Recent Complexity Results for Reachability Properties in Distributed Negotiation

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Background Review I

- Given a resource allocation setting
  RAS=<*A*,*R*,*U*>
  we are interested in negotiating an allocation of *R* among *A* when every deal - <*P*,*Q*> - is required to satisfy some condition $\Phi(P,Q)$.
- For example,
  $\Phi(P,Q)$ $\Leftrightarrow$
  (<*P*,*Q*> reallocates exactly one resource *and* is 'rational')
  describes rational *O*-contracts.

Background Review II

- 3 decision problems:

a. Φ-path(RAS,$P^{(s)}$,$P^{(t)}$)
   Can the allocation $P^{(t)}$ be reached by a sequence of Φ-deals from $P^{(s)}$?

b. Φ-accessible (RAS,P)
   Can an *optimal* allocation be reached by a sequence of Φ-deals from P?

c. Φ-convergence(RAS)
   Does *every maximal* sequence of Φ-deals end in an optimal allocation?

Rational O-contracts – earlier results

Problem	Utility Form	Complexity
Φ-path	SLP	NP-hard
Φ-path	k-additive	Open
Φ-accessible	SLP	NP-hard
Φ-accessible	k-additive	NP-hard
Φ-converge	SLP	Open
Φ-converge	k-additive	Open

Development

- At TFG-MARA in Ljubljana (Feb.-March, 2005), Jerome Lang conjectured Φ-path and Φ-accessible were PSPACE-complete (noting structural similarities with STRIPS planning and problems on CP-nets).
- Yann Chevaleyre introduced the problem Φ-convergence, conjecturing this to be coNP-hard (in both SLP and k-additive forms).

Rational O-contracts – new results

Problem	Utility Form	Complexity
(a) Φ-path	SLP	PSPACE-complete
Φ-path	k-additive	Open
(b) Φ-access	SLP	PSPACE-complete
Φ-access	k-additive	NP-hard
(c) Φ-conv	SLP	coNP-complete
(d) Φ-conv	k-additive	coNP-complete

Brief Summary of Proof Methods

- Proof of (a) is non-trivial, and has three main parts:

1. Simulation of PSPACE Turing machines by SLP.
2. Simulation of SLP from (1) by rational O-contracts in RAS *with allocative externalities*.
3. Translation of RAS from (2) into “standard” (externality free) setting.

- (1) and (3) ‘relatively easy’; bulk of argument concerns simulation required in (2).

Detailed proofs can be found in the report,

Paul E. Dunne and Yann Chevaleyre.

Negotiation can be as hard as planning: Deciding reachability properties of distributed negotiation schemes.

Tech. Report, ULCS-05-009, Dept. of Comp. Sci., Univ. of Liverpool.

http://www.csc.liv.ac.uk/research/techreports/tr2005/ulcs-05-009.pdf