

CmpE 593 Multiagent Systems

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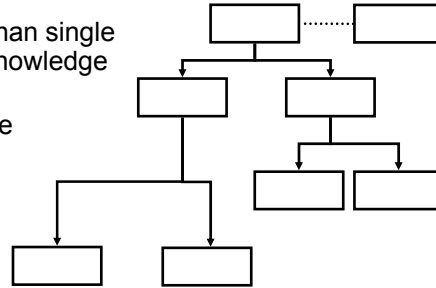
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Chapter 3 Multiagent Organizations

Based largely on
Service-Oriented Computing: Semantics, Processes, Agents
– Munindar P. Singh and Michael N. Huhns, Wiley, 2004

Organizations

- Organizations are larger-scale than single agent, goal-oriented, and with knowledge and memory beyond individual
- Organizations help overcome the limitations of agents in
 - reasoning
 - capabilities
 - perception
 - lifetime and persistence
- Concretely, organizations consist of agents acting coherently
- Abstractly, organizations consist of roles and commitments among the roles – these form a *sphere of commitment*



Legal Abstractions

- Contracts
- Directed obligations
- Hohfeldian concepts
- Compliance

Legal Concepts

- Raised by the interactions of agents
- The legal abstractions provide a basis for agents to enter into contracts, e.g., service agreements, with each other
- Contracts
 - are about behavior
 - important in open environments
- Much of the law is about the creation and manipulation of contracts among legal entities
 - people
 - corporations
 - governmental agencies

Directed Obligations

- Contracts lead naturally to one party being obliged to another party
 - more precise notion of obligation than in traditional deontic logic
 - two-party concept has a more multiagent flavor

Hohfeldian Concepts/1

Hohfeld discovered that “right” is used ambiguously and proposed a uniform terminology to distinguish the various situations. Sixteen concepts result:

- Four main concepts
- Their correlates
- Their negations
- Their negations’ correlates

Hohfeldian Concepts/2

The rights or claims a party has, as opposed to the right (ethical) thing to do.

- Each Hohfeld term has a paired correlate term (to show the other agent’s view)
- Claim:
 - Demand from another agent
 - The claims of one party are the duties of another: claim is a *correlate* of duty

Hohfeldian Concepts/3

- Privilege:
 - Freedom from the claims of others
 - Exercising your privileges is up to you
 - Exposure: Correlate of privilege
- Power:
 - Ability to change the legal relation
 - When an agent can change the claim-duty relationship of another agent
 - Liability: Correlate of power.
- Immunity:
 - Freedom from the power of another agent
 - Disability: Correlate of immunity

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9

Deontic Logic

- The logic of obligation, “obliged to do p”
- O: *It is obligatory that*
- Example: O_{pay}(A, B, \$5)
- Reason about obligations
 - $O(p \wedge q) \Rightarrow (Op \wedge Oq)$
 - $Op \Rightarrow \neg O \neg p$
- Does not separate obligations of parties
- Not directed (who is the beneficiary?)

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10

Coherence and Commitments

- Coherence is how well a system behaves as a unit. It requires some form of organization, typically hierarchical
- Social commitments among agents are a means to achieve coherence. An agent's commitment to another agent or to its society
 - Is unidirectional
 - Arises within a well-defined scope or *context*
 - Is revocable with restrictions
 - Enables coordination through the ordering and occurrence of actions by the agents

Commitments

- A social commitment is an obligation from one party to another to bring about a condition.
- **$C(x, y, p, G)$** :
 - Debtor x commits to
 - Creditor y to bring about
 - Condition p in
 - Context group G
- **$CC(x, y, p, q)$** is a conditional commitment:
 - x commits to y to bring about q if p is brought out first.

Commitments for Contracts

Commitments capture contracts. Importantly, commitments are

- Public (unlike beliefs and intentions)
- Can be used as the basis for compliance
- Contracts apply between parties, in a context
- Other approaches are:
 - Single-agent focused, e.g., deontic logic
 - Don't handle organizational aspects of contracts
 - Don't accommodate manipulation of contracts

Manipulating Commitments

- Operations on commitments:
 - Create
 - Discharge (satisfy)
 - Cancel
 - Release (eliminate)
 - Delegate (change debtor)
 - Assign (change creditor)
- Metacommitments constrain the manipulation of commitments

SoCom: Sphere of Commitment

An organization that provides the context or scope of commitments among relevant roles (*abstract*) or agents (*concrete*)

- Serves as a *witness* for the commitment, i.e., knows that the commitment exists
- Helps validate commitments and test for compliance
- Offers compensations to undo members' actions

Teams

Tightly knit organizations

- Shared goals, i.e., goals that all team members have
- Commitments to help team-members
- Commitments to adopt additional roles and offer capabilities on behalf of a disabled member

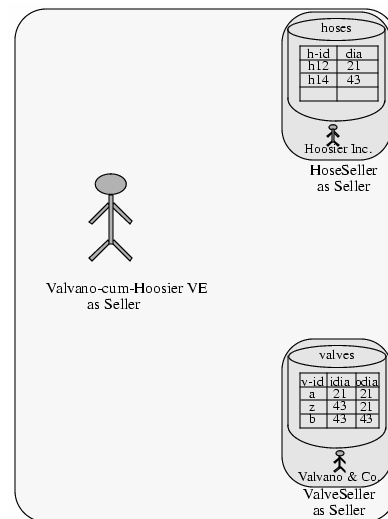
Teamwork

When a team carries out some complex activity

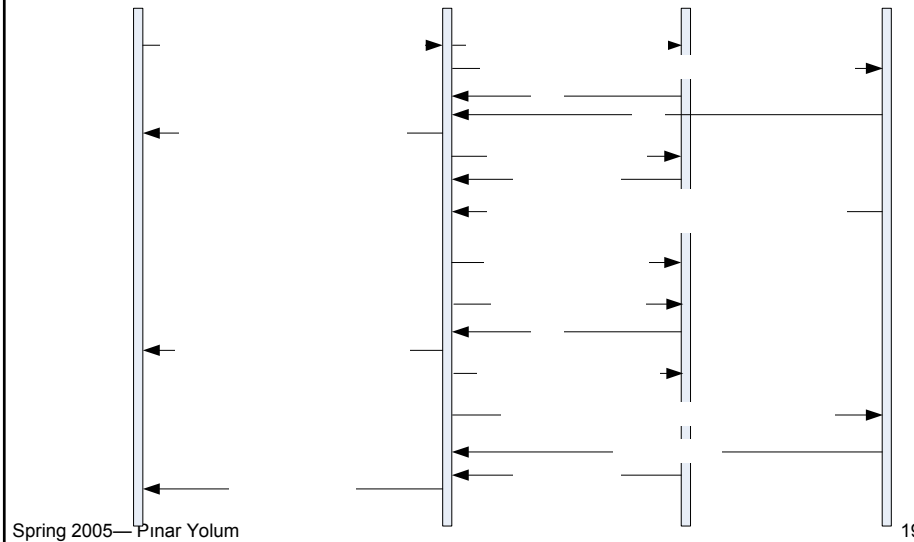
- Negotiating what to do
- Monitoring actions jointly
- Supporting each other
- Repairing plans

Virtual Enterprises (VE)

- Two sellers come together with a new proxy agent called VE
- Example of VE agent commitments:
 - Notify on change
 - Update orders
 - Guarantee the price
 - Guarantee delivery date



A Selling VE



Policies and Structure

- Spheres of commitment (SoComs)
 - abstract specifications of societies
 - made concrete prior to execution
- Policies apply on performing social actions
- Policies relate to the nesting of SoComs
- Role conflicts can occur when agents play multiple roles, e.g., because of nonunique nesting

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Negotiation

Negotiation is central to adaptive, cooperative behavior

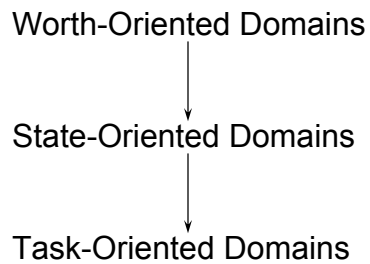
- Negotiation involves a small set of agents
- Actions are propose, counterpropose, support, accept, reject, dismiss, retract
- Negotiation requires a common language and common framework (an abstraction of the problem and its solution)

Negotiation Mechanism Attributes

- Efficiency: Should not waste resources to agree
- Stability: No agent should have incentive to deviate from agreed strategies
- Simplicity: Low computational demands
- Distribution: No central decision maker
- Symmetry: No bias for a particular agent

How to design the rules of an environment so that agents interact productively and fairly e.g., sharing book purchases, with cost decided by coin flip

Problem Domain Hierarchy



Task-Oriented Domains

- A TOD is a tuple $\langle T, A, c \rangle$, where T is the set of tasks, A is the set of agents, and $c(X)$ is a monotonic function for the cost of executing the set of tasks X
- Encounter: Agents are assigned tasks
- Examples
 - deliveries: $c(X)$ = length of minimal path that visits X
 - postmen: $c(X)$ = length of minimal path plus return
 - databases: $c(X)$ = minimal number of needed DB ops

Negotiation

- A deal is a joint plan between two agents that would satisfy their goals
- The utility of a deal for an agent is the amount he is willing to pay minus the cost to him of the deal
- The negotiation set is the set of all deals that have a positive utility for every agent. The possible situations for interaction are
 - *conflict*: the negotiation set is empty
 - *compromise*: agents prefer to be alone, but will agree to a negotiated deal
 - *cooperative*: all deals in the negotiation set are preferred by both agents over achieving their goals alone

Task-Oriented Domains (2)

- A deal is a redistribution of tasks
- Utility of deal d for agent k is
$$U_k(d) = c(T_k) - c(d_k)$$
- The conflict deal, D , is no deal
- A deal d is individual rational if $d \geq D$
- Deal d dominates d' if d is better for at least one agent and not worse for the rest
- Deal d is Pareto optimal if there is no $d' > d$
- The set of all deals that are individual rational and Pareto optimal is the negotiation set, NS

Monotonic Concession Protocol

- Each agent proposes a deal
- If one agent matches or exceeds what the other demands, the negotiation ends
- Else, the agents propose the same or more (concede)
- If no agent concedes, the negotiation ends with the conflict deal

This protocol is simple, symmetric, distributed, and guaranteed to end in a finite number of steps in any TOD. What strategy should an agent adopt?