



Verteilte Künstliche Intelligenz – Koordination I

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Gliederung

■ Koordination I

- ☐ Kommunikation, Kooperation und Koordination
- ☐ Exemplarische Koordination
- ☐ Kontraktnetz
- ☐ Soziale Wahl (social choice, voting)
- ☐ Spieltheoretische Koordination (general equilibrium, bargaining)
- ☐ Auktionen



Agent Communication

- Message passing

- ☐ Semantical background: sender & receiver must be able to decode messages with the same semantical conclusions
- ☐ Choice of content language
- ☐ Elementary messages (commonly based on speech-act theory)
- ☐ Context sensitive rules for construction of dialogs
- ☐ Interpretation of messages in communities or groups of agents

- Interaction protocols

- ☐ Series of messages produces a dialog
- ☐ Protocols are predefined structures of communicative acts
- ☐ Examples: auctions, contract net



Interaktion und Koordination

■ Interaction

- ☐ Coordination
- ☐ Cooperation
- ☐ Communication

■ Structural Coordination (Organization)

- ☐ Market-based Organization
- ☐ Hierarchical Organization

■ Dynamic Coordination (Distributed Planning)

- ☐ Negotiation
- ☐ Team and Coalition Formation



Communication, Coordination and Cooperation

- Distributed problem solving
- Preserving “natural” structure

- Coordination

- Cooperation

- Planning
(Centralized, Distributed)
 - Incidental
(Redundancy, “Incomplete”)
 - Structural

- Competition

- Negotiation
 - Conflicting

Levels of Interaction*

- Independence
- Simple collaboration
- Obstruction
- Coordinated collaboration
- Pure individual competition
- Pure collective competition
- Individual conflict over resources
- Collective conflicts over resources



Classification of Interaction levels

Interaction level	Goals	Resources	Skills
Independence	✓	✓	✓
Simple Collaboration	✓	✓	
Obstruction	✓		✓
Coordinated Collaboration	✓		
Pure individual Competition		✓	✓
Pure Collective Competition		✓	
Individual Conflicts over resources			✓
Collective Conflicts over resources			

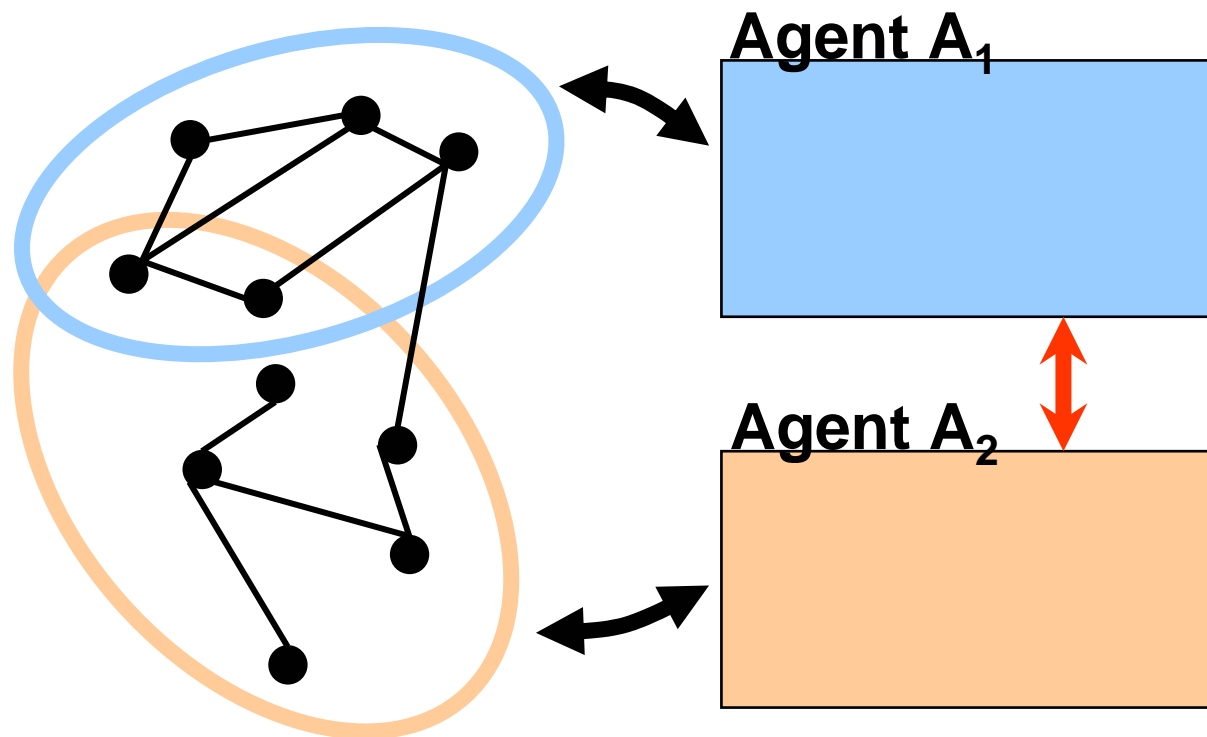


Coordination

**“Coordinating is the process of
managing
interdependencies between
activities”**

- Malone

Cooperation





Interaction Protocols

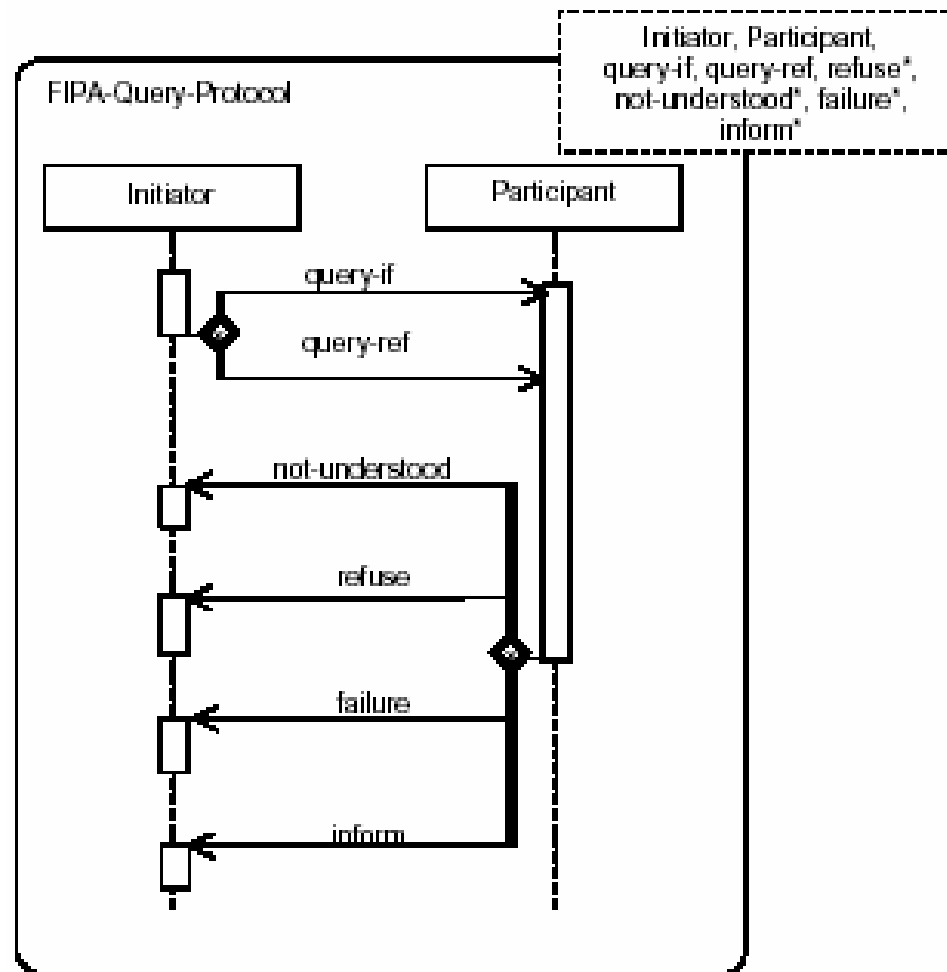
- Message exchange following predefined structures
- Protocol specifications are using AUML (protocol diagram, [Odell2000])
 - Role
 - Agent lifeline
 - Threads of interaction
 - Messages, complex message
 - Nested and interleaved protocols and complex nested protocols
 - Threads of interaction and messages inside and outside nested protocols
 - Parameterized protocols
 - Bound elements



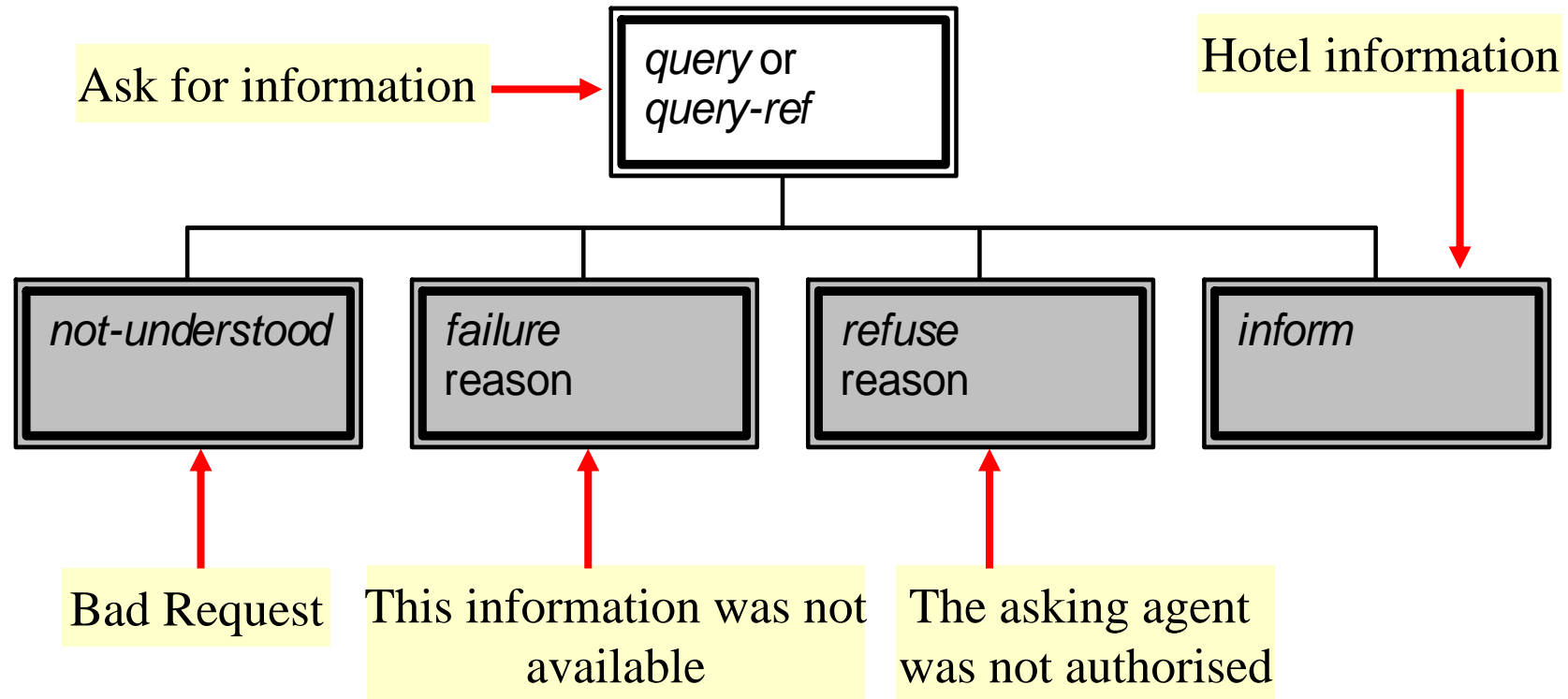
Interaction Protocols

Interaction Protocol name:	Doc. #	Mod. date	Status
FIPA Request	XC00026F	2002	Standard
FIPA Query	XC00027F	2002	Standard
FIPA Request With	XC00028F	2002	Standard
FIPA Contract Net	XC00029F	2002	Standard
FIPA Iterated Contract Net	XC00030F	2002	Standard
FIPA Action English	XC00031F	2002	Standard
FIPA Action Dutch	XC00032F	2002	Standard
FIPA Bidding	XC00033F	2002	Standard
FIPA Recruiting	XC00034F	2002	Standard
FIPA Subscribe	IP00111A	October 2000	Experimental
FIPA Propose	XC00036F	2002	Standard

Query Interaction Protocol

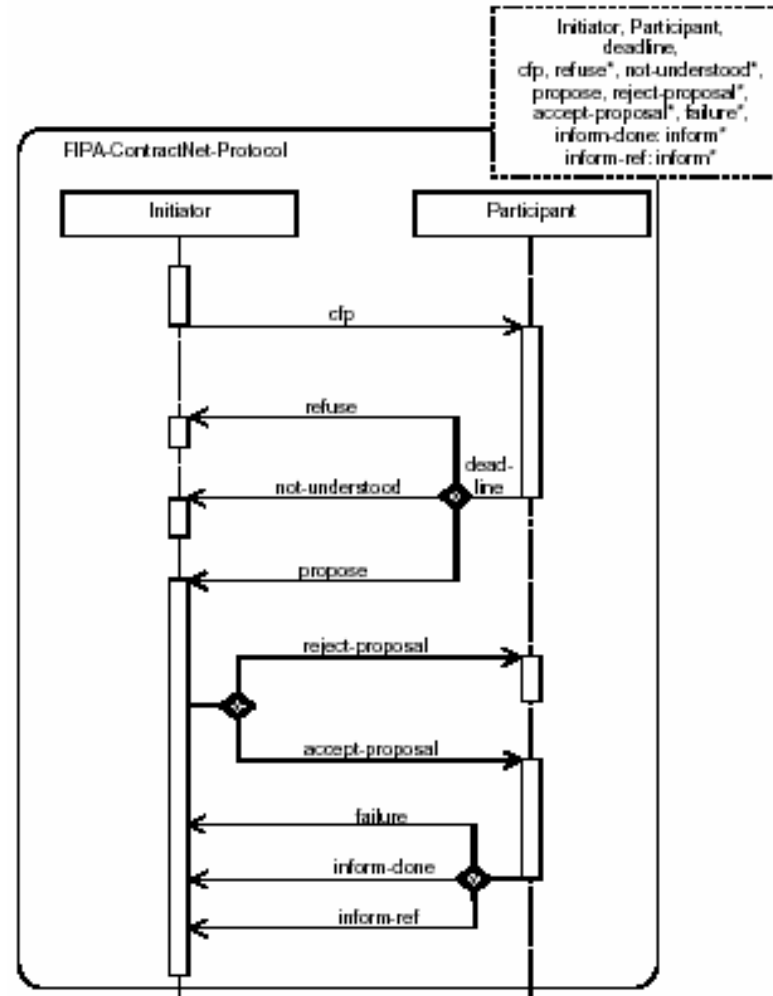


(INFO) Query Protocol

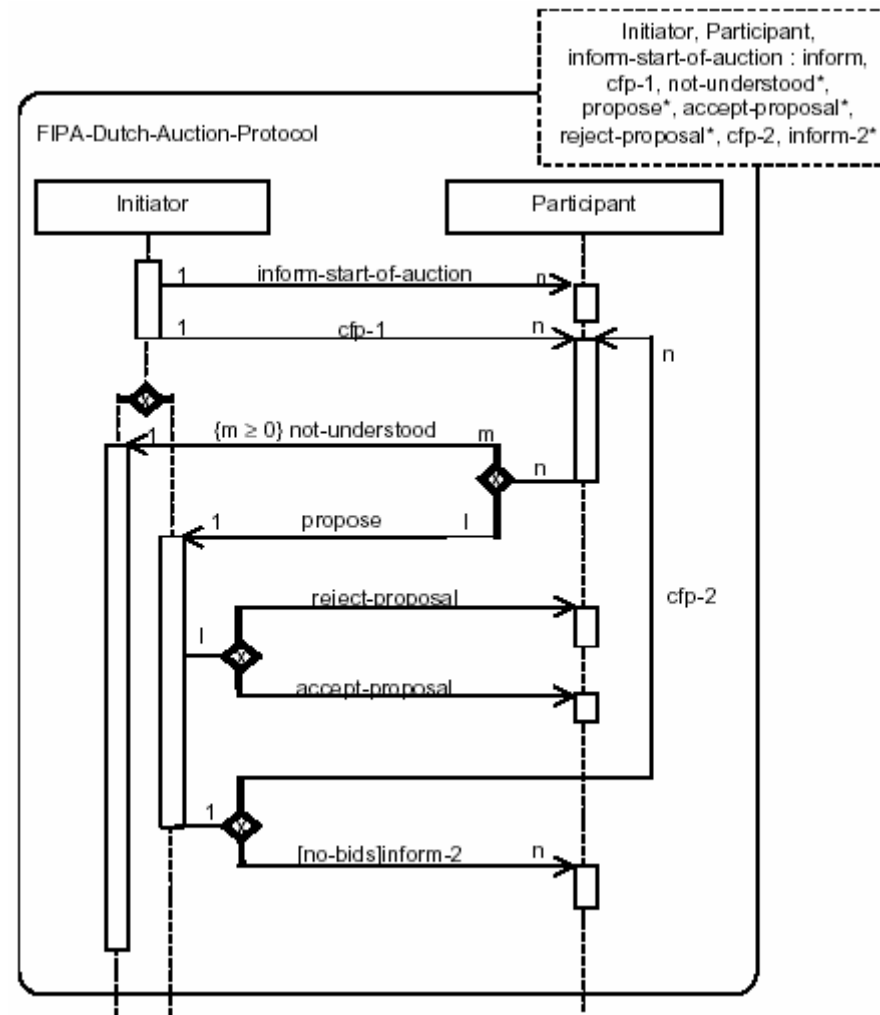


- Match the steps to hotel Information service

Contract Net Interaction Protocol

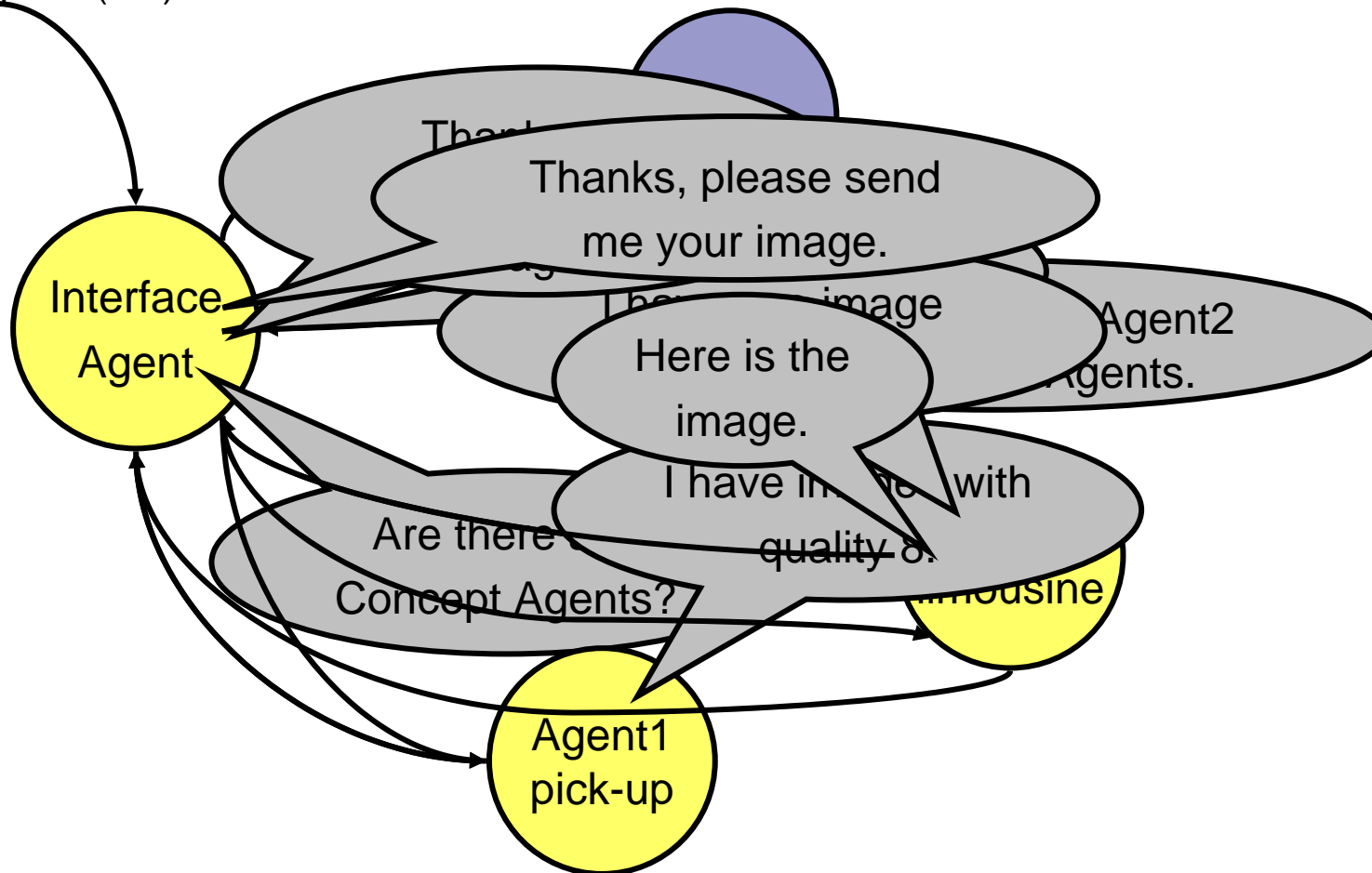


Dutch Auction Interaction Protocol

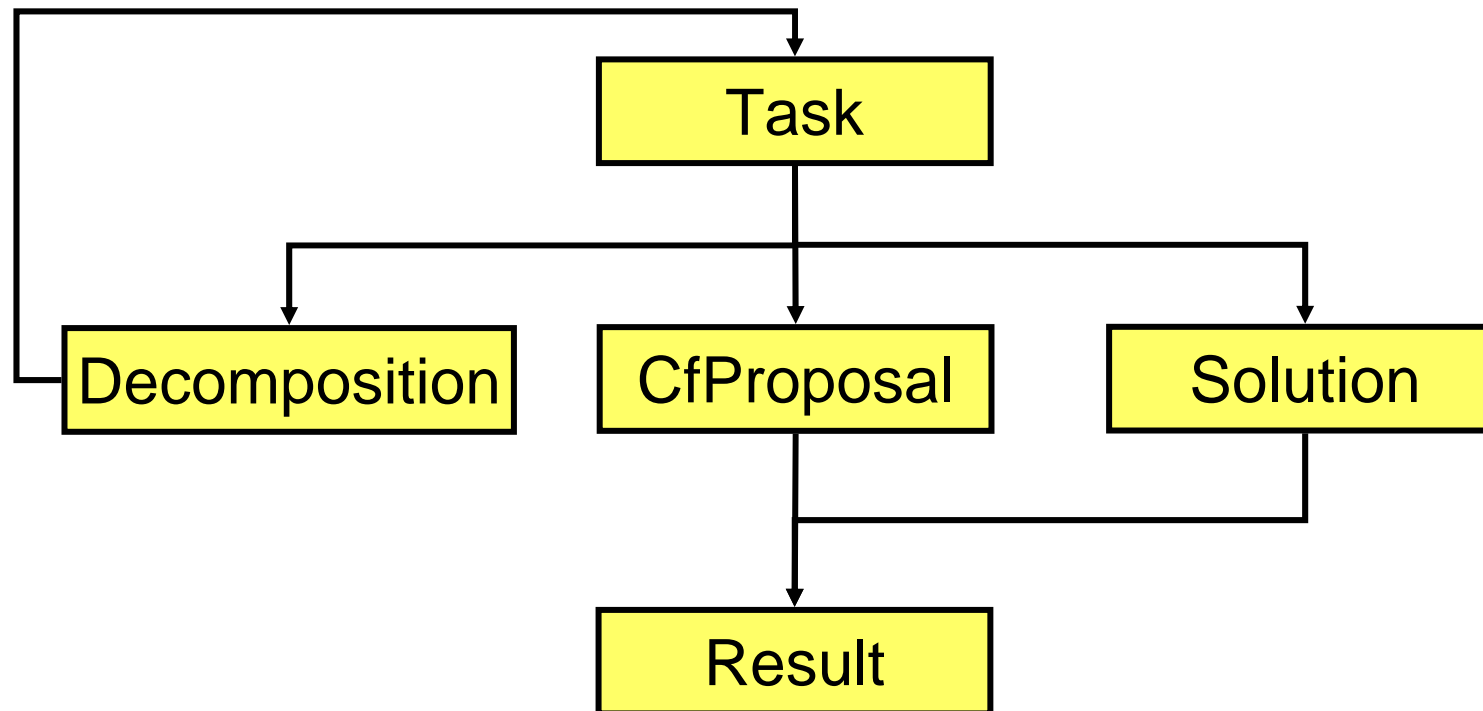


Distributed Image Retrieval

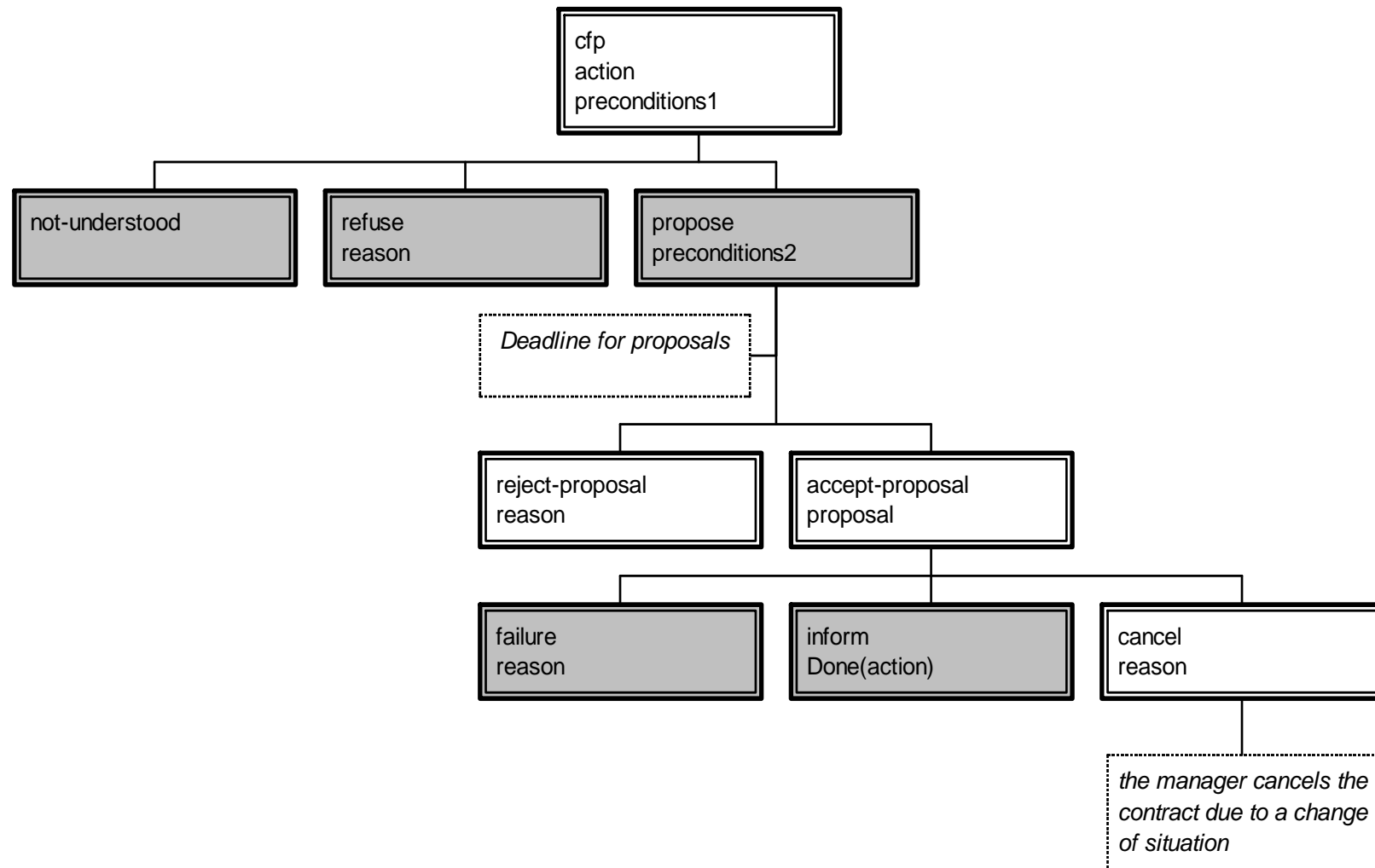
User Request (car)



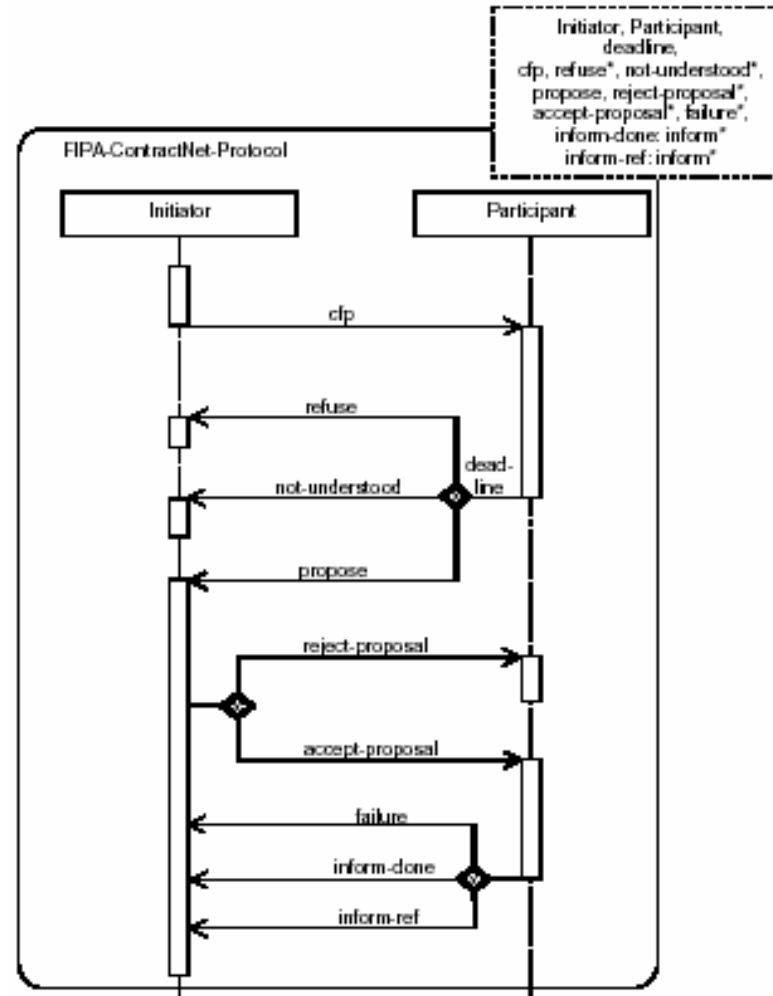
Task Decomposition by Contract Net



Example: Contract Net Protocol



Contract Net Interaction Protocol





Contract Net Protocol

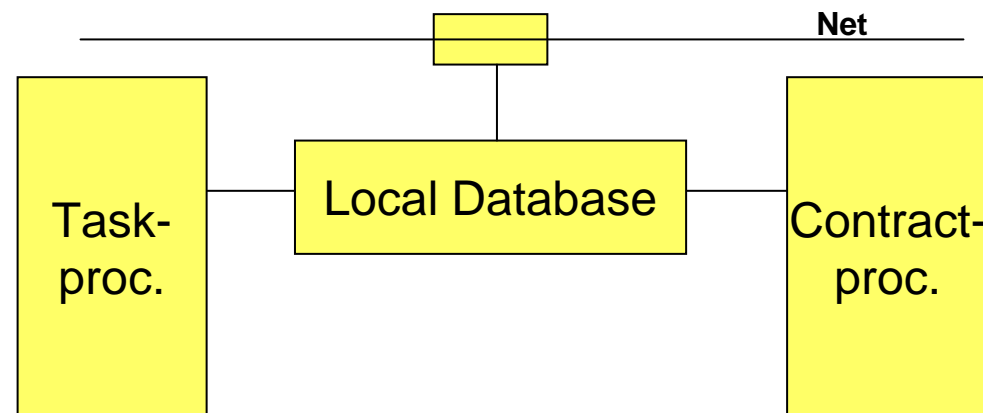
- ☐ Contractor: task announcement (broadcast)
- ☐ Contractee: task evaluation procedures
- ☐ Contractee: task bid (incl. competence description)
- ☐ Contractor: bid evaluation procedure
- ☐ Contractor: task award
- ☐ Contractee: contract establish

Contract Nets

Design of equilibrium market mechanisms uses one single centralized mediator

■ Task Allocation Negotiation

- ☐ Contractor and Contractee Roles
- ☐ Individual Rationality: an agent is better with the contract net than without it.
- ☐ Comparable to hill-climbing (hill=social welfare)

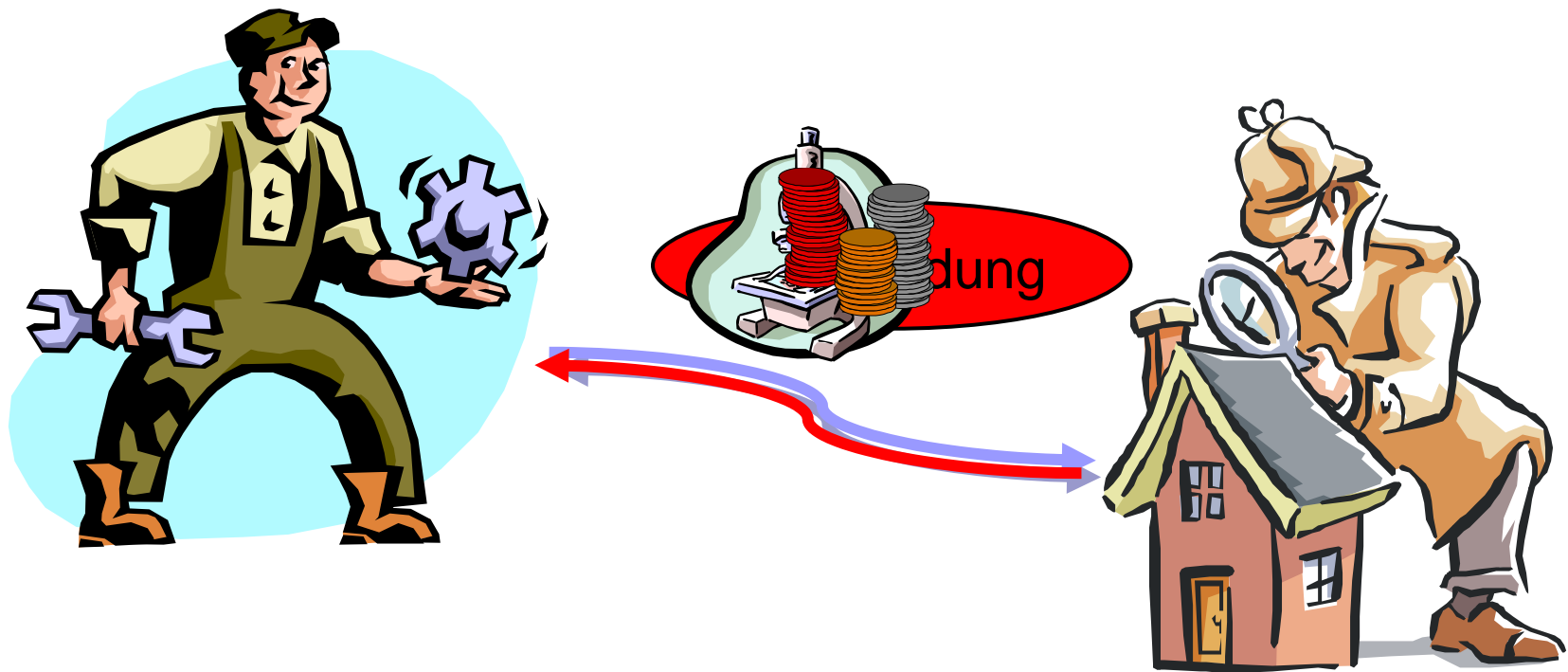




Bevor wir mit Auktionen beginnen ...

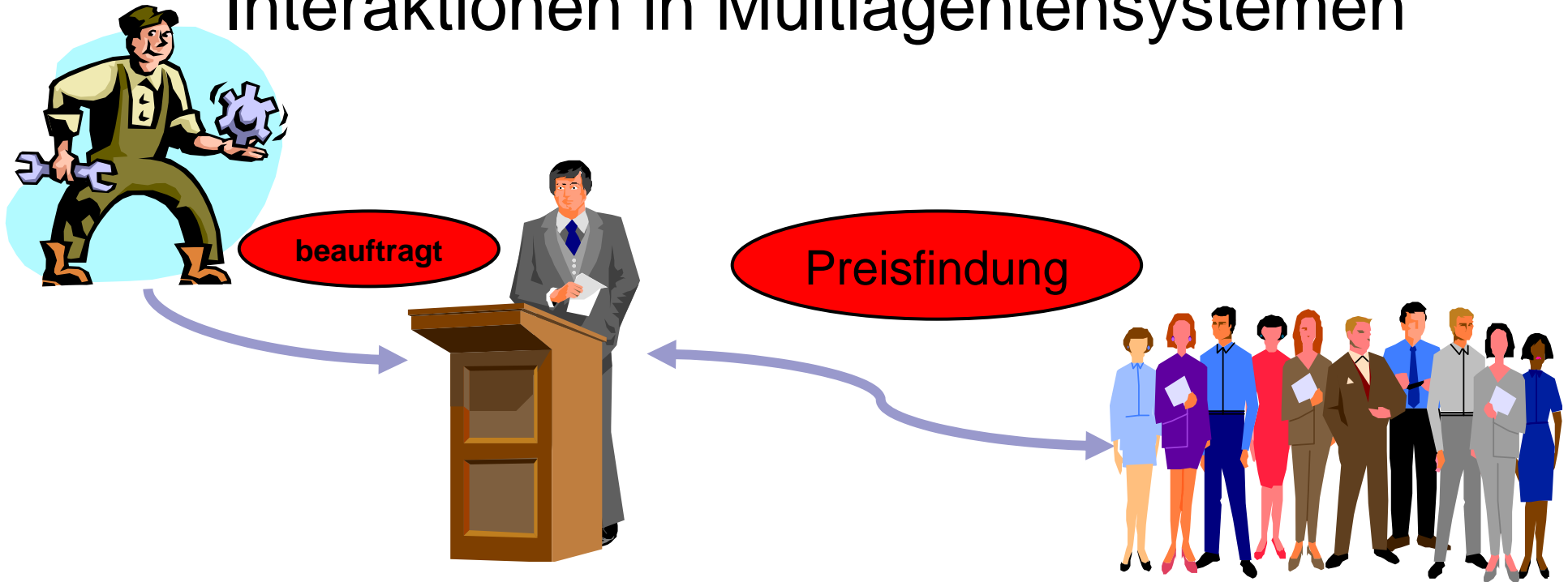
- Beispiel: Cash & Carry Contract
 - ☐ Kunde will Produkt erwerben
 - ☐ Anbieter will Geld vermehren
 - ☐ Warenfluß wird nicht betrachtet
 - ☐ *Woher kommt der Preis?*
- Interaktion in elektronischen Marktplätzen & Multiagentensystemen
- Koordination von Anbieter und Nachfrager (Wahl, Feilschen, Auktion)
- Auktionen und Auktionsprotokolle
- Betrachtung der Optimalität von Auktionsprotokollen

Interaktionen in Multiagentensystemen



Direkte Interaktion

Interaktionen in Multiagentensystemen



Mediierte Interaktion



Koordination von Anbieter und Nachfrager

- Voting
- Bargaining
- General Equilibrium Market Mechanisms
- Auctions



Voting - *social choice*

- All agents give input and accept the output as a solution
- Truthful Voters
 - Conditions (6, summarized)
 - Preference relation which: is defined for all $o \in O$ and every pair of $o, o' \in O$; and is asymmetric and transitive over O .
 - Outcome should be Pareto efficient, scheme should be independent of irrelevant alternatives and no agent should be a *dictator*
 - Arrow's impossibility theorem: no social choice rule satisfies all
 - Plurality protocol: majority, comparing all alternatives simultaneously
 - Binary protocol: pairwise voting (order has influence on outcome!)
 - Borda protocol (alternative to binary): assigning alternative points whenever it is highest in some agent's preference list, summed across voters



Strategic (Insincere) Voters

■ Motivation

- Problem with truthful voters: all preferences are known
- Using insincerely declaring for gaining benefit
- Need of motivating an agent to reveal his preference

■ Revelation principle

- If some protocol implements social choice function in Nash equilibrium (insincere) then it is implementable in Nash equilibrium via a single step protocol with agents revealing their preferences
- Problem: computational limited agents → uncoordinated strategies

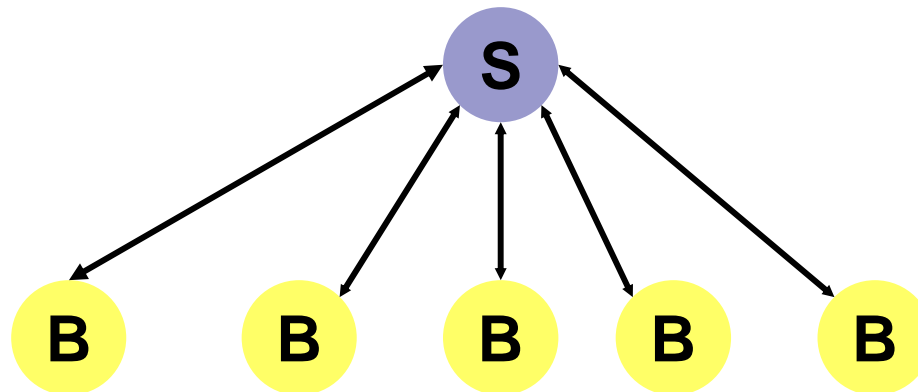
■ Gibbard-Satterthwaite Impossibility Theorem

- No rank of order for preference, one agent can be dictatorial
- Circumventing: behavior rules like no agent should care how others divide payoffs among themselves, agent's valuation should not depend on the amount of money that the agent will have. (Agents that do not end up changing the outcome do not pay any tax)
- other ways: ex ante selection of dictator (hat election)

Auctions

Auction Settings

- Private value (agent's value is independent from other agents)
- Common value (agent's value is only given by other agents' value)
- Correlated value (agent's value depends partly on its own preferences and partly on others' values)





Auction Protocols

- English auction (first-price open-cry)
 - ☐ each bidder is free to raise his bid
 - ☐ until no bidder is willing to raise
 - ☐ highest bidder wins the item at the price of his bid
- First-price sealed-bid auction
 - ☐ each bidder submits one bid
 - ☐ highest bidder wins the item at the price of his bid
- Dutch auction (descending)
 - ☐ seller continuously lowers the price
 - ☐ until one of the bidders takes the item at the current price
- Vickrey (second-price sealed-bid)
 - ☐ each bidder submits one bin
 - ☐ highest bidder wins the item at the price of the second highest bid



Ausblick auf die nächste Veranstaltung

■ Koordination II

- ☐ Koordinationsansätze (Bargaining, Voting, etc.)
- ☐ Grundlagen für die Evaluation von Kommunikationsprotokollen
- ☐ Spieltheorie im Überblick
- ☐ Evaluation
- ☐ Formale Betrachtung der Effizienz von Kommunikationsprotokollen