LECTURE 13: WORKING TOGETHER

An Introduction to Multiagent Systems

CIS 716.5, Spring 2005

Working Together

- Why and how to agents work together?

- Important to make a distinction between:

  - *benevolent agents* and
  - *self-interested agents*.

Benevolent Agents

- 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.

- Problem-solving in benevolent systems is *cooperative distributed problem solving* (CDPS).

- *Benevolence simplifies the system design task enormously!*
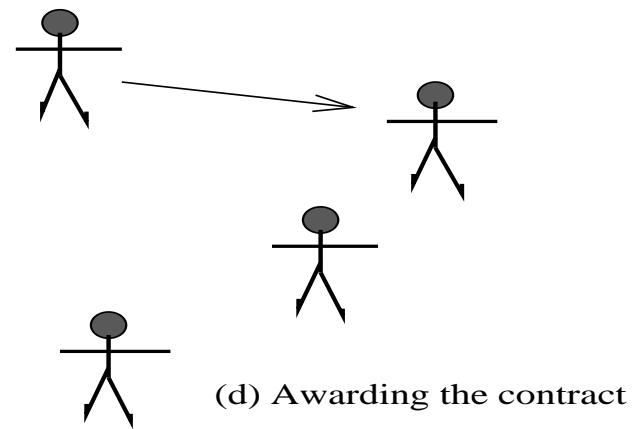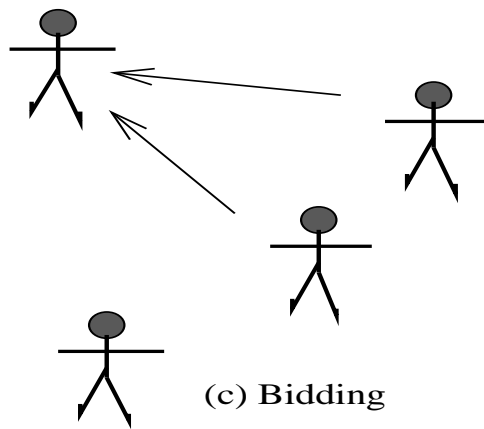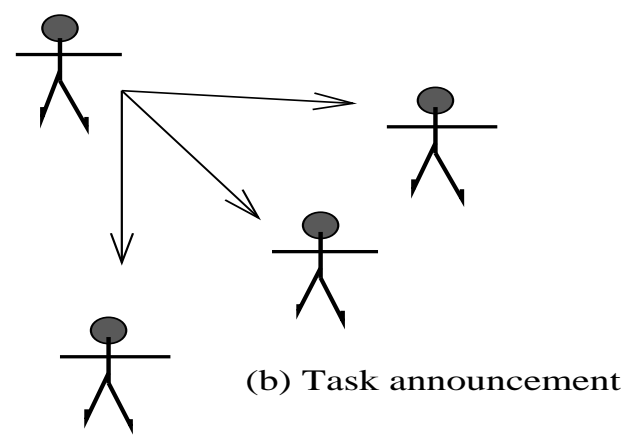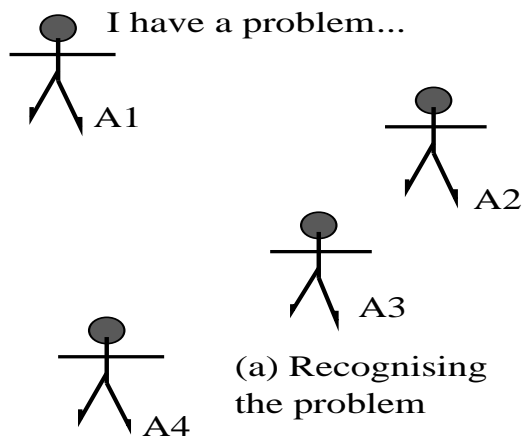
Self-Interested Agents

- If agents represent individuals or organisations, (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.

Task Sharing and Result Sharing

- Two main modes of cooperative problem solving:

  - *task sharing*:
    components of a task are distributed to component agents;
  - *result sharing*:
    information (partial results etc) is distributed.

The Contract Net

- Well known task-sharing protocol for *task allocation* is *contract net*:

  1. Recognition;

  2. Announcement;

  3. Bidding;

  4. Awarding;

  5. Expediting.

I have a problem...

A1

A2

A3

(a) Recognising
the problem

A4

(b) Task announcement

(c) Bidding

(d) Awarding the contract

Recognition

- In this stage, an agent recognises it has a problem it wants help with.

  Agent has a goal, and either...

  – realises it cannot achieve the goal in isolation — does not have capability;

  – realises it would prefer not to achieve the goal in isolation (typically because of solution quality, deadline, etc)

Announcement

- In this stage, the agent with the task sends out an *announcement* of the task which includes a *specification* of the task to be achieved.

- Specification must encode:

  – description of task itself (maybe executable);

  – any constraints (e.g., deadlines, quality constraints).

  – meta-task information (e.g., "bids must be submitted by. . .")

- The announcement is then *broadcast*.

Bidding

- Agents that receive the announcement decide for themselves whether they wish to *bid* for the task.

- Factors:

  - agent must decide whether it is capable of expediting task;
  - agent must determine quality constraints & price information (if relevant).

- If they do choose to bid, then they submit a *tender*.

Awarding & Expediting

- Agent that sent task announcement must choose between bids & decide who to "award the contract" to.

- The result of this process is communicated to agents that submitted a bid.

- The successful *contractor* then expedites the task.

- May involve generating further manager-contractor relationships: *sub-contracting*.

The Contract Net via FIPA Performatives

- `cfp` (*call for proposals*):

  Used for *announcing* a task;

- `propose, refuse`:

  Used for making a proposal, or declining to make a proposal.

- `accept, reject`:

  Used to indicate acceptance or rejection of a proposal.

- `inform, failure`:

  Used to indicate completion of a task (with the result) or failure to do so.
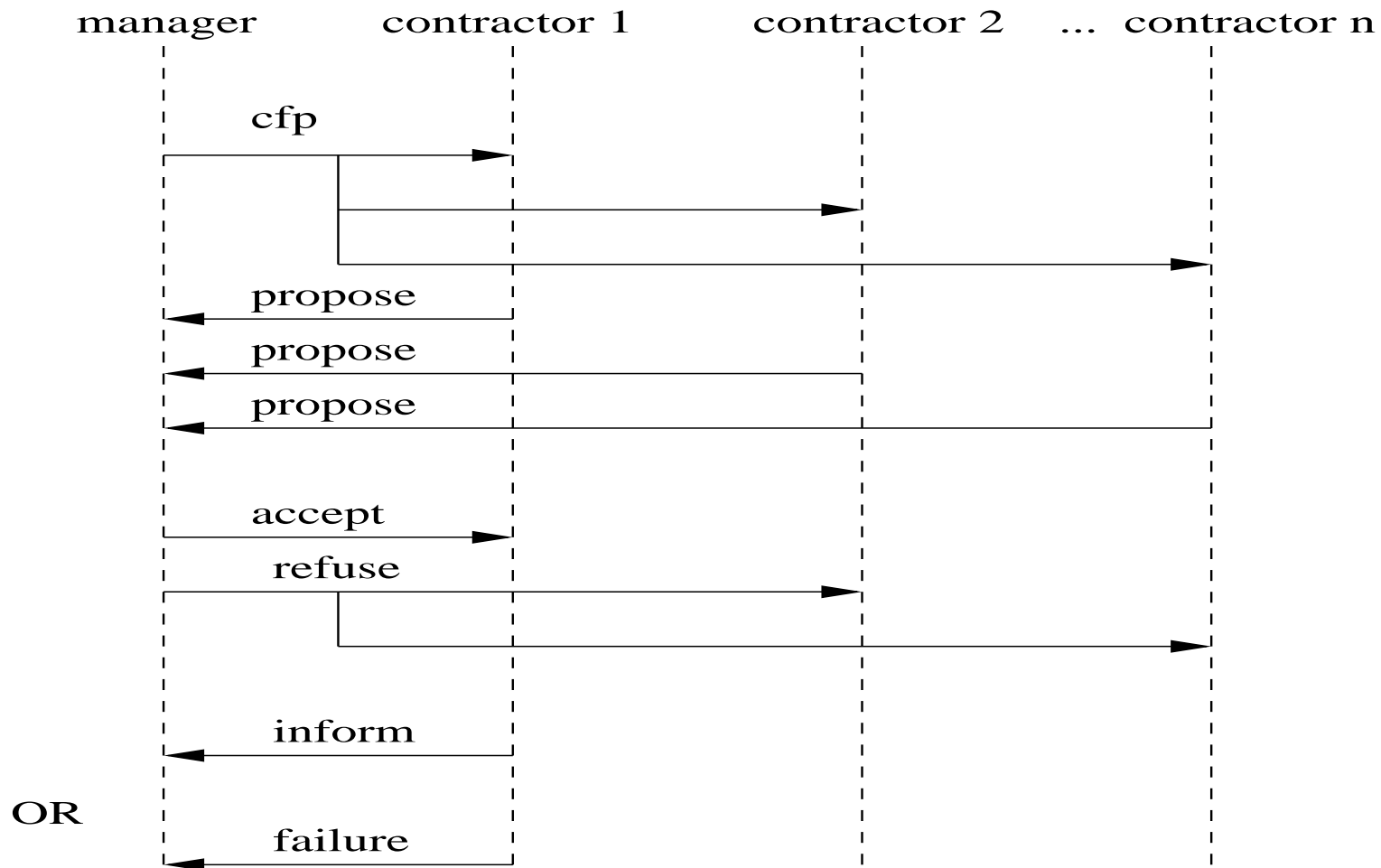
Issues for Implementing Contract Net

- How to...

  - ... specify *tasks*?

  - ... specify *quality of service*?

  - ... select between competing offers?

  - ... differentiate between offers based on multiple criteria?

Result Sharing in Blackboard Systems

- The first scheme for cooperative problem solving: the *blackboard system*.

- Results shared via shared data structure (BB).

- Multiple agents (KSs/KAs) can read and write to BB.

- Agents write partial solutions to BB.

- BB may be structured into hierarchy.

- Mutual exclusion over BB required $\Rightarrow$ bottleneck.

- Not concurrent activity.

- Compare: LINDA tuple spaces, JAVASPACES.

Result Sharing in Subscribe/Notify Pattern

- Common design pattern in OO systems: *subscribe/notify*.

- An object *subscribes* to another object, saying "tell me when event e happens".

- When event e happens, original object is notified.

- Information pro-actively *shared* between objects.

- Objects required to know about the *interests* of other objects $\Rightarrow$ inform objects when relevant information arises.

Summary

- This lecture has discussed how to get agents working together to do things.

- In particular it has concentrated on the *contract net*, a protocol for task distribution.

- The contract net is simple, robust and widely used.

- (It is basically a first-price sealed bid auction).

- There are more powerful protocols than the contract net.