Multi-Agent Systems Seminar

Team: Triple Threat
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Presentation Subject

- **Horling, B., & Lesser, V. (2005). A Survey of Multi-Agent Organizational Paradigms. *The Knowledge Engineering Review, 19*(14), 281-316.**

- Well over 100 references used– we spotted this one
  ▫ L.-K. Soh, C. Tsatsoulis, and H. Sevay. A Satiscing,Negotiated, and Learning Coalition Formation Architecture. In V. Lesser, C. Ortiz, and M. Tambe, editors, *Distributed Sensor Networks: A multiagent perspective*, pages 109.138. Kluwer Academic Publishers, 2003.

Intro

- No one organizational paradigm is suitable for all situations
- For some situations multiple interacting paradigms are necessary
- All approaches have different characteristics
  ▫ There is no one best solution

What do organizations provide?

- Limit to scope of interactions
- Strength in numbers
- Reduce or manage uncertainty
- Reduce or explicitly increase redundancy
- Formalize high-level goals
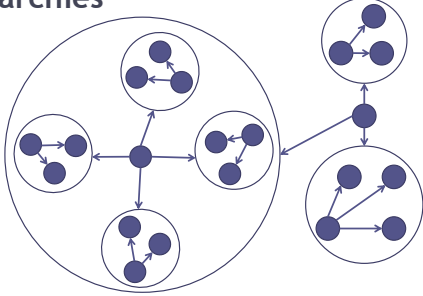- Regulate increased complexity of problems

Hierarchies
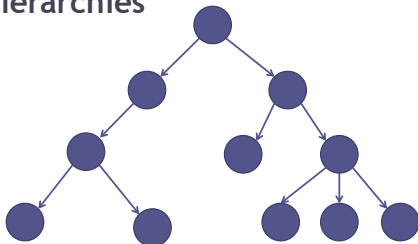
Hierarchies

- Data Flows up, Control flows down
- Well suited to decomposition tasks
- Vulnerable to overloading or loss of the top agent
- Contract Net Protocol creates these easily
- Flat Hierarchy can overload agents
- Tall Hierarchy can slow performance

Holarchies

Holarchies

- Hierarchical nested structure, made of ***Holons***
- Suited to tasks that can be broken down
- Each Holon is semi-autonomous
  - Flexibility in carrying out tasks
  - Requesters don't need knowledge of subordinates
  - Performance not very predictable
- Holons can be either static or dynamic
  - Dynamic searches for organization needed
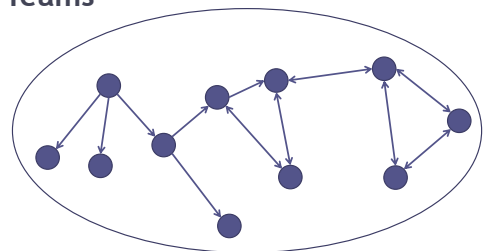
Coalitions
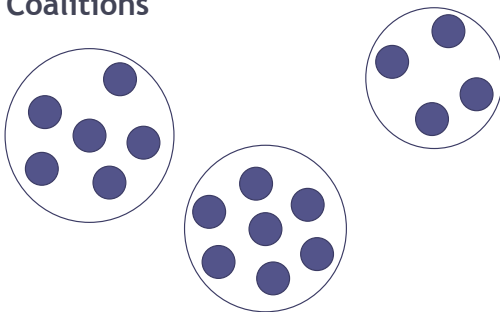
Coalitions

- Subsets of Agents ($S \subseteq A$)
- Goal directed and short lived
- Members in a coalition have better individual utility by joining
- Motivation: value of participants greater than each separate, *superadditive*

Coalitions

- Centralized formation is expensive—searching
- Local decisions to form coalitions is very problem specific as to effectiveness
- Easier to form with cooperative agents

Teams

Teams

- Like Coalitions, but maximize utility for the team rather than individual
- Tend to be short lived
- Benefits: address larger problems, redundancy
- Explicit inter-agent interactions
  - Agents in a team know about shared tasks
  - Tighter coupling between agents, increased communication

Teams

- Teams can be created as part of system design
- Contract Net Protocol can also be used to find team members dynamically
- Team members have different roles for the combined goal
- Teams plans, intentions, and beliefs can be encoded with a cost in reaction time

Congregations
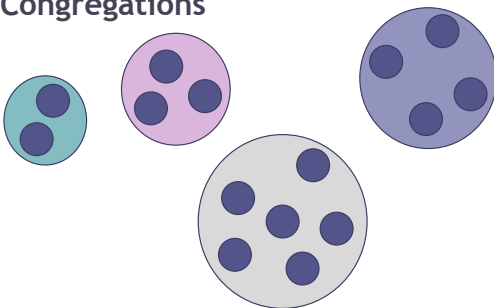
Congregations

- Like Coalitions and Teams, but long lived, without a single goal
- Agents have a stable set of capabilities and requirements
- Agents are self-interested, maximizing long-term utility

Congregations

- Restricts the size of agent population that needs to be searched to form a group
- Each agent decides on a tradeoff between utility and computational complexity
- Agent capabilities can be determined at design time or dynamically

Societies
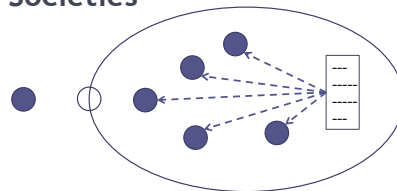
Societies

- Open, flexible arrangement
- Long-lived, agents can come and go at will
- Interactions between agents is flexible
- Uses social laws explicitly
  - Laws can make it more difficult for an agent to complete its task
  - Laws can make interactions much simpler

Societies

- Social and interaction models encoded and read my the agents at runtime
- Tradeoff between complexity and flexibility
  - Smallest set
  - Dynamic emergence
- Complex systems can be implemented with social laws
  - Paradox: Simplicity can be more complex

Federations
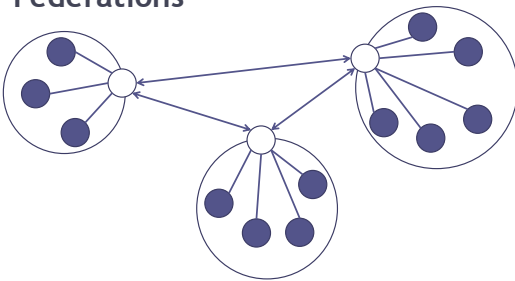
Federations

- A group of agents cede autonomy to a single delegate
- Delegate is intermediary from group to the outside world
- Consistent interface
- Some similarities with Holons
- Communications between groups are handled by the delegates

Federations

- Useful for integrating legacy systems
- Delegate can function as a number of roles
  - Translator, taskmaster, monitor
- Delegate can be the bottleneck of the system
- Delegates can be specially designed for translating, but restrict emergent behavior
- Dynamic systems loose out on translating functionality, as delegates are determines automatically

Markets
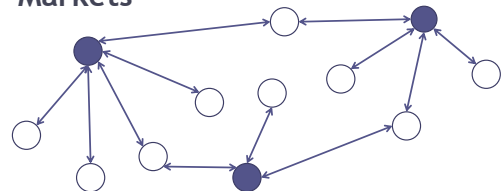
Markets

- Make up of buyers and sellers
  - Very similar to real world market economies, so economic research is very useful
- Typically competitive
- Common to be an open system
- Buyers and sellers aren't just about trading items
 - Time estimates for production, queries

Markets

- Truthful bids are necessary for effective allocation
- Many different types of auctions are available
- Two significant drawbacks
  - Complexity, especially in counter-speculation
  - Security of the auction, preventing collusion
- Depends on temporal integrity and atomic transactions

Markets

- Virtual Organizations incorporate other organization ideas
  - Fixed purpose, but transient shape and membership
  - Concept similar to coalition and congregation organizations
  - Many of the benefits of a federation
 - Best thought of as an entity in itself

Matrix Organizations
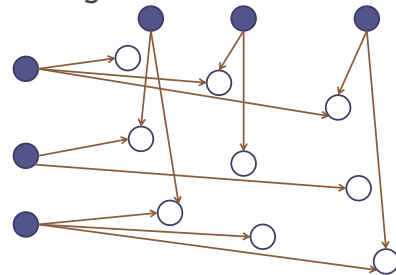
Matrix Organizations

- Like hierarchical, but lets more agents have decision making influence
- Multiple influences—success come from reason about local effects of actions
- Agents can share resources for two tasks
- Resource contention among managers
- Need commitment ranking and the ability to resolve local conflicts

Compound Organizations
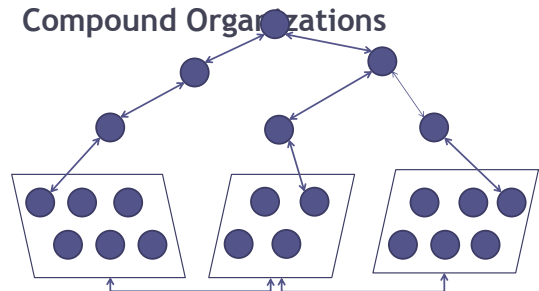
Compound Organizations

- A system can have one organization for control and another for data flow
- Or one for interpretation and another for managing coordination
- Can be very complex, need sophisticated agents
  ▫ Agents can have competing objectives
  ▫ Knowledge from multiple requirements can help make better decisions

Compound Organizations

- Organizations can be overlapped or nested
- One type of organization can create another
  ▫ Congregations → markets
  ▫ Markets or hierarchies → coalitions
  ▫ Societies can be a common pool of agents for other organizations
- Sensor net examples
  ▫ Federation contains a matrix organization
  ▫ Federation contains a hierarchy

Final Points

- No single approach is inherently better than others in all situations
- Hierarchical, team-centric, coalition-based organizations and marketplaces are popular for flexibility in studies
- Different strategies are gradually converging to a common form

Take Away Points

- Organizations
  ▫ Assist designers looking at whole or parts of a system
  ▫ Help evaluate approach to a problem (or sub-problem), fleshing out benefits and drawbacks
  ▫ Relate knowledge from other disciplines (Sociology, Economics, etc.) to problem

Ways to use this paper

- Quick Reference Guide summarizing many different approaches to organize agents
- Surfacing implicit aspects of the structure of systems (and sub-systems)
- Matching problems to solutions

In our project

- Monster Hunting
  ▫ Main organization is Society, with scripted rules
  ▫ Overseer to Heroes is a flat Hierarchy
  ▫ Combat between Heroes and Monsters is a simple Market

Hierarchies

Holarchies

Coalitions

Teams

Congregations

Societies

Federations

Markets

Matrix Organizations