Integrative Negotiation in Complex Organizational Agent Systems

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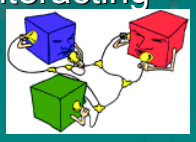
Outline

- Background
- Motivation
- Motivational Quantities
- Integrative negotiation mechanism
- Experimental results
- Future work

Agents and Multi-Agent Systems

- Multi-agent system – intelligent agents interacting
- Agent – complex and large-grained
  - Multiple tasks – scheduling
  - Complex tasks – planning
  - Soft real-time concerns
- Applications
  - Agent-mediated electronic commerce
  - Supply-chain management
  - Distributed sensor network
  - Intelligent environment control



Negotiation in MAS

- Negotiation – an interactive communication
  - Task allocation
  - Resource allocation
  - Conflict resolution
- Research on Negotiation
  - Negotiation language: communication part including primitive, semantics, protocols, and topics, etc.
  - Negotiation decision: evaluation process, how to select bids, strategies.
  - Negotiation process: negotiation behavior, models, etc.

Two major trends

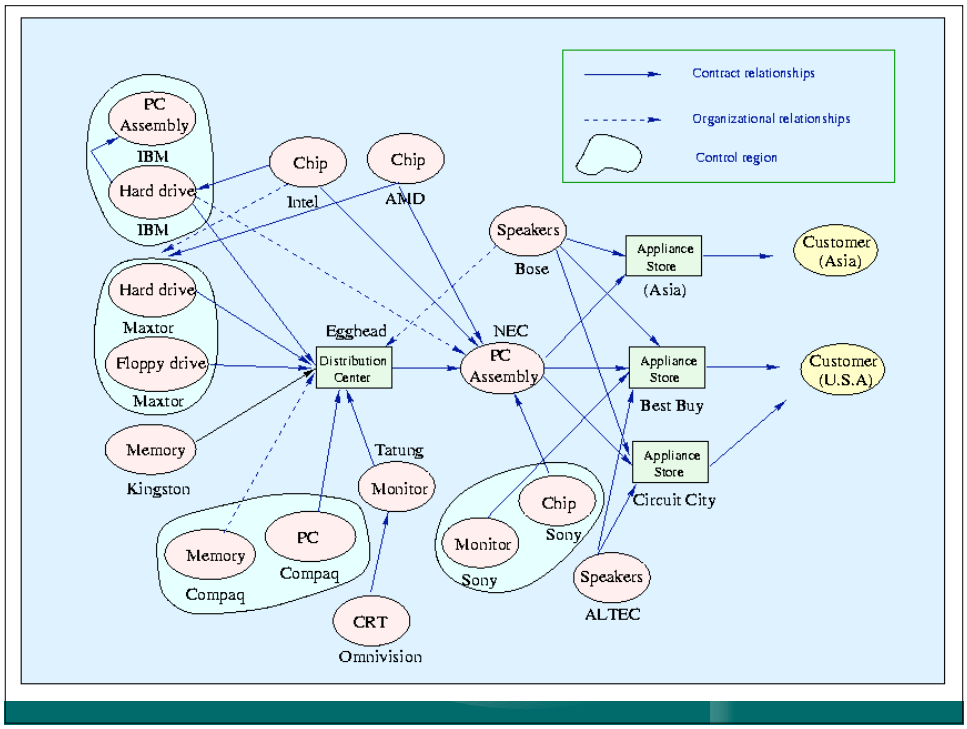
- Competitive negotiation
  - agents are self-interested and negotiate to maximize their own local utility
  - social welfare is not a concern
  - Example: TRACONET, leveled commitment [sandhlom & lesser,96]
- Cooperative negotiation
  - agents work to find a solution that increases their joint utility or solve conflict
  - no notion of individual agent utility
  - Example: Distributed meeting scheduling [sen96]

Organization Structures

? simple market systems

distributed problem solving systems

- Dynamically formed virtual organizations
- Involved concurrently with more than one virtual organization
- Pure self-interested may hurt repeated transactions
- Bounded rationality prevents fully cooperative

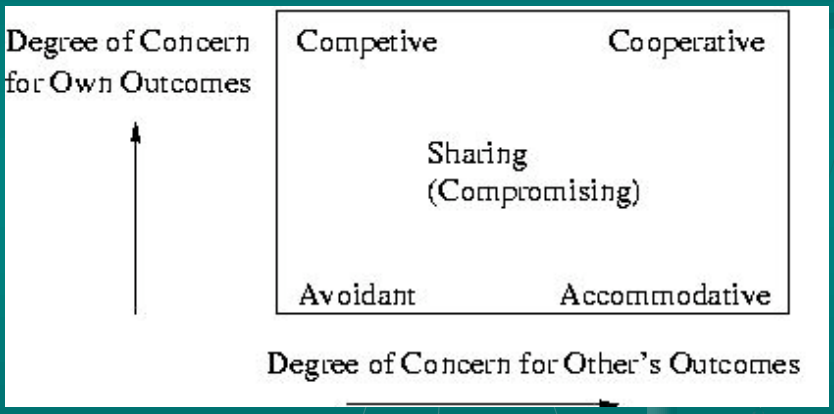


Different partners

Agent_IBM_2 provides hard drives for:

- agent_IBM_1, who belongs to IBM but assembles PC.
- A NEC agent, a virtual organization formed based on the recent more frequent transactions.
- a distributor center, occasionally, based on a simple marketing mechanism.

Dual concern model



R. Lewicki and J. Litterer, 1985, Negotiation

What is needed?

- The agent can choose from many different negotiation strategies in the spectrum from purely self-interested to accommodative.
- The choice should depend on the agent's organizational goals and the current environmental circumstance.
- No requirement of a centralized controller which coordinates the agent's behavior.

What have been done? - brownie point

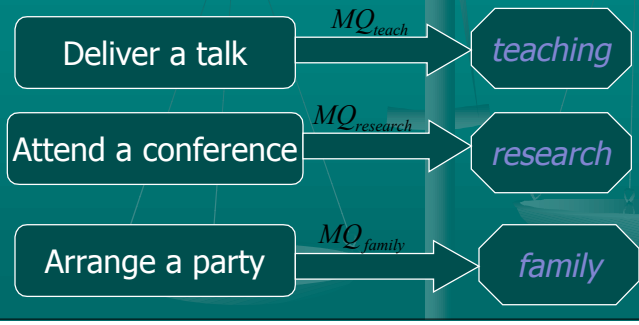
- Brownie points [Glass and Grosz 00], a measure of social consciousness
- Agent belongs to a group, receives both group tasks and outside offers.
- Agent collects brownie points by not defaulting group task.
- BP-weight: varying levels of social consciousness.
- A central mechanism controlling the assignment of group tasks according to agent's rank.

What have been done? - reciprocity

- Probabilistic reciprocity mechanism [Sen,96]
- Reciprocity: promote cooperative behavior among self-interested agents
- Probability of accepting a request depends on:
  - extra cost of this cooperation behavior
  - how much effort it owes
  - Adjustable parameters allow agent choose a specific cooperation level
- Assumes that cooperation always leads to aggregate gains for the group; no organizational structure.

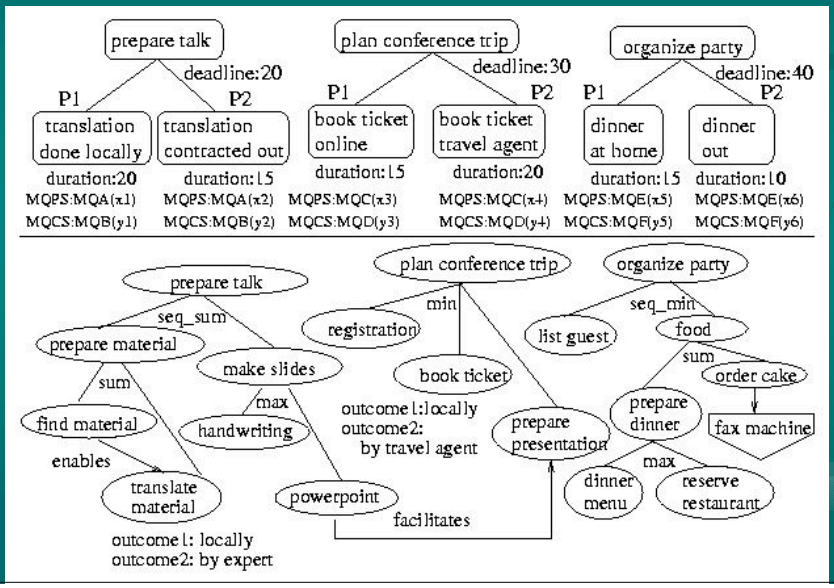
Motivational Quantities

- Agent has multiple roles, multiple goals
- MQ represents progress towards organizational goal
- Preference function F_i: MQ_i → utility



Schedule on MQ Tasks

MQ scheduler: select task to maximize utility



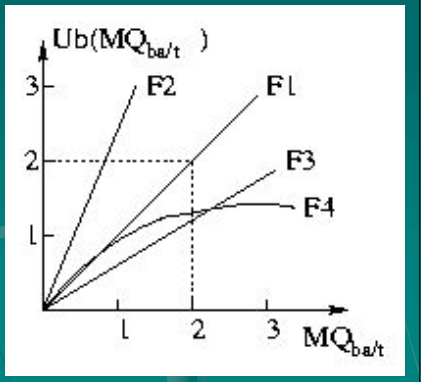
Two types of MQ

- Goal related MQ
  - Mapped into agent's utility, utility function is determined by agent designer
  - Transferred between agents who have the same organizational goal.
- Relational MQ
  - Mapped into "virtual" utility
  - Utility curve reflects the relationship between agents

Relational MQ

$MQ_{ba/t}$

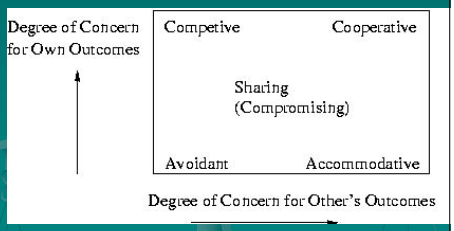
- Relational MQ (*motivational quantity*)
  - Transferred from agent A to B with task t
  - How important task t is for agent A
  - How much agent B cares

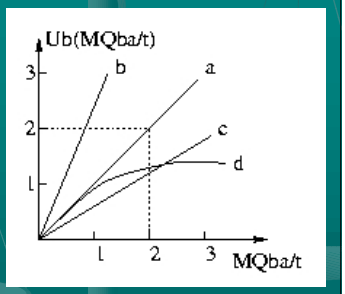


- Function F1: completely cooperative
- Function F2: accommodative (over cooperative)
- Function F3: partially cooperative (half cooperative)
- Function F4: first cooperative, then indifferent

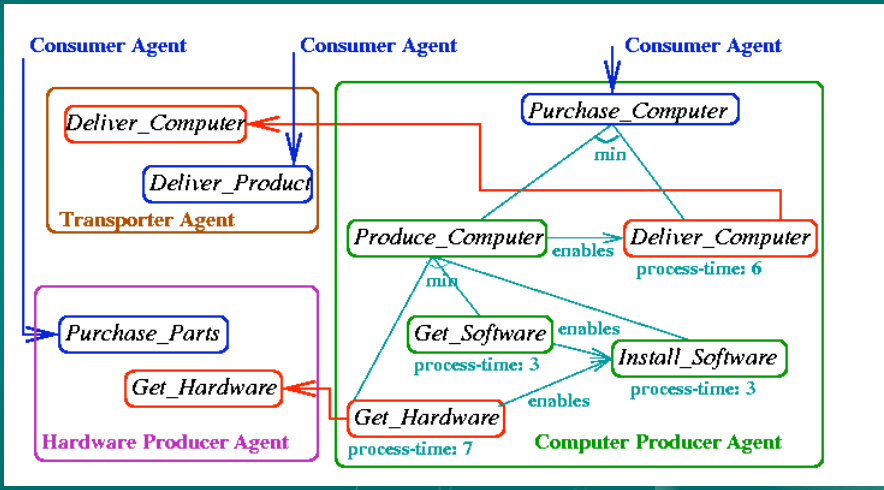
Integrative Negotiation

- Agents negotiate
  - With agents from different organizations, different roles, authority relationships
  - Concern different issues
- Dynamic strategies
  - Wide range of selections
  - Depends on negotiation party and issue
  - Related to organizational concerns





PCT Scenario



Computer producer agent

Get a contract

task name : Purchase_Computer_A
est: 10
deadline: 70
reward: 20 units $MQ_{\$}$
early finish reward rate: e=0.01
Finish time: 40
Early reward: (70-40)*0.01*20=6

task name	*Get_Hardware_A*	*Deliver_Computer_A*
est	*10*	*30*
deadline	*20*	*40*
reward	*3 units* $MQ_{\$}$ *10 units* $MQ_{hc/t}$	*3 units* $MQ_{\$}$ *10 units* $MQ_{tc/t}$
e	*0.01*	*0.01*

Hardware agent

What should I do?

task name	*est*	*deadline*	*process time*	*MQPS*
Get_Hardware_A	*10*	*20*	*10*	$[MQ_{\$},3]$ $[MQ_{hc/t}, 10]$
Purchase_Parts_A	*10*	*30*	*10*	$[MQ_{\$},4]$
Purchase_Parts_B	*10*	*20*	*10*	$[MQ_{\$},9]$

$$U_{ha}(MQ_{hc/t}) = k * MQ_{hc/t}$$

- k=1, ***completely-cooperative***
  [10, 20] Get_Hardware_A [20, 30] Purchase_Parts_A
- k=0.5, ***half-cooperative*** (partial cooperati
  [10, 20] Purchase_Parts_B [20, 30] Purchase_Parts_A
- k=0, ***self-interested***
  [10, 20] Purchase_Parts_B [20, 30] Purchase_Parts_A

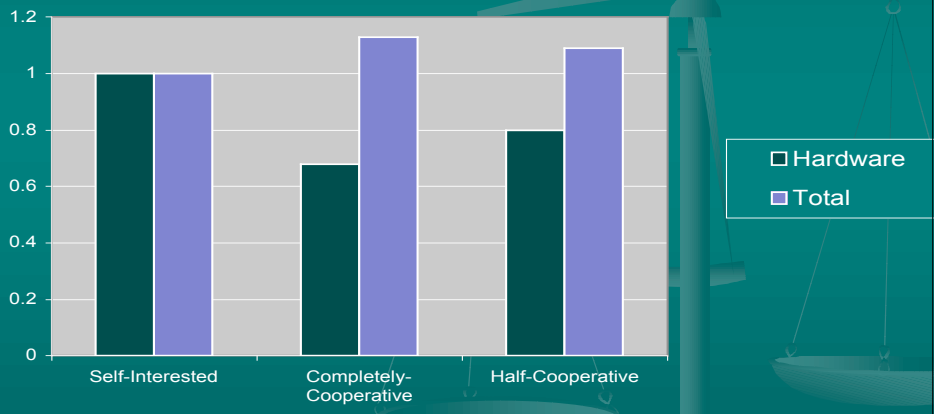
Experimental Setup

- Agent society: computer producer agent, hardware agent, transport agent
- Three attitudes: completely-cooperative (C), half-cooperative (H), and self-interested (S)
- Nine combinations: CC, HH, SS, HC, CH, HS, SH, CS, SC
- comparison of each agent's utility and the social welfare under different situations

Cooperation not always help

S: self-interested
C: completely cooperative
H: half cooperative

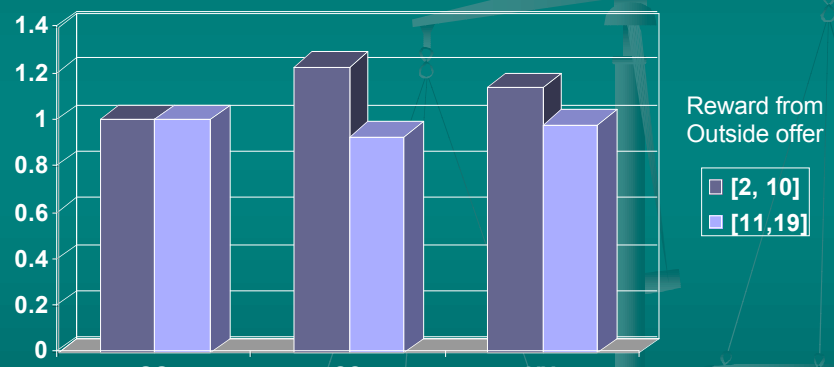
Be conservative when works with unknown agents



Uncertainty play a role

- Uncertainty comes from lack of information
  - The other agent's attitude
  - How good is its outside offer, and frequency
- Fully cooperative is impossible given complete global information is not available

Uncertainty in the organization environment



Alternative view of MQ

- Another reason of uncertainty in a distributed system: uncertainty about the relationships with other agents
- MQ can be used as a means to deal with this uncertainty
  - Dynamically adjust MQ (the agent's attitude) towards another agent based on how certain/uncertain it is about the other's commitment to itself

Conclusions and Future Work

- Integrative negotiation with attitude from self-interested to complete cooperative
- In a uniform reasoning framework
- Model human society
- How should an agent select its attitude? Learning from experience?