Framework?

Decision-makers (agents) select\n
*degrees of decision-making control*

corresponding to different\n
**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

Network of decision-makers, including agents and humans

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
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
  - 3rd Party Accessibility