The Ecological Domain of Warfare

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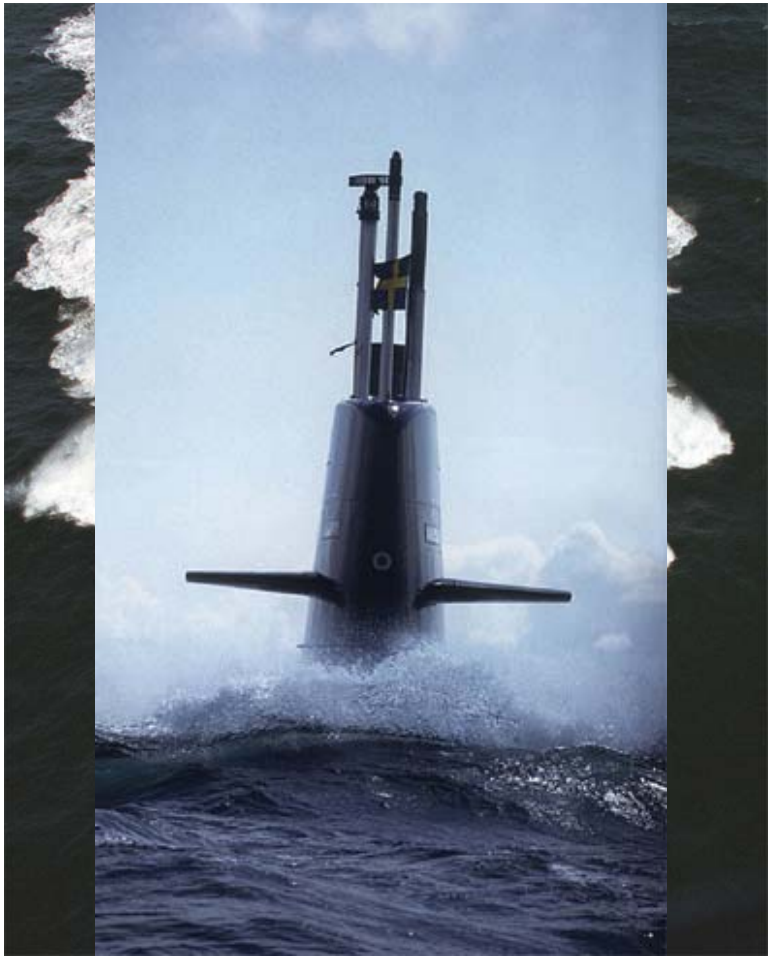
Introduction

- Kockums AB (HDW-group)
  - Surface ships and submarines
  - Stealth and light-weight naval technologies
  - Network enabled capabilities
- The Societies of Computation research group and laboratory (SOCLAB) at Blekinge Institute of Technology (BTH)
- Mergning naval domain knowledge with e.g., multi-agent, software and knowledge engineering.



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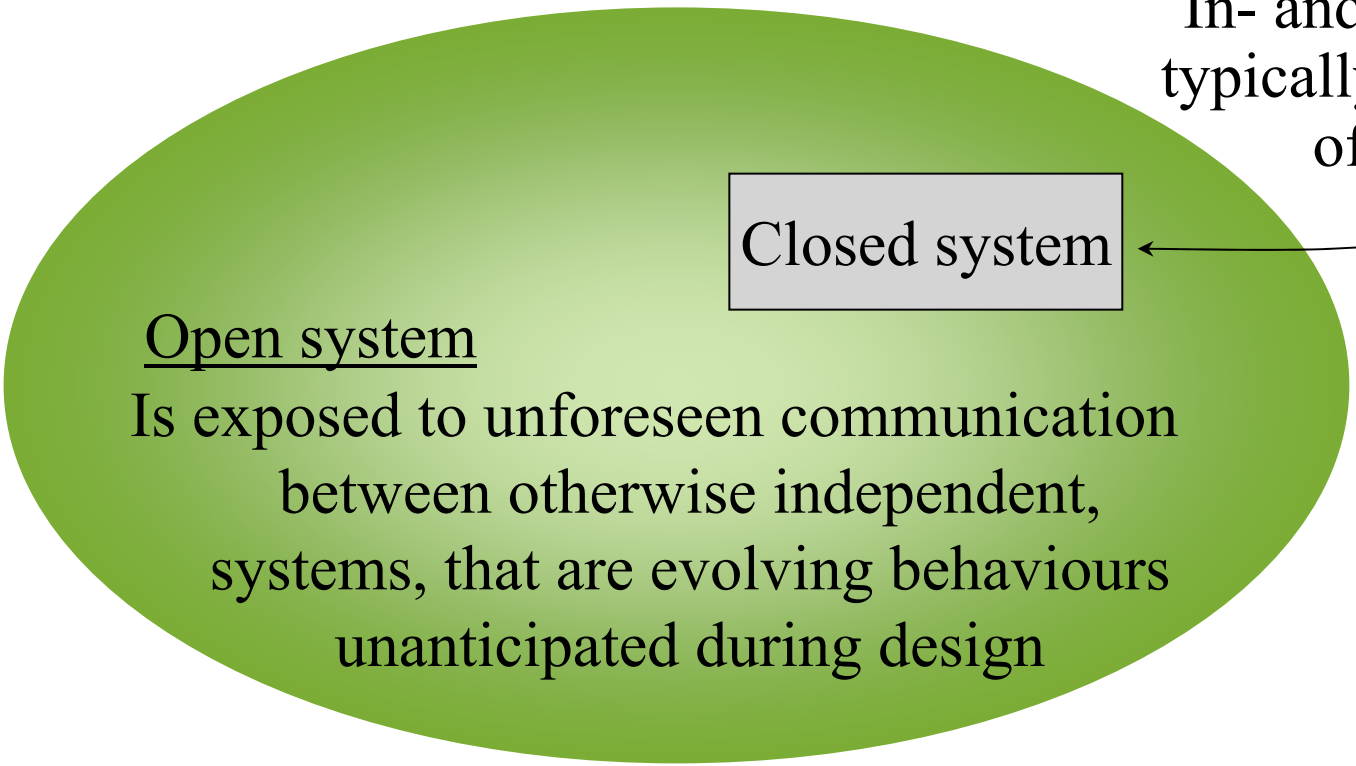
This paper

- Suggest systems with network enabled capabilities are open and have inherent ecological properties
- Introduce the architecture for open computational systems (OCS, there is also a methodology)
- Present demonstrator-based indications of capabilities
- Compare the OCS-model to the domains of warfare
- Investigate the compliance of OCS to some requirements on networks and the GIG.

Closed and open systems



Ad hoc interaction and network establishment is needed

Domains of warfare

[Alberts et al (2001), Alberts & Hayes (2003)]

The Ecological domain

The Social domain:
Rules for interactions between and among force entities

The Cognitive domain:
Perceptions, awareness, beliefs, and values; decisions are made

The Information domain:
Information is created, manipulated and shared

The Physical domain:
Strike, protect and manoeuvre; different environments

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The case for the Ecological domain

1. Open systems are evolving with the real environment in which physical actions (e.g., missions) take place
2. Such actions are consequences of behaviours guided by rules of interaction. Such rules are defined in the social domain
3. Emergent behaviours manifest as changes in capabilities of some system(s) with respect to changes in other systems and the environment: Evolution

=> The Ecological domain relates the evolutionary properties of some systems to the resulting effects on other systems and the physical world

Open computational systems (OCS)

Open systems are evolving over time

- the system(s) is continuously up and running
- the operating circumstances are not known in advance

Computation and cognition are merging

- there may be a significant amount of computers and software in the loop, enabling unmanned autonomy
- cognitive agents can be either men or machines

=> Connectivity and bandwith are technical issues.
Capabilities are provided by control.

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OCS model/architeecture

Domain	The words (symbols) used for adressing a common task.
System	The minds and code (services) needed for creating behaviour.
Fabric	The hardware needed for computation and communication.
Environment	Everything in the real world: platforms, geography etc.

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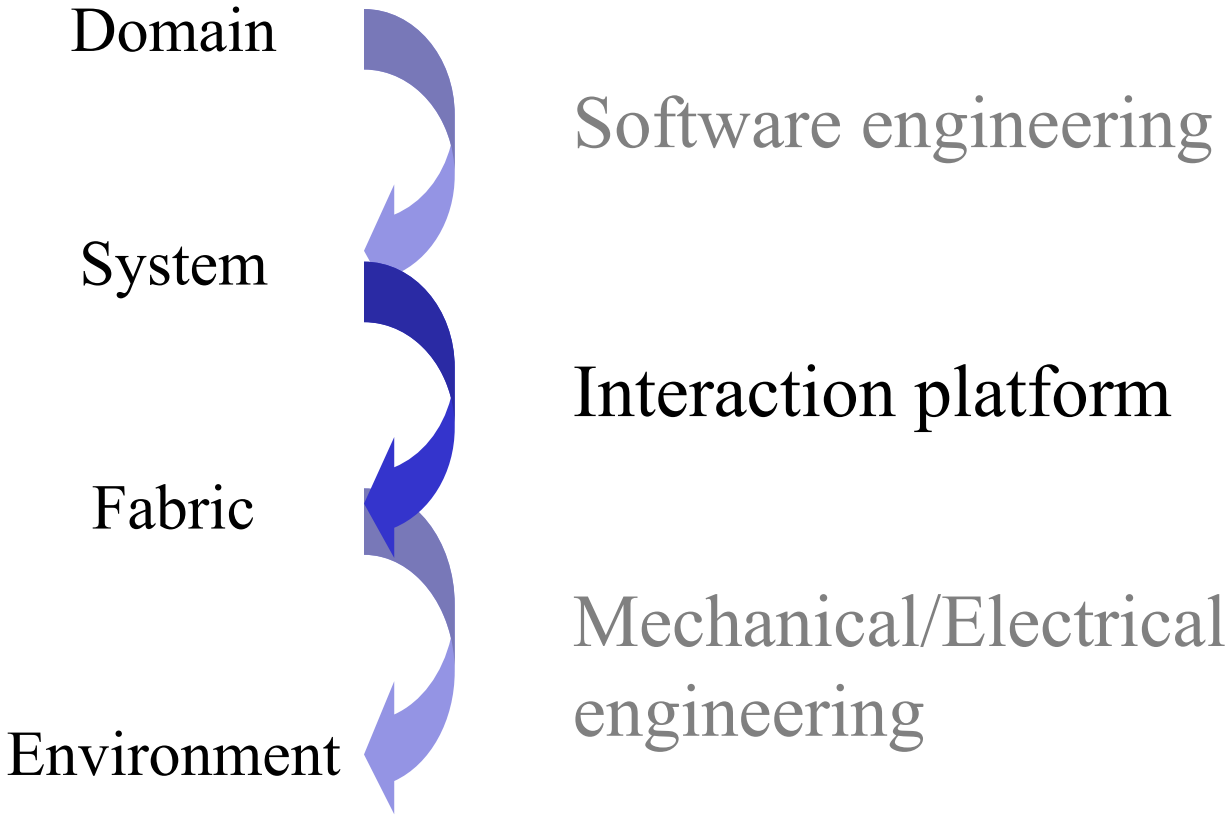
OCS interfaces



Interaction platform

SOLACE: Service oriented layered architecture for interacting entities

- Provides an interface between system level services and fabric level hardware,
- Enables observation and recognition of available domains
- Makes sure that services can find other services in the same domain (using the same language), so that they can interact

Enables the *ad hoc* network construction needed in an open environment.

Assumes IP-based communication

Interaction tool

DISCERN: Distributed interaction system for complex entity relation networks

- Any defined geography and/or symbol can be mapped to specific graphics
- The visuals are created by the tool
- Only the data asked for, need to be distributed over the network. Bandwidth requirements depends on e.g., domain definitions and operational needs (the desired update-rate)

Multiple domains can be inquired from each tool

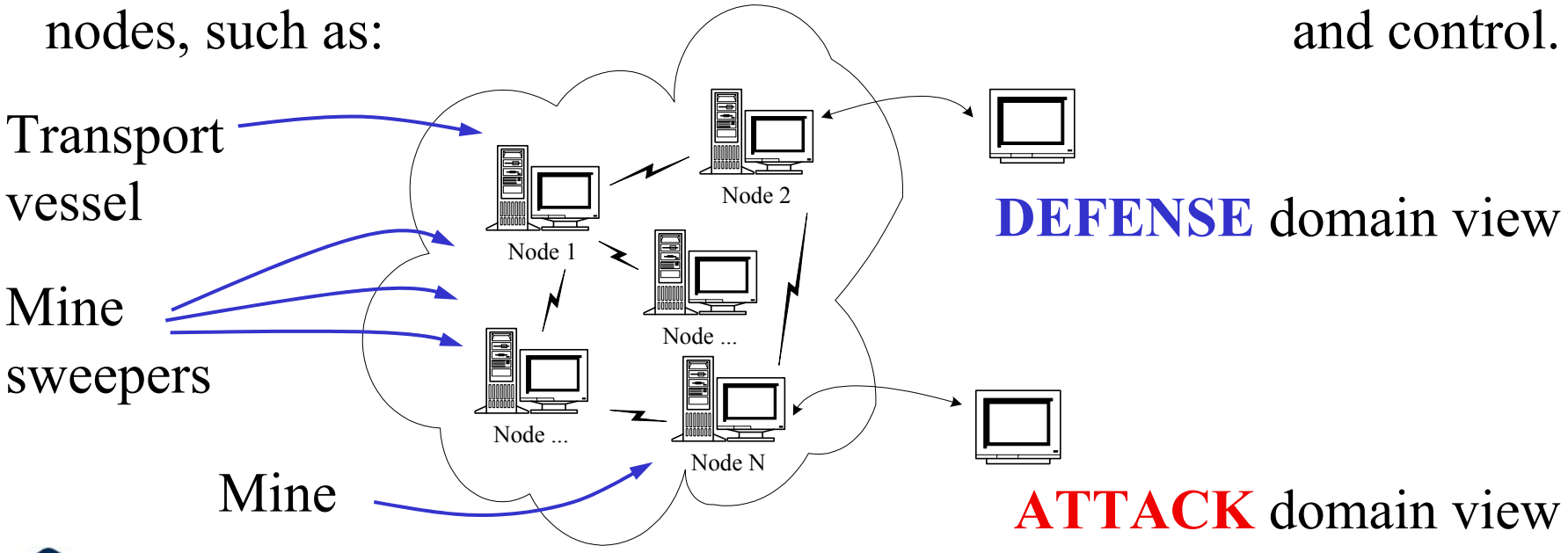
Domain selection is the same as Network selection

The TWOSOME demonstrator

Trustworthy and Sustainable Operations in Marine Environments
TWOSOME is designed to investigate NCW capabilities.

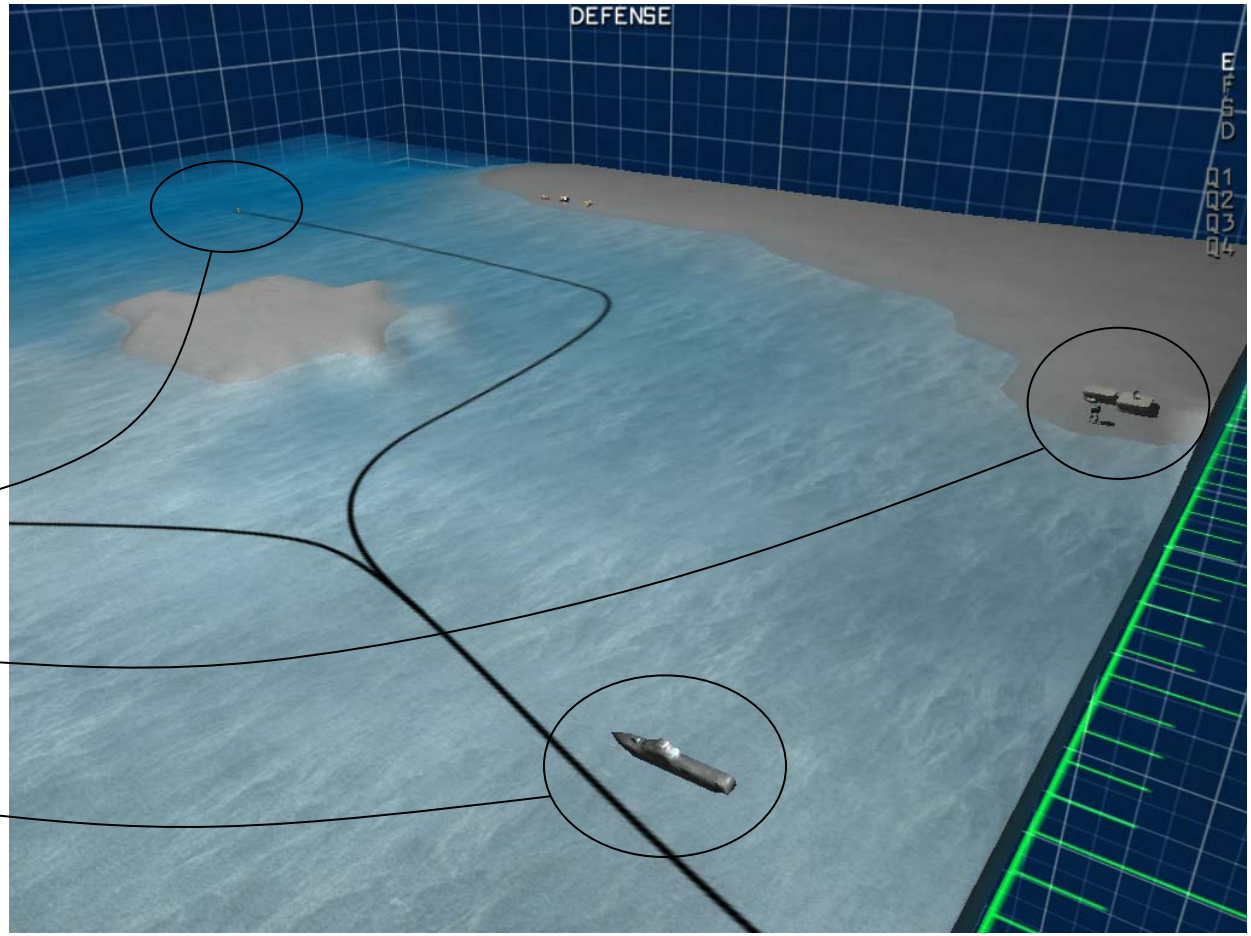
Distributed asynchronous nodes, such as:

Interaction tools for observation and control.



Visualise states and events

The operator has full freedom of movement in the 3D environment.



Sonar buoy

Operations centre

Transport vessel

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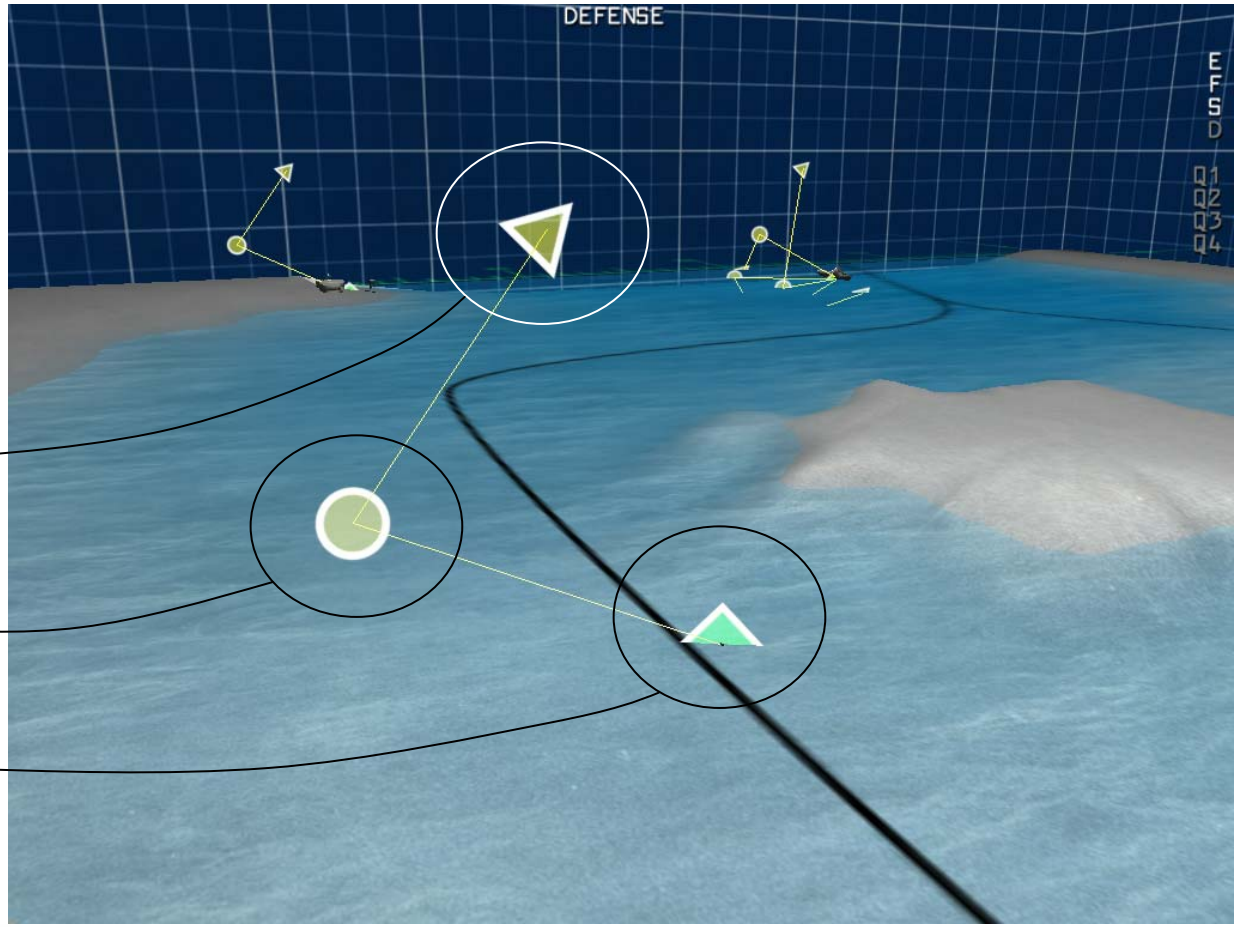
Visualise architectural components

Switch-on/off symbols for architectural components.

System level connectors

Services

Computational nodes (computers)



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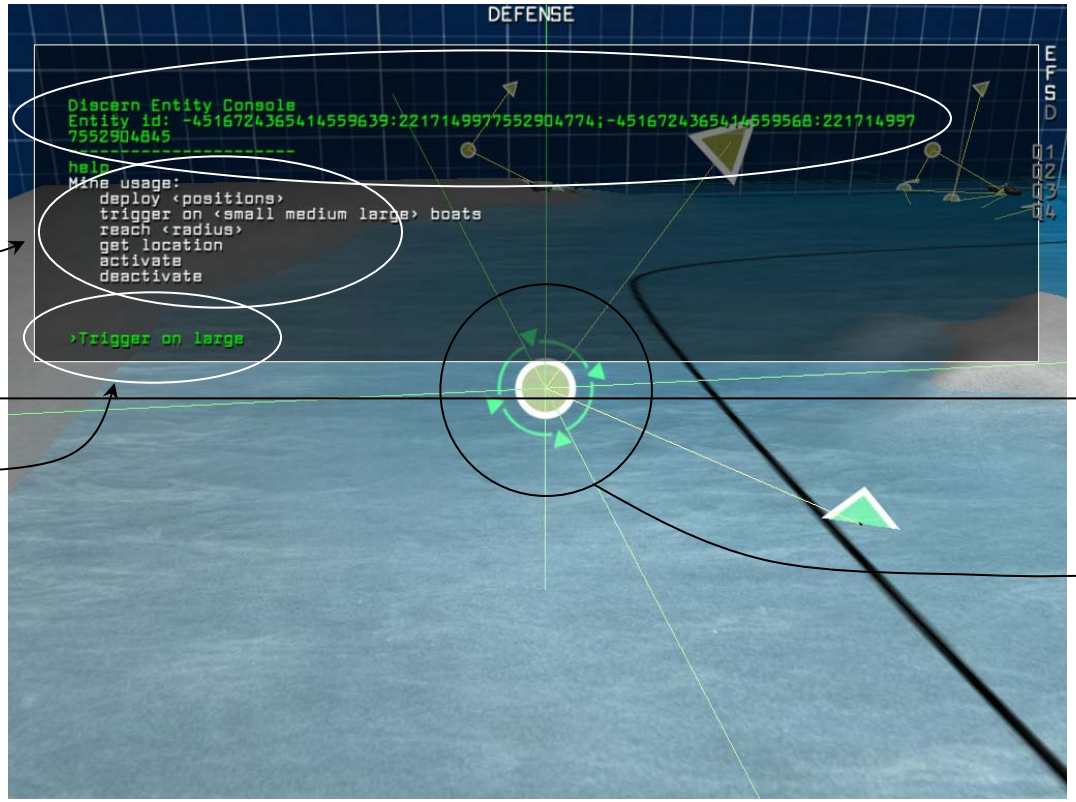
Connect direct to services

View states

Ask for information

Issue commands

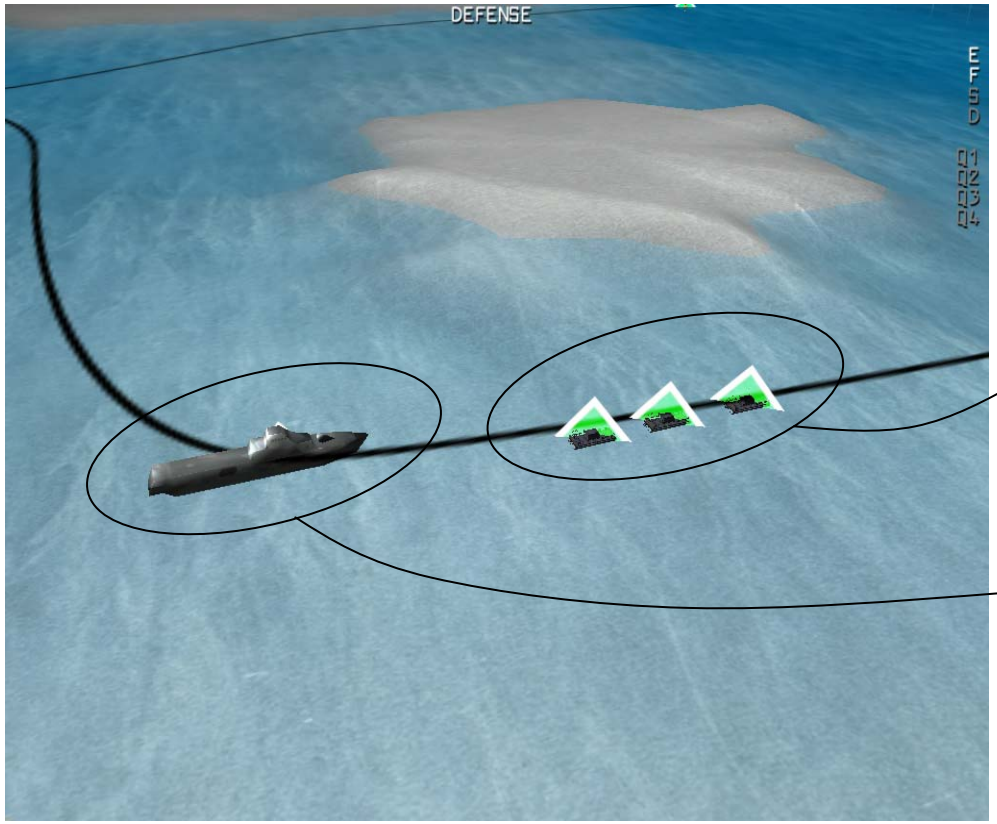


Command window

Point-and-click at symbol for service

Observation of new nodes

Any (new) node that (is activated and) reports within a domain, is detected and visualised.



A group of self-propelled autonomous mine-sweepers (SAMs) have been activated and deployed by a transport vessel.

No node-repository exists => *ad hoc* network establishment

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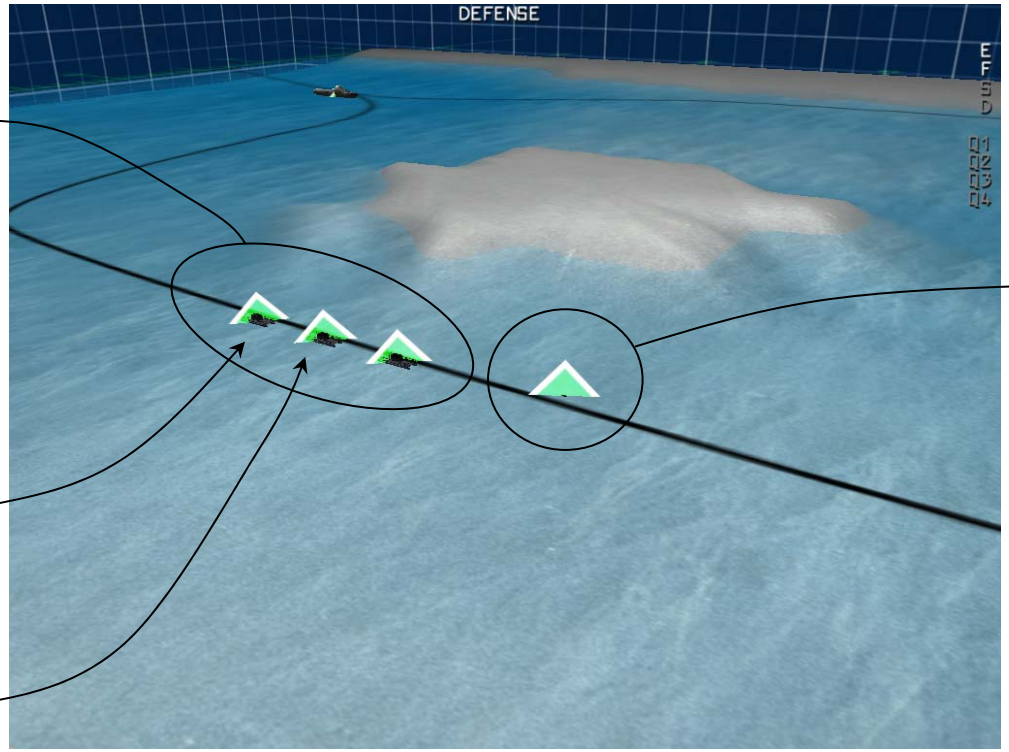
Self synchronisaton

The SAMs self-synchronise and configure services, pretending to be a large ship.

Last SAM activate propulsor sound

Middle SAM activate engine sound



A mine that assess signatures, waiting for a target.

All SAMs activates magnetic signature

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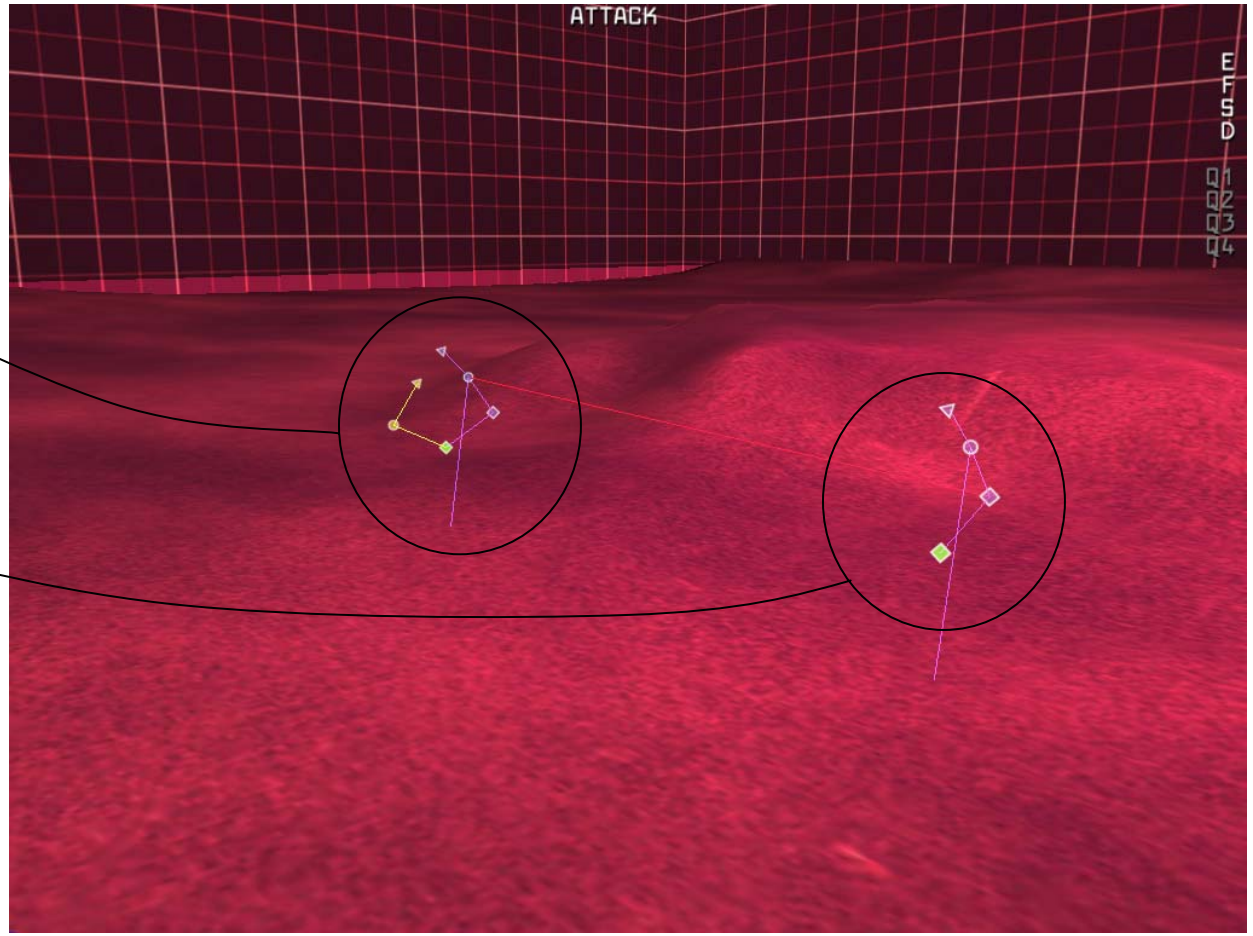
Concept creation (1)

The mines declaration of a signature

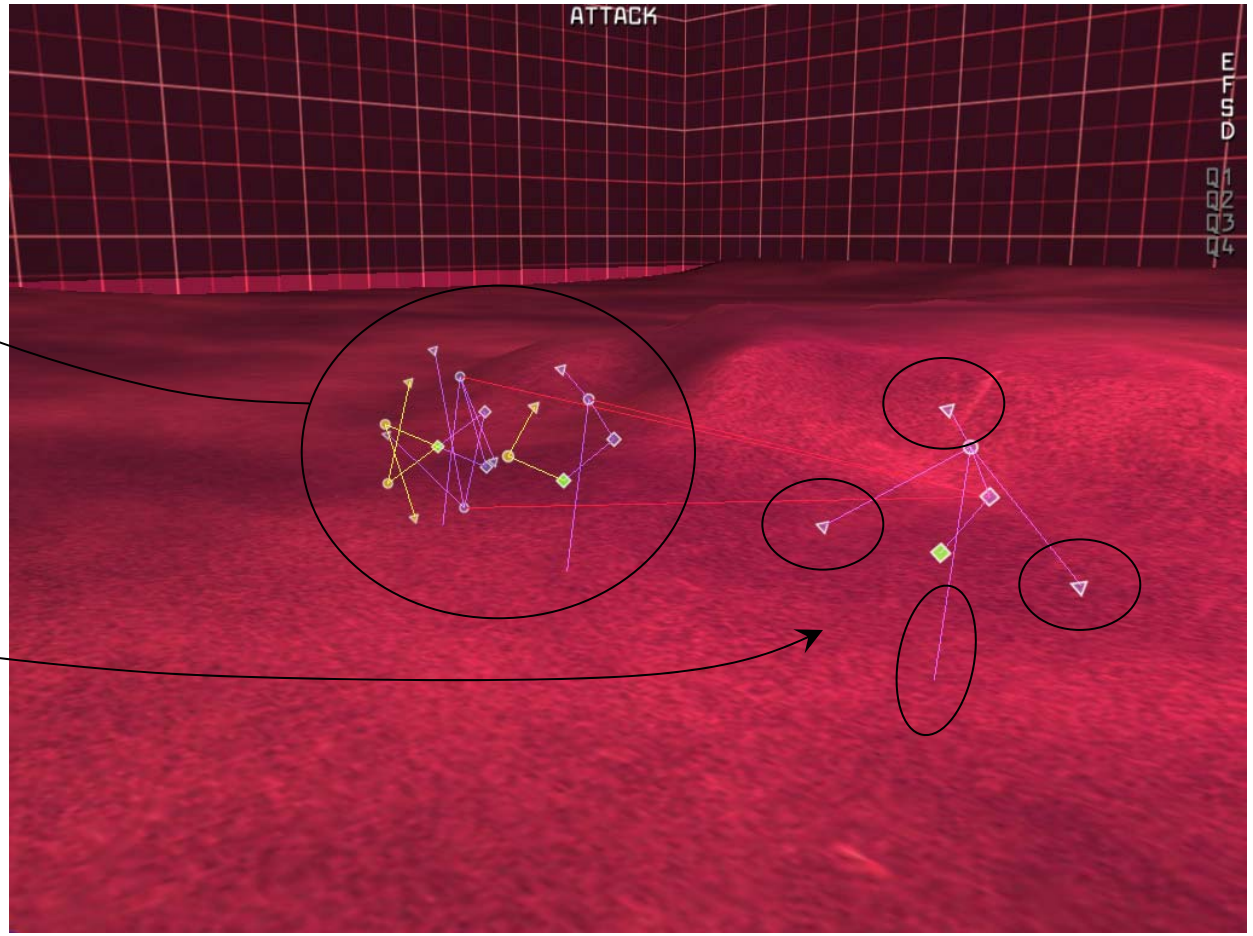
The mines declaration of itself



Concept creation (2)

Signatures from two SAMs

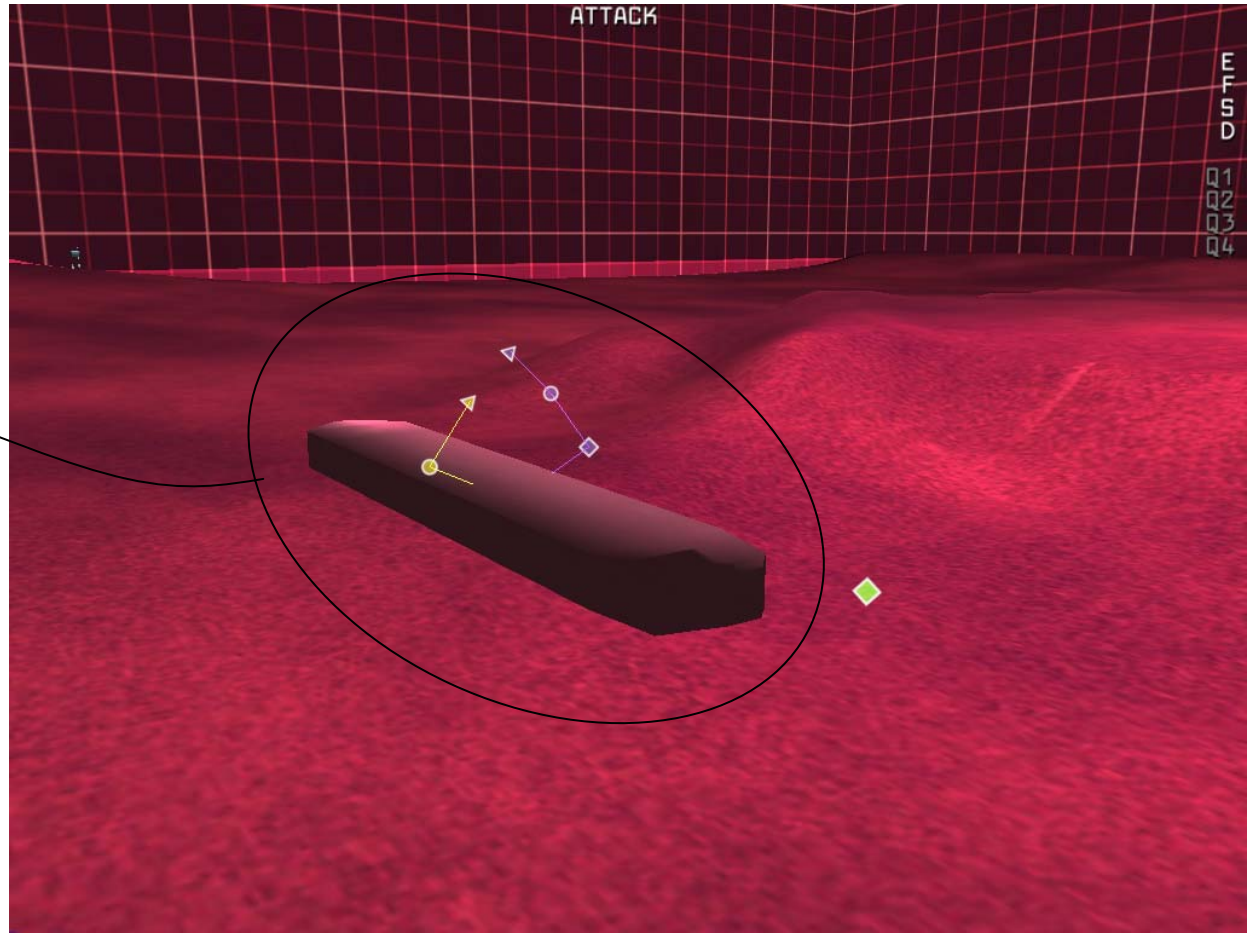
Four possible solutions to a pattern matcing problem (i.e., hypotheses), all unknowns.



Concept creation (3)

Six signatures at three different locations are classified as being one large vessel.

This is an example of information fusion.



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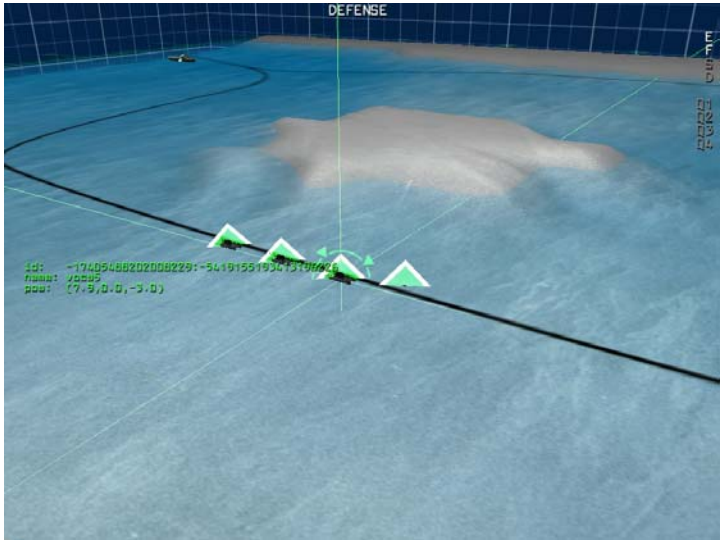
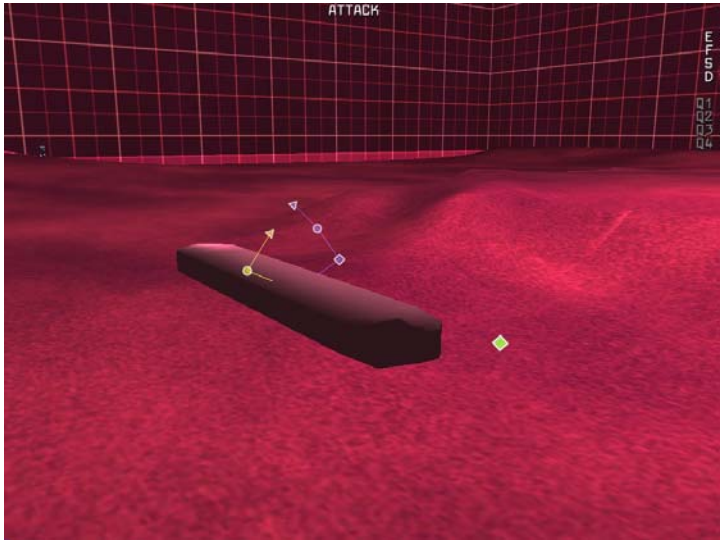
Shared awareness

Nodes are exchanging information within task-groups



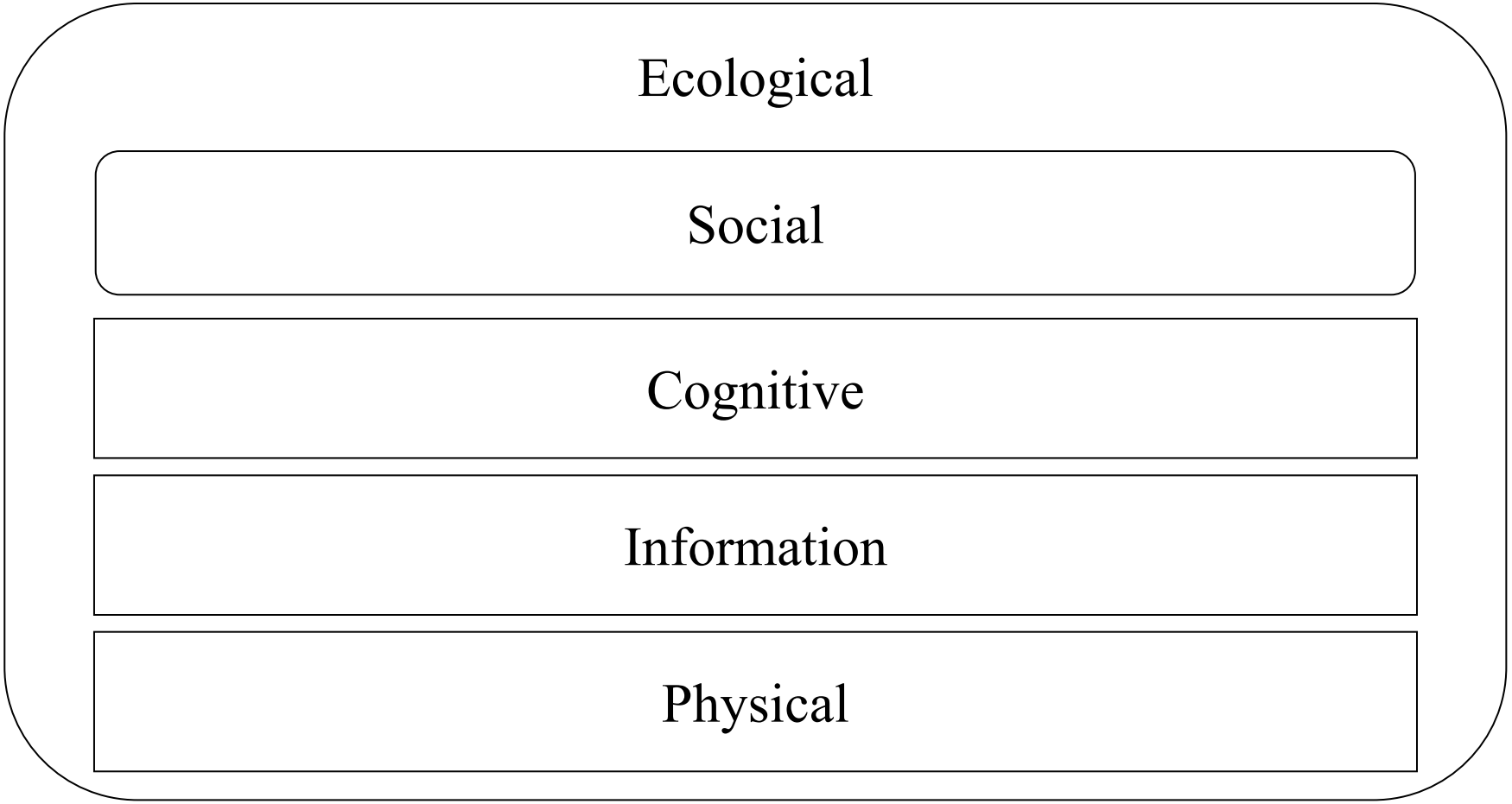


Different views/networks can be monitored at one location
One view/network can be monitored at different locations

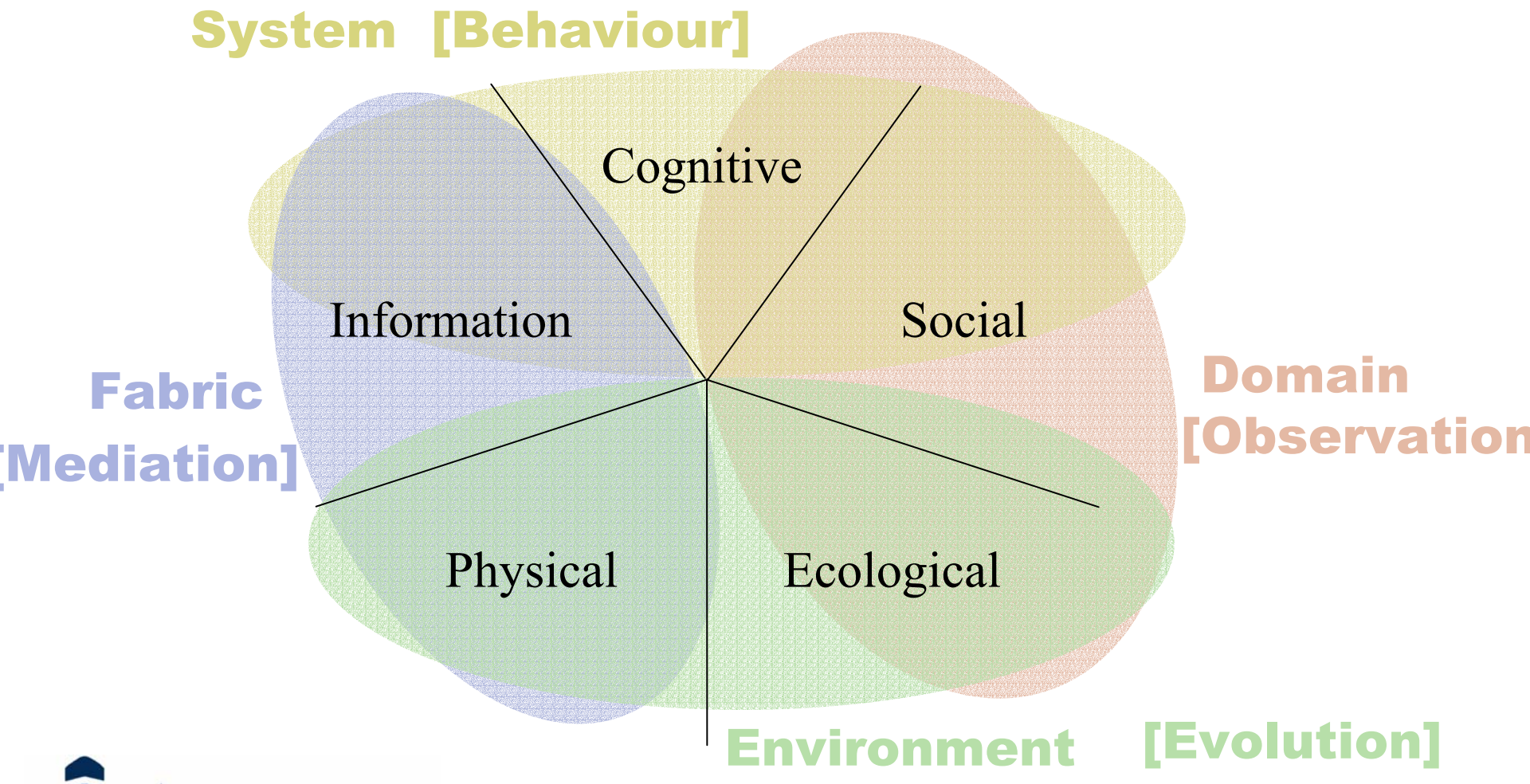
TWOSOME Results

- Ad hoc insertion, observation and extraction of nodes
- Information sharing and fusion
- Shared situation awareness by two means:
  (i) the interaction tool enables distributed and parallell human interaction in and between networks, and
  (ii) the system level code enable machine-to-machine interaction
- Collaboration and self-synchronization between asynchronous and distributed nodes

Domains of warfare (revisited)



OCS and the five domains of warfare



Basic Requriements on Networks

[Alberts & Hayes (2003)]

1. *Make sense of the information*: Domain level definitions encompass purposes, understanding and decisions
2. *The ability to work in a coalition environment including partners from different organisations:* (i) Common languages are defined as Domains and (ii) interaction platforms and tools enable communication, command and control
3. *Appropriate means to respond using the tools of war and policy implementation:* Would not be affected by the OCS
4. *Orchestrate the available means to respond in a timely manner:* (i) the interaction components enable operator control, (ii) services on distributed nodes allows self-synchronisation, (iii) common language supports collaboration

OCS and the Global Information Grid

[Alberts & Hayes (2003)]

1. *Discovery of new nodes in a network:* Enabled by the interaction platform, given existing Domain definitions
2. *Modular implementation of e.g., software based agents, as services:* Enabled as code at the System layer
3. *Mediation of information between nodes:* Enabled by the interaction platform and the Fabric layer
4. *Shared awareness and situated responses to perceived situations:* Enabled by the interaction tool
5. *Grounding of the emergent properties of self-synchronised systems to the realities of the physical world:* Enabled by the architechture for Open Computational Systems itself

Conclusions

- NCW systems have open properties; they have to be designed, maintained and prepared for situations and technologies that we do not know
- Capabilities of forces in networks are enabled through control. Connectivity in itself is not enough
- The Ecological domain relates the behaviour of some systems to the resulting effects on other systems and the physical world; describing e.g., the feed-forward capabilities needed for control
- The OCS architecture (i) fulfils basic requirements on networks and (ii) is compliant with the GIG, and (iii) it works

Thank You for listening!

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