Agility Through Adaptive Autonomy

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Agility Through Adaptive Autonomy
Dynamic coordination in networked organizations

Introduction and context
Adaptive autonomy in multi-agent organizations
Agile coordination using adaptive autonomy
Application scenarios
Further work and conclusions

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Introduction

• This work is about decision making in artificial agent communities
  • decision making models for artificial agents
  • focus on autonomy and coordination mechanisms

• is academic, but relevant for research into NEC organizations
  • stresses importance of the topics of autonomy and coordination
  • opportunities to deploy agents in NEC structures
  • executable models for distributed coordination in NEC structures
Agility, autonomy and coordination

- **Agile**  
  
  - *a:* marked by ready ability to move with quick easy grace  
  - *b:* having a quick resourceful and adaptable character

- **Resilient**  
  
  - *a:* capable of withstanding shock without permanent deformation or rupture  
  - *b:* tending to recover from or adjust easily to misfortune or change
Agility, autonomy and coordination

• An agile and resilient organization must be able to cope with:
  • .. changing situations and environments
  • .. changing organizational structures

• .. and respond with:
  • .. alternate solutions (plans, goals)
  • .. alternate ways of working (coordination)
  • .. or both ..

• In NEC environments, many parties, many constraints and limited options for centralized command.
  → How to achieve agile, dynamic coordination?
  → How to make sure that individual autonomy is respected?
Agility, autonomy and coordination

• Usual approach to coordination challenges (top-down):
  • Achieve coordination of activities by designing rules for all parties involved
  • Agile coordination follows from pre-designed rules
  • Predictable behaviour, but may lead to problems in unforeseen situations, and leaves little room for autonomy

• Alternative approach (bottom-up):
  • Agile coordination follows from interaction between agents
  • Make the agent reason about its own objectives and role in the organization, and collaborate to reach objectives
  • Agile and adaptive, but may

→ challenge: find an approach that accommodates both options
Agent Autonomy

- Autonomy: to have control over internal state and behaviour

(Bradshaw, 2003)
Autonomy and agent reasoning

• Autonomy is about how much you let external events influence your decision making.

• Influence Control:
  • Operationalize concept of autonomy
  • Component preceding decision making
  • Gives the agent control of its autonomy
Influence Control

• Rule-based reasoning rules
• Rules represent the attitude of the agent towards the environment and towards other agents

• **Format: Head <-- Guard | Body**

message(X, Info) <-- trusted(X) | accept(Info)
message(X, Info) <-- NOT trusted(X) | reject(Info)
message(X, Info) <-- relevant(X) | accept(Info)
observation(X) <-- busy() | ignore(X)
Influence control

- Meta-knowledge for influence control
  - heuristics for relevant types of knowledge
  - what information is relevant for the agent and its objectives?

<table>
<thead>
<tr>
<th>Type of knowledge</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self knowledge</td>
<td>Is this information relevant for my objectives?</td>
</tr>
<tr>
<td></td>
<td>Does my state of mind permit new requests?</td>
</tr>
<tr>
<td>Organizational/Social knowledge</td>
<td>Relation to information source</td>
</tr>
<tr>
<td></td>
<td>Can the source be trusted?</td>
</tr>
<tr>
<td>Environmental knowledge</td>
<td>Availability of communication</td>
</tr>
<tr>
<td></td>
<td>Availability of information sources</td>
</tr>
</tbody>
</table>

- Heuristics result in adaptive autonomy for the agent
- The agent will only allow influences that are relevant from an agents’ own perspective
• Instruct agents to map **organizational rules** to their event processing rules
• The 'interface' between organizations and agent are **contracts**, that specify behavioural rules.
• Contracts contain organizational knowledge and **norms**
• Agent interpret contracts and translate them to **event-processing rules**
• Event-processing rules affect **agent reasoning** and **decision making**
Translation

• Translate organizational rules to event-processing rules

<table>
<thead>
<tr>
<th>Result of norm</th>
<th>Effect on mental state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obliged (action)</td>
<td>AddGoal (action)</td>
</tr>
<tr>
<td>Permitted (action)</td>
<td>AddBelief (permitted(action))</td>
</tr>
<tr>
<td>Forbidden (action)</td>
<td>AddBelief (forbidden(action))</td>
</tr>
</tbody>
</table>

• Agent **attitude** results from event-handling

<table>
<thead>
<tr>
<th>Event</th>
<th>Effect</th>
<th>Basic Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>Update Beliefs</td>
<td>Self-reliant</td>
</tr>
<tr>
<td></td>
<td>Ignore Event</td>
<td>Non-self-reliant</td>
</tr>
<tr>
<td>Inform message</td>
<td>Update Beliefs</td>
<td>Trusting</td>
</tr>
<tr>
<td></td>
<td>Ignore Event</td>
<td>Non-trusting</td>
</tr>
<tr>
<td>Request message</td>
<td>Add Goal</td>
<td>Cooperative</td>
</tr>
<tr>
<td></td>
<td>Ignore Event</td>
<td>Non-cooperative</td>
</tr>
</tbody>
</table>
Prior knowledge about the organization

- An agent joining an organization needs prior knowledge:
  - deontic aspects: obligation, permission, prohibition
  - relational aspects

- Relational aspects can be represented in event-processing rules
  - e.g. hierarchical relation:

```prolog
request(Sender, Task) <- supervisor(Sender) | AddGoal(Task)
```
Translation examples

• “Whenever engage-request from coordinator then actor is obliged to do accept-request”

\[
\text{message(coordinator, request, engage(contact) ) <-- TRUE | AddGoal( engage(contact) )}
\]

• “Whenever status-change then actor is obliged to do inform-coordinator-about-status”

\[
\text{observation( status-change ) <-- TRUE | AddGoal( send( coordinator, inform, new-status) )}
\]
Benefits

• Modular approach
  • Easy to change the organizational layout or behavior
  • Decision making is minimally restricted by prior knowledge
  • Options for prioritization and individual preferences via meta-knowledge

• Separation of organizational reasoning and decision making allows for agile and resilient responses to events
  • Agents ‘adapt’ to new organizational structures via meta-reasoning
  • Coordination follows from interaction within dynamic organizations
Application example – agents as proxies
Application example

• Let the agents act as *proxies* for participating groups in the NEC mission force
  • Instruct agents by giving them their *local policies* in the form of influence control rules (event-processing rules)
  • When agile behaviour is needed, *update local policies*
  • Let the agents *collaborate* to solve the coordination puzzle

• Results in:
  • Dynamic coordination
  • Respect for individual policies
  • Facilitate the coordination process in a distributed environment
From centralized to decentralized command

- Commander issues a new local policy to fleet members
- Fleet members adopt new heuristics to determine what contacts are relevant
- Fleet members now have the permission to act autonomously
Scaling up

- Commander offers a social contract to the new member
- New member enters interaction agreements with other members
- Existing members adopt new member in their mental state
Reorganization

- Contact with commander is lost
- Norms specify that in case of a broken command line, actors may adopt a self-serving attitude
- Fleet members take on a novel attitude (self-serving)
- Fleet members enter into a negotiation to decide on a new command structure
Conclusion

- Research into the role of autonomy in agent reasoning
- Model that allows artificial agents to control their autonomy
- Method for agents to adopt organizational rules
- Modular and extensible approach to describing organizational rules and policies

- Relevance for NEC purposes
  - Inspirational – use as a way to think about autonomy
  - Model – use as a way to represent local policies and organizations
  - Application – use as a blueprint to solve coordination challenges

- Current application areas
  - Human – machine organizations (‘augmented teams’)
  - Adaptive support agents for tactical decision makers
  - Collaborative decision making model in NEC simulations
More information

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Bob van der Vecht
‘Adjustable Autonomy - Controling Influences on Decision Making’
Thesis available via the Utrecht University Library, or via:
  bob.vandervecht@tno.nl

Thank you for your attention!