New Slides

Coordinated Problem Solving
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Distributed Computing vs. Distributed AI Viewpoints
- Distributed Computing
  - Tightly coupled, parallelization, centralized control
  - [Distributed OS] Independent processes
    - Resource coordination: centralized locking, load balancing
  - Total database consistency
- Distributed AI
  - Loose coupling, distributed control
  - Interdependent processes (data coordination)
  - “Functionally Accurate” (often inconsistent)

Coordinating Computational Actions
- Abstraction
  - Goals
  - Plans
  - Schedules
- Location
  - Centralized
  - Decentralized
- Learning
  - Static
  - Dynamic
- Structure
  - Implicit
  - Explicit

Coordination and Planning
- Plan Merging Analyses
  - Given complete plans, look for cross plan threats (dropping or abstracting away independent parts)
- Plan Combination Search [Ephrat & Rosenschein]
  - Refine set of all possible local plans by working through a global state space one step at a time
- Hierarchical Behavior-space Search [Durfee & Montgomery]
  - Work out joint plan at highest level of detail, resolve conflicts at next more specific level

Partial Global Planning [Durfee]
- Assume that tasks are interrelated, but not known a priori
- Develop a local abstract plan in terms of goal sequences
- Communicate to other agents (using meta-level organization)
- Identify partial global goals between abstract plans
- Create new, partial global plans from local plans and send them back to the appropriate agents

GPGP: The Idea
- Have A wait and see (poll)
- Have A ask B
  - “If”
  - “When”
- Have B tell A
  - B sends result when available
  - B commits to a deadline by which it will send the result
- Etc.
Some Coordination Mechanisms for Enablement

- Avoidance (with/without quality sacrifice);
- Reservation schemes;
- Simple predecessor-side commitments (to do in future time point, do by deadline, do after EST);
- Simple successor-side commitments;
- Polling approaches (busy querying, timetabling, constant headway);
- Shifting task dependencies by learning or mobile code (promotion/demotion shift);
- More complex multi-stage negotiation strategies;

Other Coordination Mechanisms

- Redundant tasks (more than one agent under an OR node)
  - Avoidance
  - Load balancing
- Soft Facilitation
  - Predecessor commitment
- Mutual Exclusive Resources
  - Simple bidding

Minimizing non-local information

Example: Coordination by Reservation

Agent A’s View

Agent B’s View

Objective Task Group

Agent A

Agent B

Agent B’s View

Agent A’s View

Example: Coordination by Reservation

Agent A

Agent B

Implementation

- Assume agent has local scheduling capability
- Attempt to maximize utility (self, shared, whatever) by future action sequence
- Problem is non-local effects make schedule more uncertain or simply unknown (I can’t start my task until Agent B does Task B)
- Other assumptions needed for full range of mechanisms
- Some way to do “what-if” schedule reasoning
- Ability to make commitments to do, don’t, and do w.r.t earliest start times and deadlines
- Ability to move code for action promotion/demotion

1. Where can you finish TaskB? [GPGP Reservation CM Protocol]
2. Commit TaskB finish at time t1, quality 34, cost 6.
3. Agreed
4. Here is TaskB’s result.
Coordination Module

Coordination Module takes advantage of the local scheduler’s scheduling ability to evaluate/estimate the features of actions for the remote agents.

DECAF Architecture

Summary: Coordination

- Process of managing the interdependencies between activities
  - Choice of actions
  - Ordering of actions
  - Timing of actions
- Difficulties occur because of uncertainties
  - Incomplete view (partly inaccessible state)
  - Dynamic situation
  - Action outcome nondeterminism

Summary: Coordination Mechanisms

- Explicitly negotiated commitments, schedules, plans
- Explicit or implicit laws, rules, behavioral norms
- Long-term, generalized versions of the above
  - organizations, roles, standard operating procedures

Summary: Mechanism design space

- Abstraction
  - Goals
  - Plans
  - Schedules
- Location
  - Centralized
  - Decentralized
- Learning
  - Static
  - Dynamic
- Structure
  - Implicit
  - Explicit
Summary: (Mostly) Implicit Approaches

- Social Conventions
  - Standardization
  - Slack
  - Rules/Social Laws
  - Forecasting
  - Benevolence
- Agent Modeling
  - Game Theory
  - RMM
  - Markets
  - Observation

- Organizations
  - Authority/hierarchy
  - Standard Operating Procedures (Business Processes)
  - Specialization
  - Professionalization
  - Informal channels
  - Vertical Integration
  - Structured Communities
  - Teams

Summary: (Mostly) Explicit Approaches

- Commitments
  - Distributed goal search
  - Types of commitments
    - Concept
    - Related constraints
  - Joint Commitment
  - Conventions

- Planning
  - Controlled
  - Plan merging
  - Plan Synchronization

- Scheduling (continuum w/ planning)
  - Partial Global Planning
  - Other Distributed Scheduling Approaches

Summary

- Coordination: locally choosing and temporally ordering actions
- TÆMS: representing coordination problems
- GPGP: mechanisms for dealing with coordination problems
- DECAF: agent building toolkit
  [http://www.cis.udel.edu/~decaf]
- Information gathering applications in finance & bioinformatics
  [http://udgenome.ags.udel.edu/]

http://www.cis.udel.edu/~decker