AOT LAB

Agent and **O**bject **T**echnology **Lab**
Dipartimento di Ingegneria dell'Informazione
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Distributed and Agent Systems

Coordination

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- ◆ Coordinating is the process of managing interdependencies between activities

- ◆ There are two types of coordination

  - ▪ Cooperation
    - • Planning
    - • Incidental
    - • Structural

  - ▪ Competition
    - • Negotiation
    - • Conflicting

- ◆ If we "own" the whole system, we can design agents to help each other whenever asked
  - ▪ In this case, we can assume agents are *benevolent*: our best interest is their best interest
    - • *Benevolence simplifies the system design task enormously!*

- ◆ If agents represent individuals or organizations, (the more general case), then we cannot make the benevolence assumption
  - ▪ Agents will be assumed to act to further there own interests, possibly at expense of others
    - • Potential for *conflict*
    - • May complicate the design task enormously

- ◆ Arrangement of relationships between components or individuals
- ◆ Organizational links create a new component of a whole
- ◆ Relatively high degree of interdependence and reliability
- ◆ Determination of "social rules" for agent interaction
- ◆ Three main types of organization
  - ▪ Hierarchical
  - ▪ Bi- multi-lateral
  - ▪ Complete

◆ **Centralized planning**

- A master agent decomposes the plan into sub-plans
- Checks the preconditions to select the sub-plans
- Synchronizes the sub-plans
- Allocates the sub-plans to agents

◆ **Partial global planning**

- Agents generates a partial plan (sub-plan) in parallel
- Then they merge these plans into a global plan
- After negotiation the agents execute their plans

Coalition and Team Formation

- ◆ Coalition and team formation allows the saving of costs by coordinating activities with other parties

- ◆ Coalition formation approach derives from game theory:
  - Agents are maximizing utility
  - Multiple coalitions possible
  - Formation of "most-promising" team

- • Team formation approach derives from logics:
  - • Individual agent is unable to solve problem
  - • Logical reasoning determines team or potential teams

Social Laws and Conventions

- ◆ Social laws and conventions can be seen as constraints on actions

- ◆ Social laws and conventions offer a basis for trust and security:

  - ▪ Decrease uncertainty

  - ▪ Reduce conflict of meaning

 - ▪ Create expectations of outcome

  - ▪ Simplify the decision process

◆ Interaction among agents is governed by a particular *mechanism*, or *protocol*

◆ The mechanism defines the "rules of encounter" between agents

◆ *Mechanism design* is designing mechanisms so that they have certain desirable properties

◆ Given a particular protocol, how can a particular *strategy* be designed that individual agents can use?

Mechanism Desirable Properties

- Convergence/guaranteed success
- Stability
  - No incentive to deviate
- Simplicity
  - Low computational and communication cost
- Distribution
  - No central decision-maker
- Symmetric
  - Agents play equivalent roles
- Efficient
  - Satisfy at least one of the following criteria
    - Maximizing social welfare
    - Pareto optimal
    - Individual rationality

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- ◆ S is a Pareto-optimal solution
  if

  $$\forall S' \; \exists x \; (U_x(S') > U_x(S)$$
  $$\rightarrow \exists y \; U_y(S') < U_y(S))$$

  - ▪ i.e., if X is better off in S', then some Y must be worse off

- ◆ Social welfare, or global utility, is the sum of all agents' utility

  - ▪ If S maximizes social welfare, it is also Pareto-optimal (but not vice versa)

Y's utility

A

D

C

E

B

F

X's utility
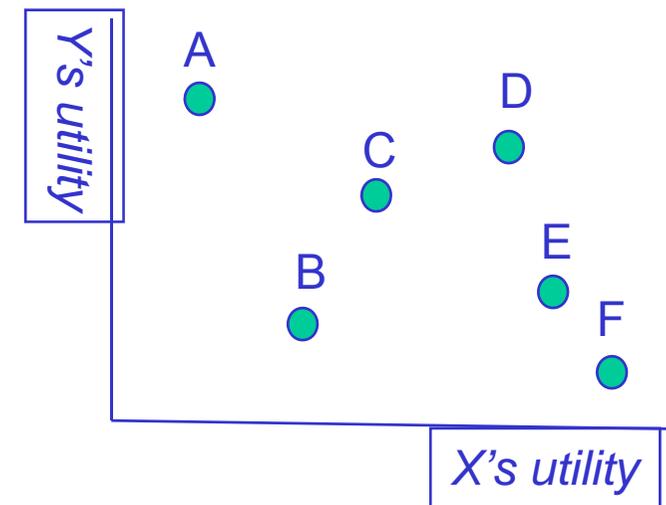
- ◆ **Plurality voting**
  - The outcome with the highest number of votes wins
  - Irrelevant alternatives can change the outcome
- ◆ **Borda voting**
  - Agents rankings are used as weights, which are summed across all agents
  - Agents can "spend" high rankings on losing choices, making their remaining votes less influential
- ◆ **Binary voting**
  - Agents rank sequential pairs of choices ("elimination voting")
  - Irrelevant alternatives can still change the outcome
 - Very order-dependent

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- *Negotiation* is the process of reaching agreements on matters of common interest

- Any negotiation setting will have four components

  - A negotiation set, possible proposals that agents can make

  - A protocol

  - Strategies, one for each agent, which are private

  - A rule that determines when a deal has been struck and what the agreement deal is

- Negotiation usually proceeds in a series of rounds, with every agent making a proposal at every round

- ◆ Participants
  - Buyers, sellers, auctioneers, brokers
- ◆ Data
  - Good description, bid, deal
- ◆ Messages
  - Sent by the participants to modify the deal
    - Examples: bids and offers to buy/sell, price changes
  - Sent to the participants as the deal changes
- ◆ Process flow
  - Describes how the state of the negotiation changes as a result of messages

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- ◆ **Seller offers to sell**

- ◆ **Buyer can accept the offer to conclude**

- ◆ **Seller can withdraw offer to abort the negotiation**

Deal Template

DT

<Seller, Offer to sell>

Offer

<Buyer, Accept>

Deal

D

<Seller, Withdraw offer>

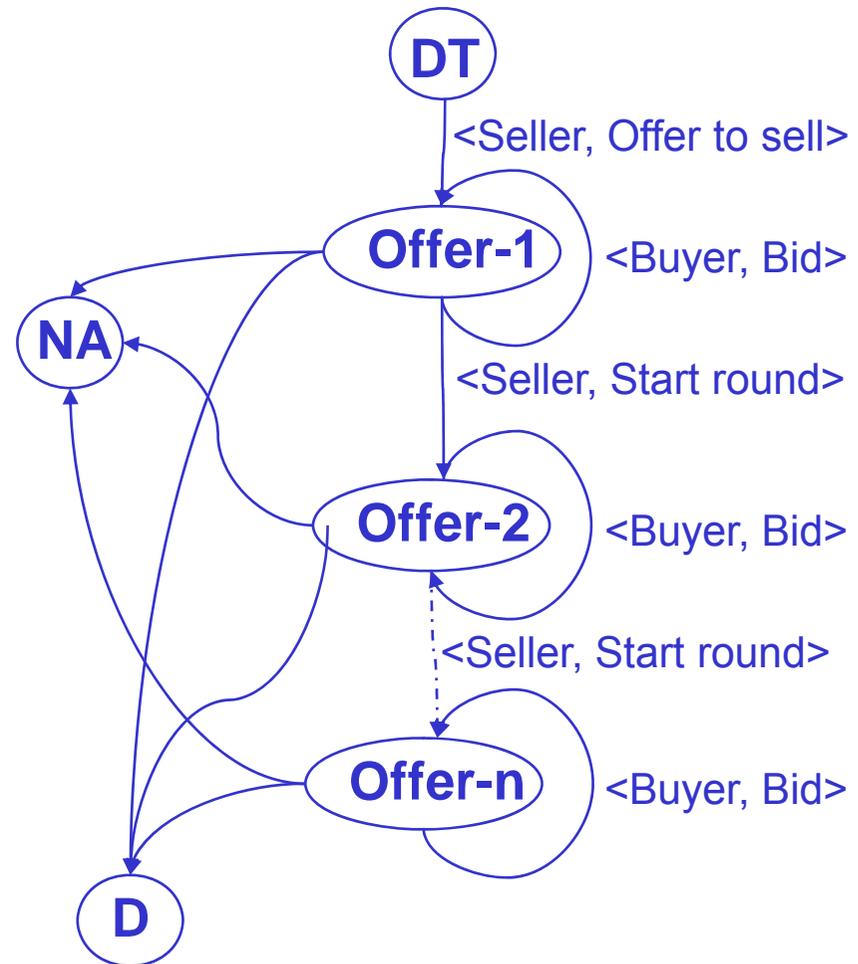**NA**

Negotiation aborted

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- ◆ Seller offers to sell, does not specify price

- ◆ Buyers submit bids

- ◆ Negotiation ends when the seller closes the auction

- ◆ Deal happens if there is at least one bidder and the highest bid meets requirements

DT

<Seller, Offer to sell>

Offer

<Buyer, Bid>

<Seller, Close auction>

NA

D

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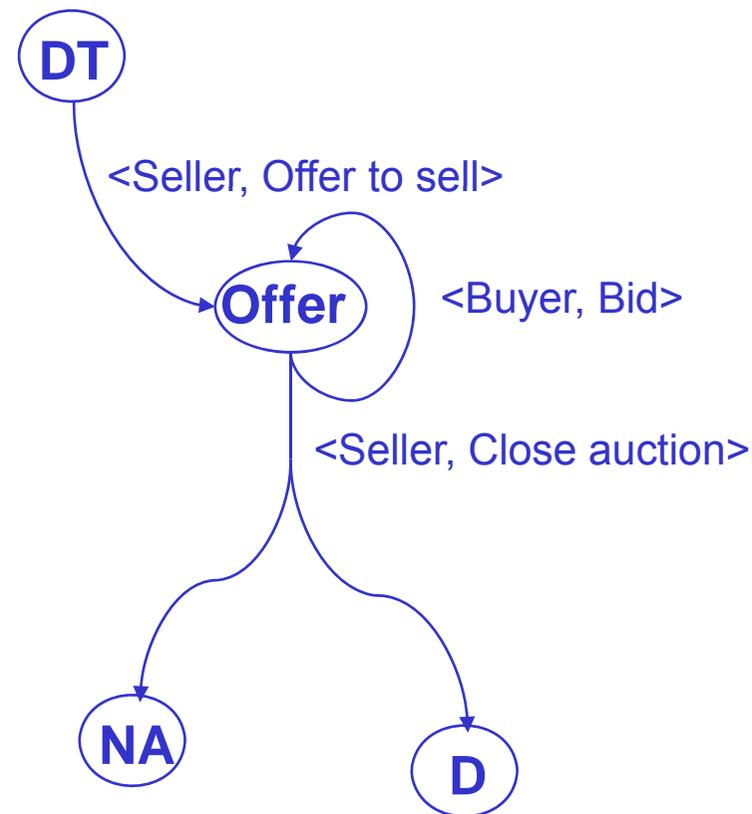
- The most known example of open cry auction is the English auction

- A buyer need to submit a bid higher than the last bid proposed by another buyer

- Good is awarded to the buyer that submit the last bid when no other buyer is interested in submitting a new bit

- The buyer gets the good at the price of her/his last offer

- The two most known examples of sealed bid auction are

    - First-price

    - Vickrey auctions

- In a first-price auction good is awarded to the buyer that made the highest bid at the price of her/his offer

- In a Vickrey auction good is awarded to the buyer that made the highest bid at the price of the second highest bid

- ◆ Seller offers to sell, does not specify price

- ◆ Buyers submit bids at every phase

- ◆ At the end of a phase the seller publishes the highest bid and can
  - ■ Close the auction
  - ■ Abort it
  - ■ Start another phase

DT

<Seller, Offer to sell>

Offer-1 <Buyer, Bid>

NA

<Seller, Start round>

Offer-2 <Buyer, Bid>

<Seller, Start round>

Offer-n <Buyer, Bid>

D

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- ◆ Seller offers to sell on a high initial price
- ◆ Seller makes a new (lower) offer at regular intervals
- ◆ A Buyer's bid is the decision to buy the item at the current price
- ◆ Auction ends when
  - A buyer accepts the current price of seller
  - The seller aborts the auction

DT

<Seller, Offer to sell>

Offer

<Seller, Reduce prize>

<Buyer, Accept>

D

<Seller, Close Auction>

NA

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- Seller offers to sell on a high initial price a certain number of items

- Buyers bid to purchase a number of items at the price currently offered by the seller

- Auction ends only when the seller closes the auction

DT

<Seller, Offer to sell>

<Seller, New prize>

D   Offer

<Buyer, Bid>

<Seller, Close Auction>

NA

- One problem with the previous auction protocols is that they are susceptible to lying on the part of the auctioneer

  - A dishonest auctioneer can exploit the Vickrey auction by lying about the second highest bid

- Another problem with these auction protocols is that they are not collusion proof

  - Shills can be introduced to inflate bidding prices in English auctions

  - The bidders could coordinate their bid prices so that the bids stay artificially low. In this manner, the bidders get the item at a lower price than they normally would

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- The English auction and the Vickrey auction actually self-enforce some of the most likely collusion agreements

- Therefore, from the perspective of deterring collusion, the first-price sealed-bid and the Dutch auctions are preferable

- As an example, let bidder Smith have value 20, and every other bidder have value 18 for the auctioned item

English Auction Bidder Collusion

- ◆ Say that the bidders collude by deciding that Smith will bid 6, and everyone else will bid 5

- ◆ In an English auction this is self-enforcing, because

  - ▪ If one of the other agents exceeds 5

  - ▪ Smith will observe this, and will be willing to go all the way up to 20

  - ▪ The cheater will not gain anything from breaking the coalition agreement

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- Say that the bidders collude by deciding that Smith will bid 20, and everyone else will bid 5

- Bidding 20 removes the incentive from any bidder to break the coalition agreement by bidding between 5 and 18, because no such bid would win the auction

- ### In a first-price sealed-bid auction

  - If Smith bids anything below 18

  - The other agents have an incentive to bid higher than Smith's bid because that would cause them to win the auction

- ### In a Dutch auction

  - If Smith waits for a prize below 18

  - The other agents have an incentive to bid because that would win the action at a favorable cost

- ◆ However, for collusion to occur under the Vickrey auction, the first-price sealed-bid auction, or the Dutch auction
  - ▪ The bidders need to identify each other before the submission of bids
  - ▪ Otherwise a non-member of the coalition could win the auction
- ◆ On the other hand, in the English auction this is not necessary, because the bidders identify themselves by shouting bids
  - ▪ To prevent this, the auctioneer can organize a computerized English auction where the bidding process does not reveal the identities of the bidders
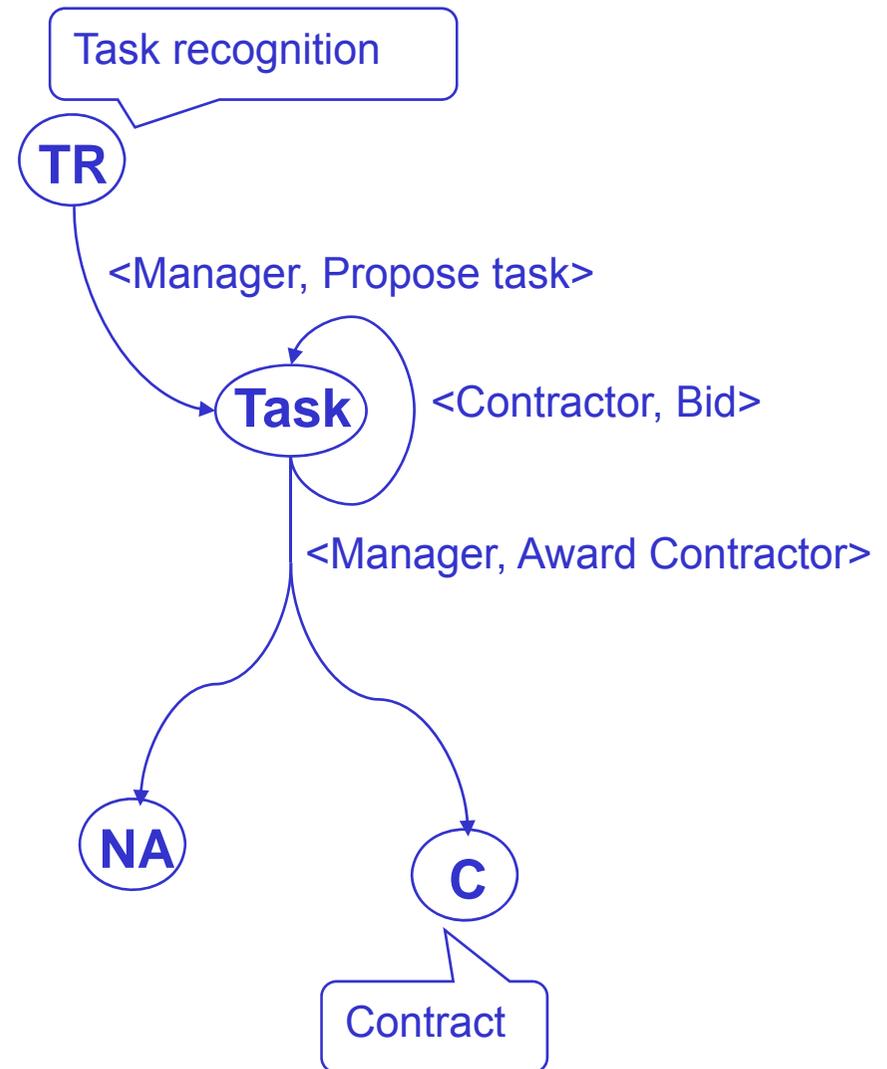
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- ◆ Seller wants to sell and buyer wants to buy

- ◆ Either the buyer or seller can start a negotiable deal

- ◆ Deal contains the seller's asking price and buyer's bid

- ◆ Either buyer or seller can create a final offer

- ◆ If the seller initiates a final offer he can withdraw it or the buyer can accept and vice-versa

DT

<Seller, Offer to sell>

<Seller, Ask prize>
<Buyer, Update>

ND

<Seller, Update>
<Buyer, Bid>

<Buyer, Final offer>

<Seller, Final offer>

Offer-B

Offer-S

<Seller, Accept>

<Buyer, Accept>

NA

D
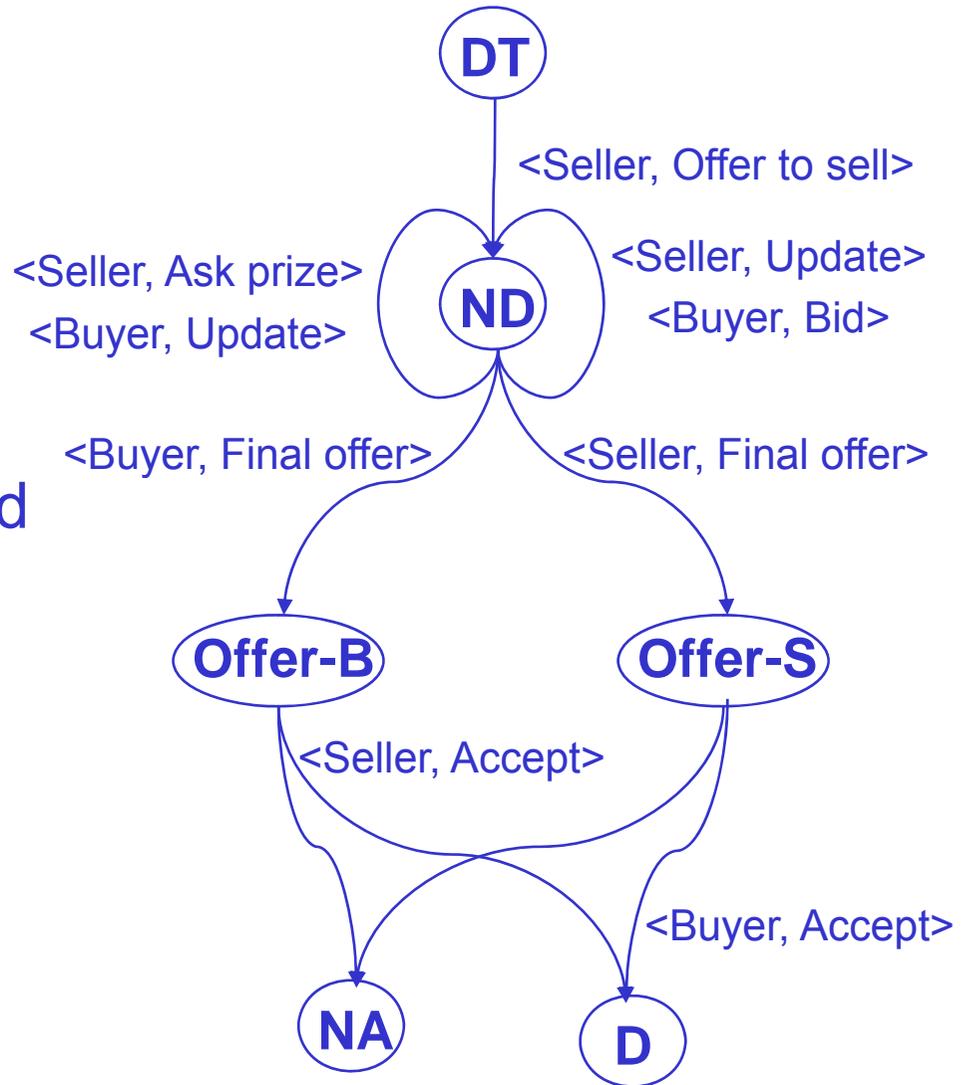
- ◆ **Participants**
  - ▪ Managers and contractors

- ◆ **Data**
  - ▪ Task description, bid, contract

- ◆ **Messages**
  - ▪ Sent by the managers to ask for bids or to assign contracts
  - • Sent by the contractors to submit bids

- • **Process flow**
  - ▪ Describes how the state of the negotiation changes as a result of messages

- ◆ Allocation can be managed centrally or in a distributed fashion

- ◆ Centralized allocation approaches are used in static and hierarchical structures

- ◆ Distributed allocation allows each agent to obtain a service individually

  - ▪ Maintaining information about the skills of known agents (acquaintance network)

  - ▪ Negotiating about the task execution with the other agent (contract net)

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- ◆ **Manager announces tasks via (possible selective) multicast**

- ◆ **Contractors evaluate the announcement and some of them submit bids**

- ◆ **Manager awards a contract to the most appropriate contractor**

Task recognition

TR

<Manager, Propose task>

Task

<Contractor, Bid>

<Manager, Award Contractor>

NA

C

Contract

Acquaintance Network Vs. Contract Net

	Acquaintance Network	Contract Net
Skills required for tasks	Identified	Not identified
Capabilities of other agents	Known	Unknown
Agent community	Closed	Open
Relationships	Colleagues	Business
Degree of trust	High	Unknown

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- ◆ Tasks can be redistributed for the benefit of all agents

- ◆ Task redistribution is usually based on an agent to agent negotiation whose result is a deal

- ◆ A deal can be of different types:

  - ▪ Conflict deal, if agents fail to reach an agreement

  - ▪ A deal that is not dominated by any other deal is pareto optimal

  - ▪ A deal is individual rational if it weakly dominates the conflict deal

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Utility for agent i

Pareto optimal

Individual rational

B

Utility of conflict
deal for agent i

A   C
E

Conflict deal   D

The circle
delimits the
space of all
possible deals

Utility for agent j

Utility of conflict
Deal for agent j