Agility Through Adaptive Autonomy

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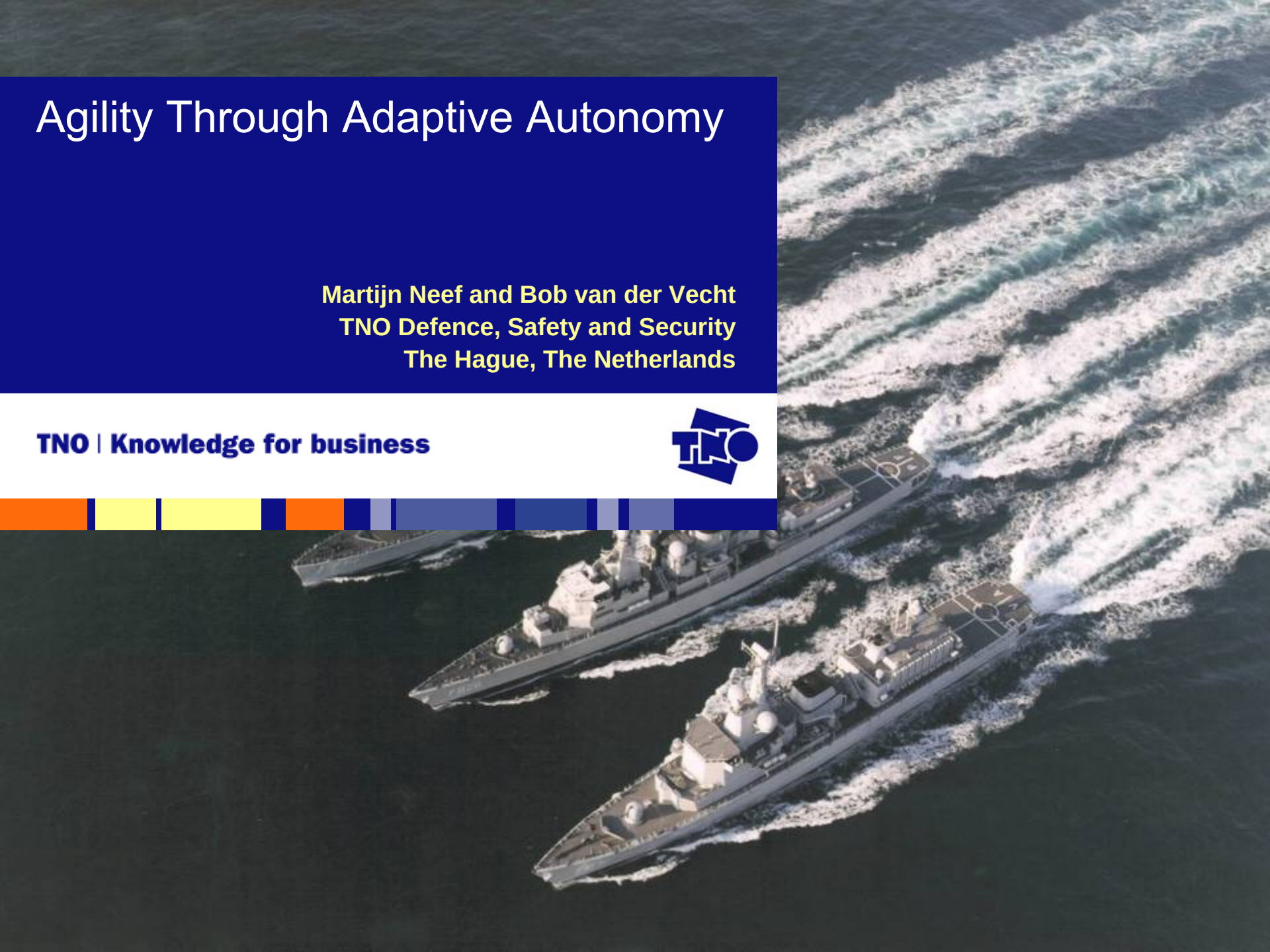

Agilty Through Adaptive Autonomy
Dynamic coordination in networked organizations

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

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-jəl, -jī(-ə)l\
  - *a : marked by ready ability to move with quick easy grace*
  - *b : having a quick resourceful and adaptable character*

- *Resilient* \ri-zil-yən(t)\
  - *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

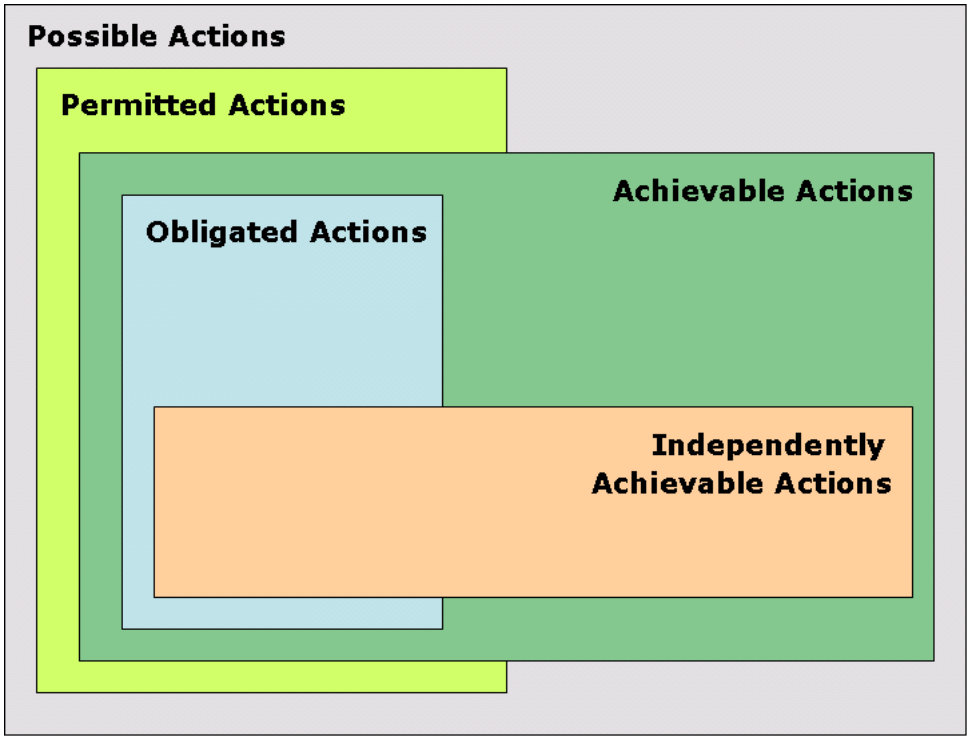
- Usual approach to coordination challenges (**top-down**):
  - Achieve coordination of activities by designing rules for all parties involved
  - Agile coordination follows from pre-designed rules
  - Predictable behaviour, but may lead to problems in unforeseen situations, and leaves little room for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

Agent Autonomy

- Autonomy: to have control over internal state and behaviour

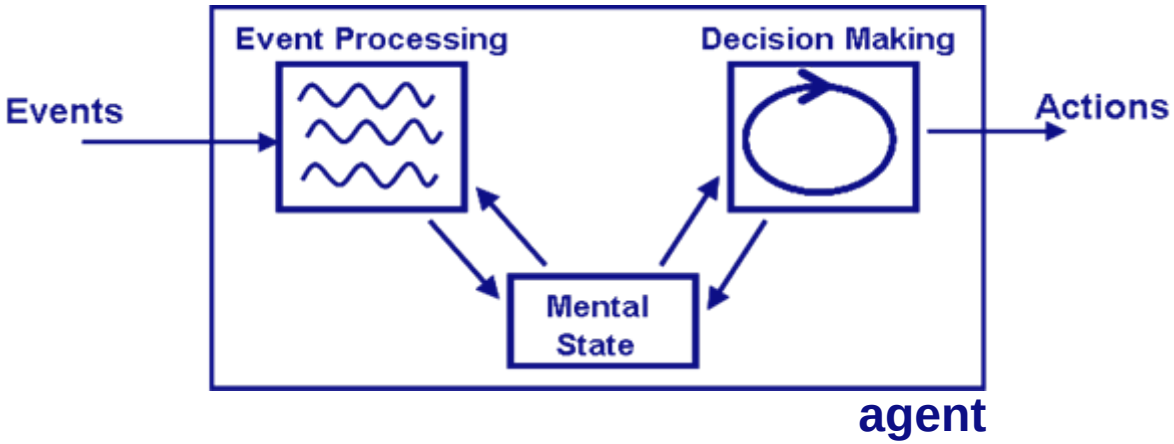


(Bradshaw, 2003)

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**

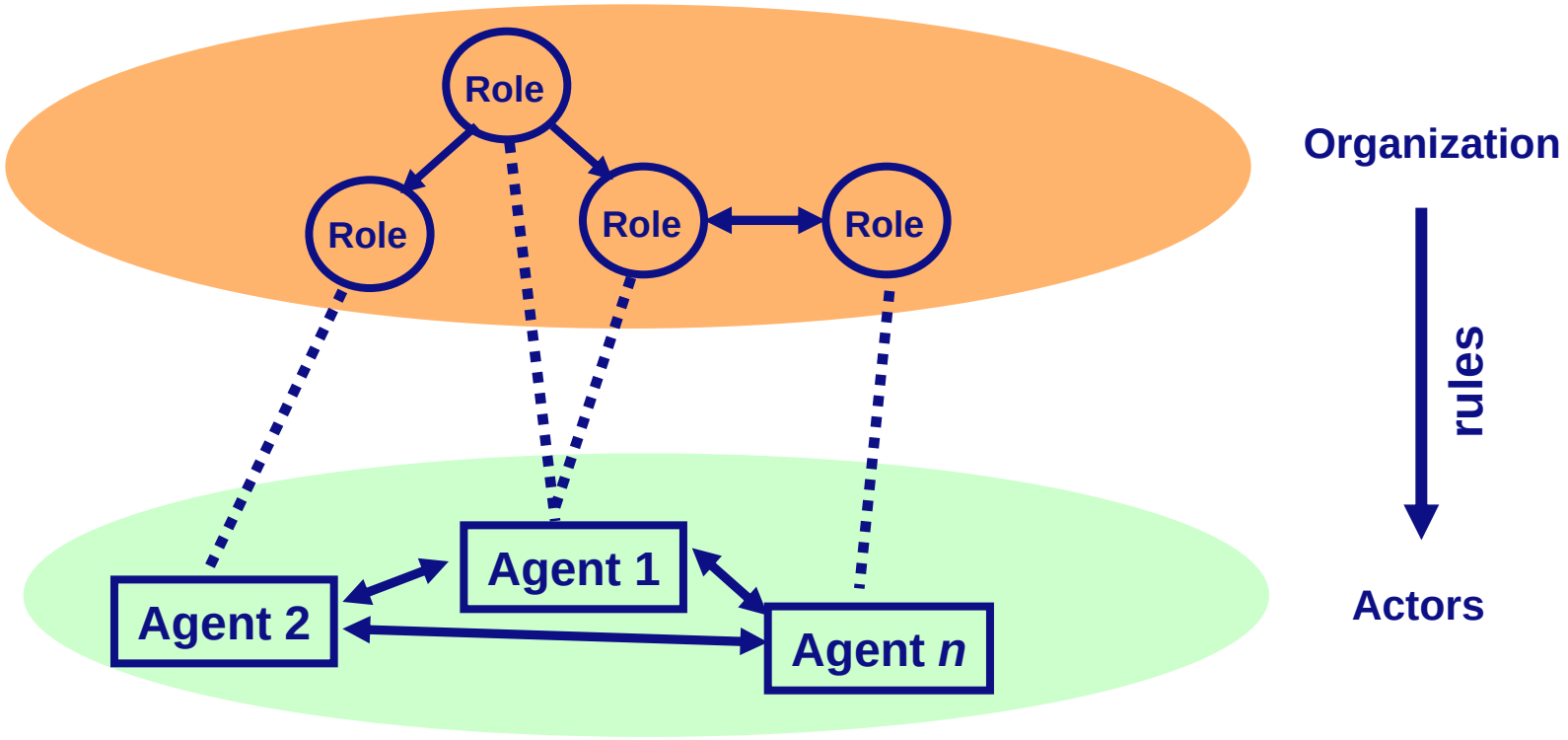
```
message(X,Info) <-- trusted(X) | accept(Info)
message(X,Info) <-- NOT trusted(X) | reject(Info)
message(X,Info) <-- relevant(X) | accept(Info)
observation(X) <-- busy() | ignore(X)
```

Influence control

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

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

- 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 knownledge 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

Result of norm	**Effect on mental state**
Obliged (action)	AddGoal (action)
Permitted (action)	AddBelief (permitted(action))
Forbidden (action)	AddBelief (forbidden(action))

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

Event	Effect	Basic Attitude
Observation	Update Beliefs Ignore Event	Self-reliant Non-self-reliant
Inform message	Update Beliefs Ignore Event	Trusting Non-trusting
Request message	Add Goal Ignore Event	Cooperative Non-cooperative

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:

request(Sender, Task) <- supervisor(Sender) |
AddGoal(Task)

Translation examples

- "Whenever engage-request from coordinator then actor is obliged to do accept-request"

message(coordinator, request, engage(contact)) <-- TRUE |
AddGoal(engage(contact))

- "Whenever status-change then actor is obliged to do inform-coordinator-about-status"

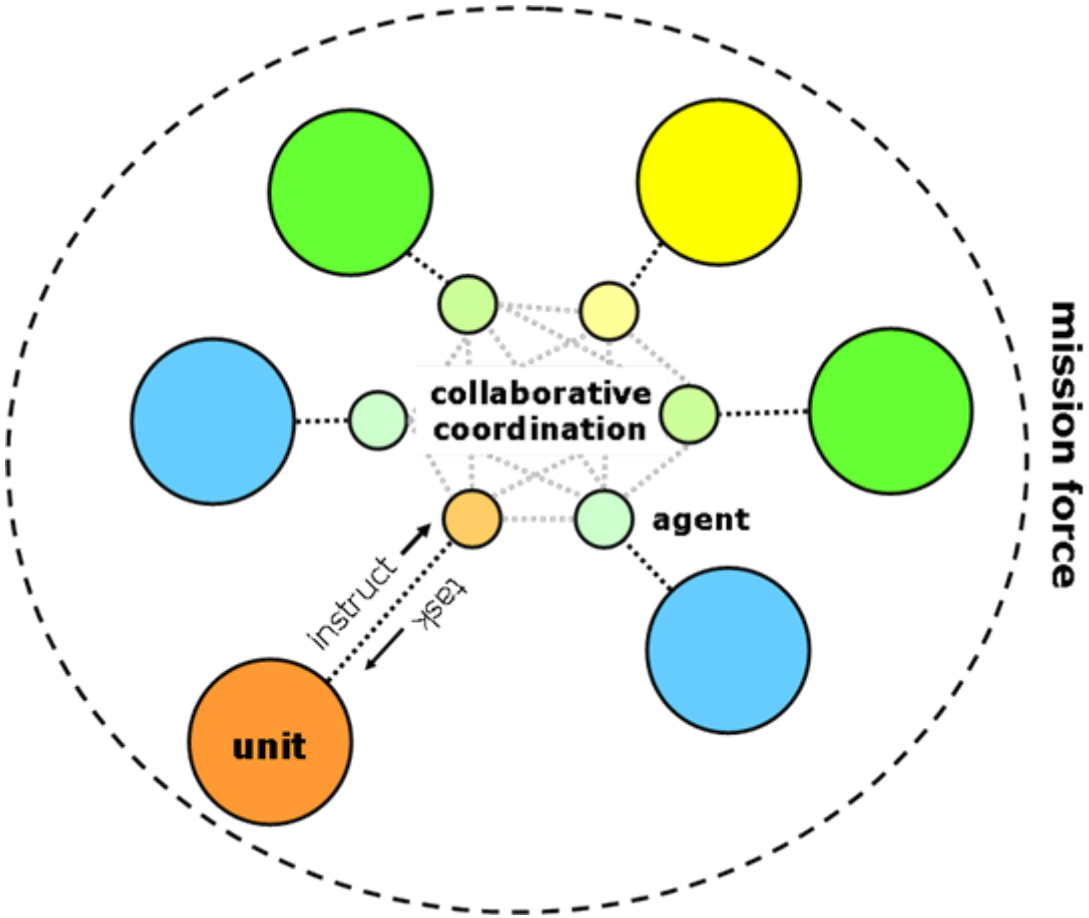
observation(status-change) <-- TRUE |
AddGoal(send(coordinator, inform, new-status))

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

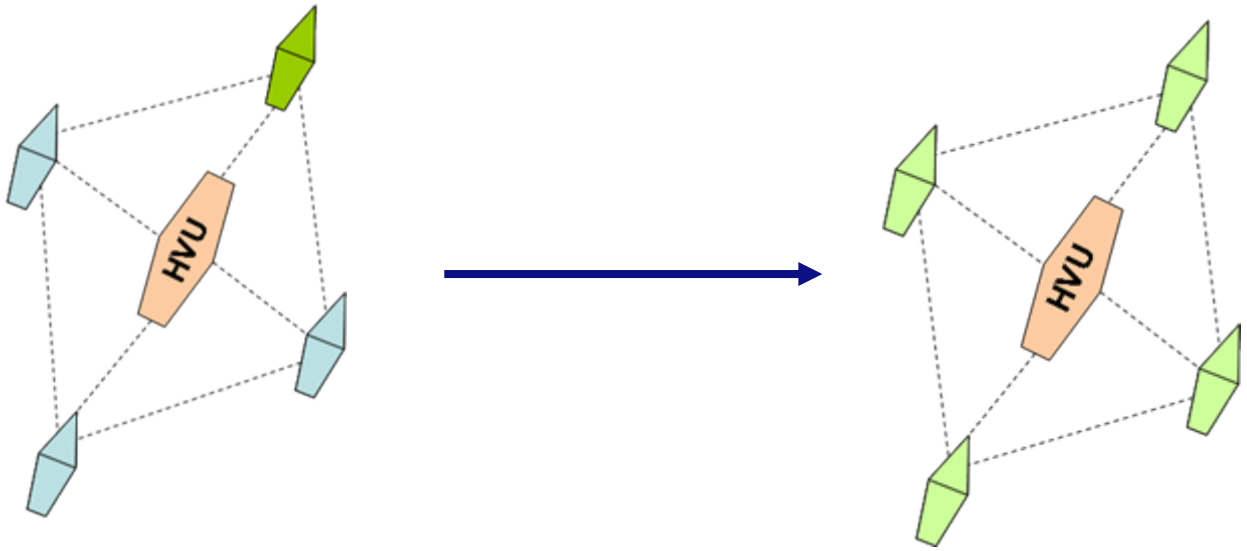


Application example

- 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

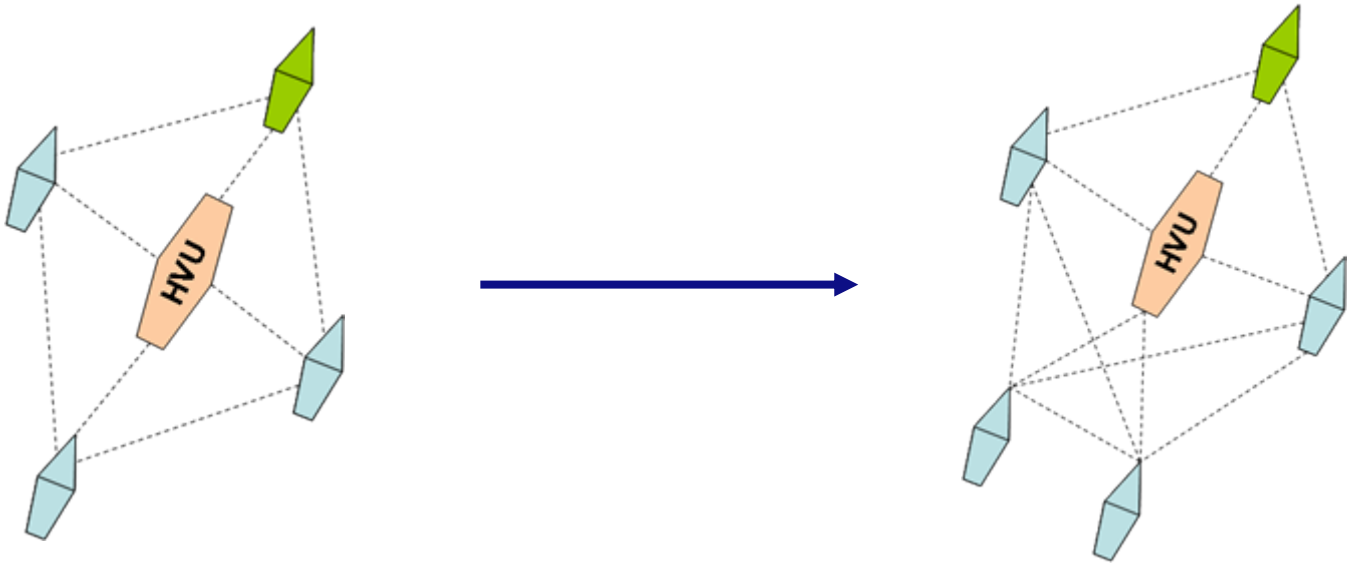
- Results in:
  - Dynamic coordination
  - Respect for individual policies
  - Facilitate the coordination process in a distributed environment

From centralized to decentralized command



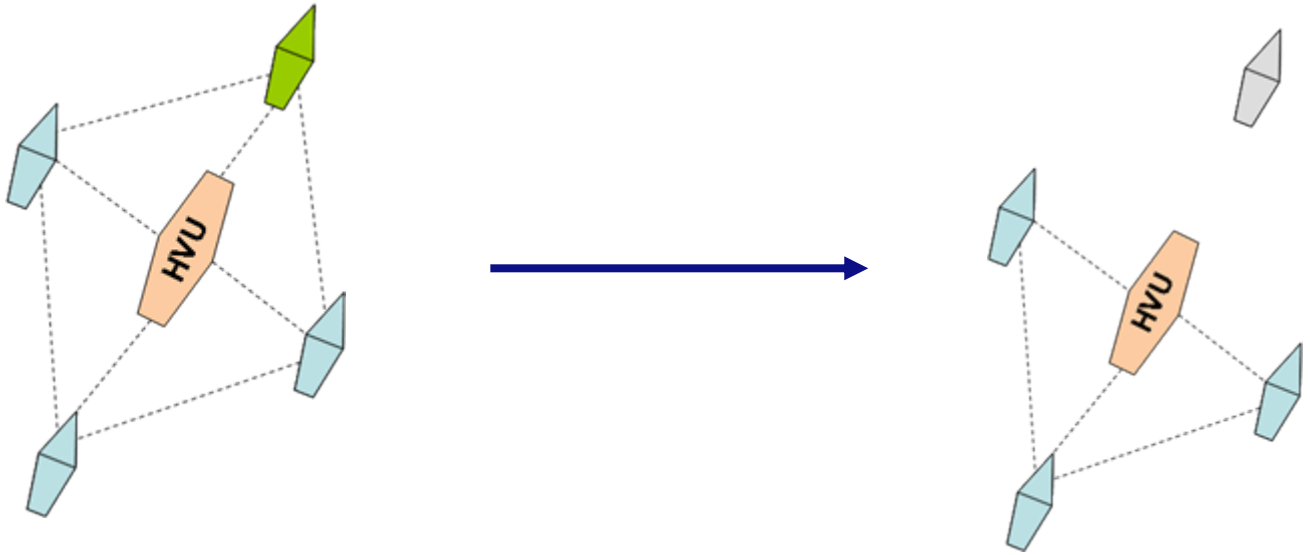
- Commander issues a new local policy to fleet members
- Fleet members adopt new heuristics to determine what contacts are relevant
- Fleet members now have the permission to act autonomously

Scaling up



- Commander offers an 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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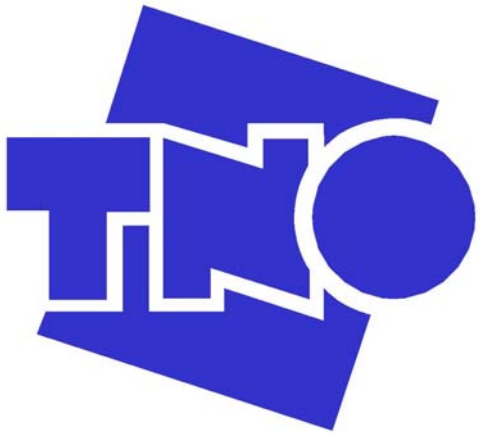

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PhD Thesis Bob van der Vecht (defence: 6 July 2009)
‘Adjustable Autonomy - Controling Influences on Decision Making’
Thesis available via the Utrecht University Library, or via:
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Thank you for your attention!