The Ecological Domain of Warfare

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Introduction

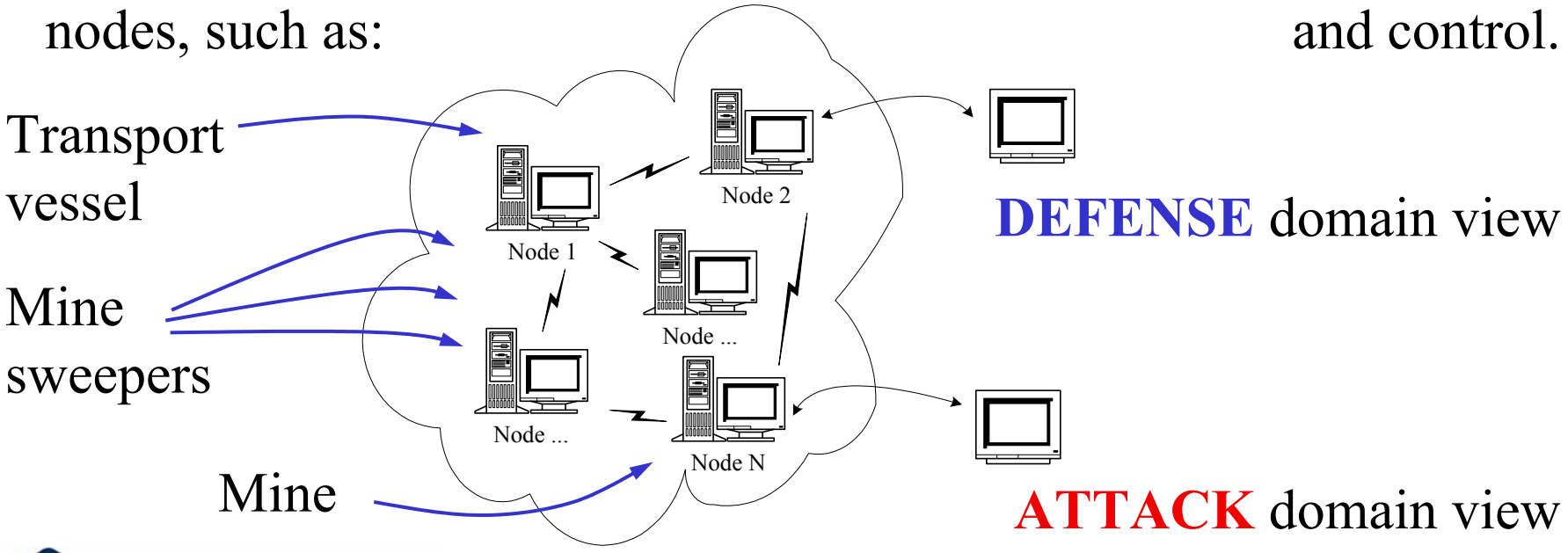
- Kockums AB
  - Stealth and Composite naval technologies
  - Network Enabled Capabilities
  - Analysis dept., Concept studies
- The Societies of Computation research group and laboratory at Blekinge Institute of Technology (BTH)
- Mergning naval domain knowledge with e.g., multi-agent, software and knowledge engineering.

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.



3D Littoral environment

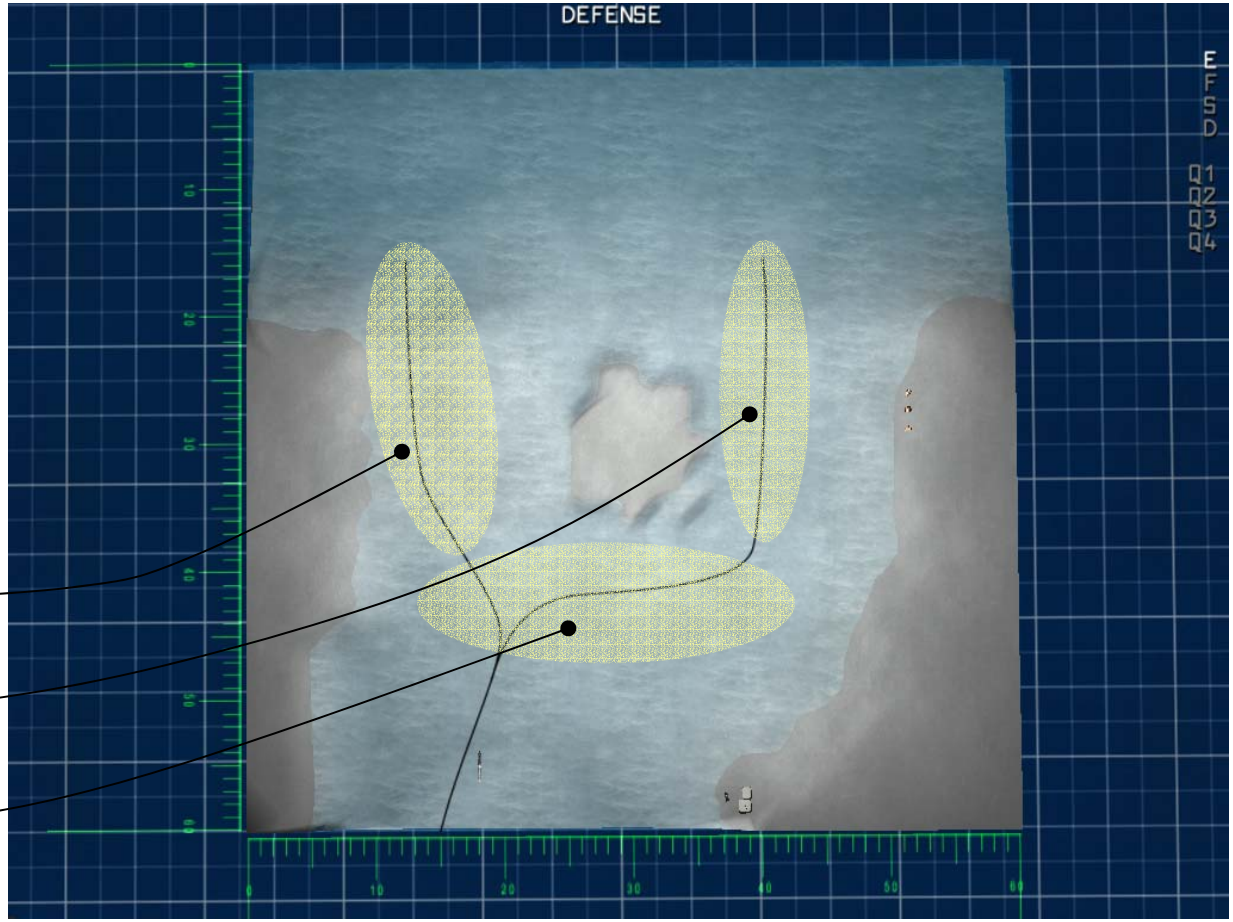
The environment is a 1 NM cube with 1 m resolution

3 channels are defined:

Shallow

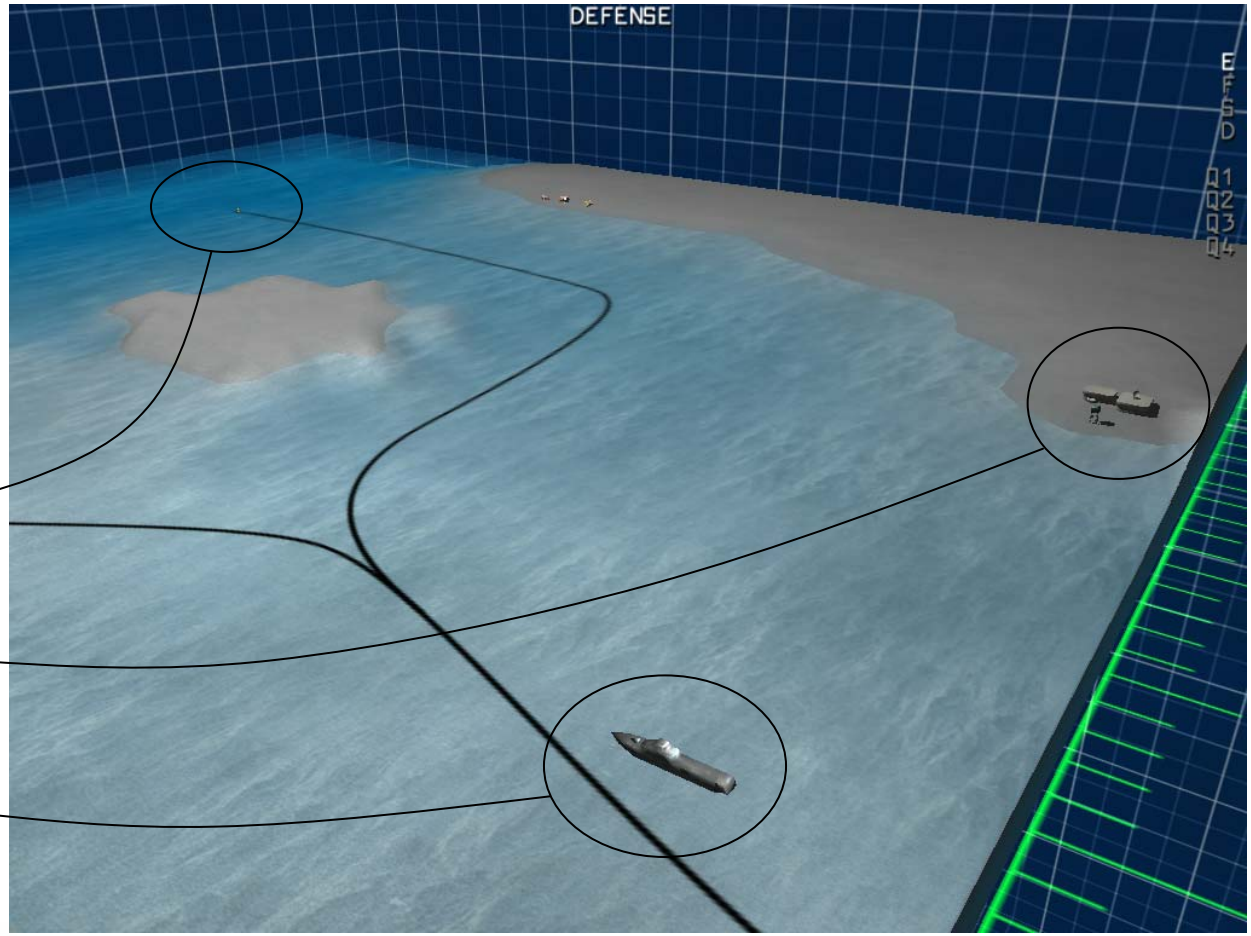
Deep

Complex



Visualise states and events

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



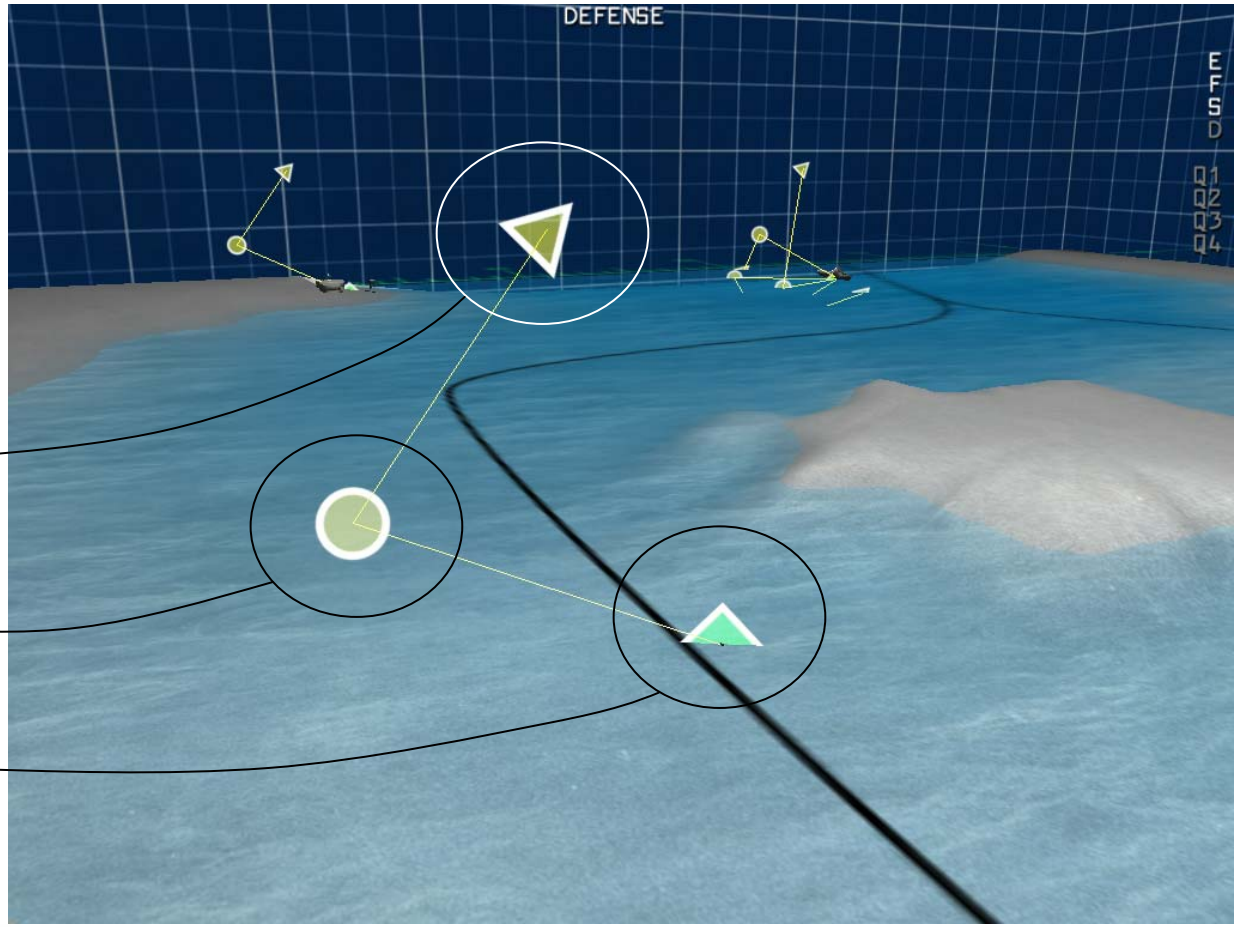
Visualise architectural components

Switch-on/off symbols for architectural components.

System level connectors

Services

Computational nodes (computers)

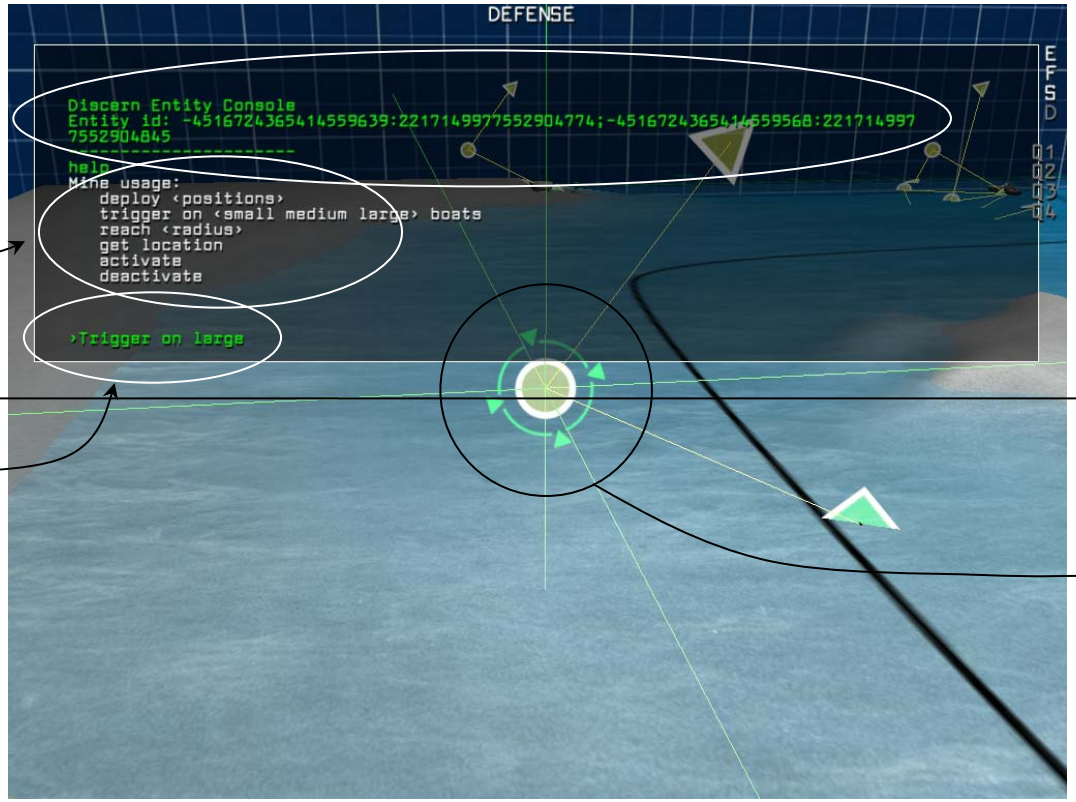


Connect direct to services

View states

Ask for information

Issue commands

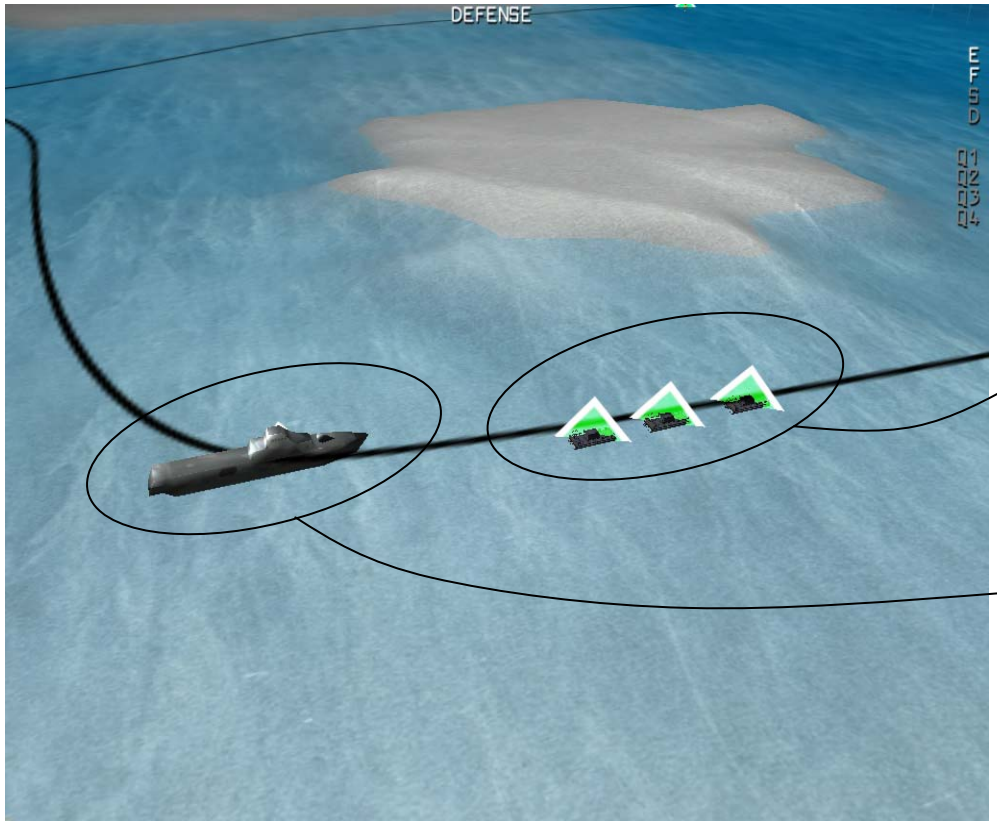


Command window

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.

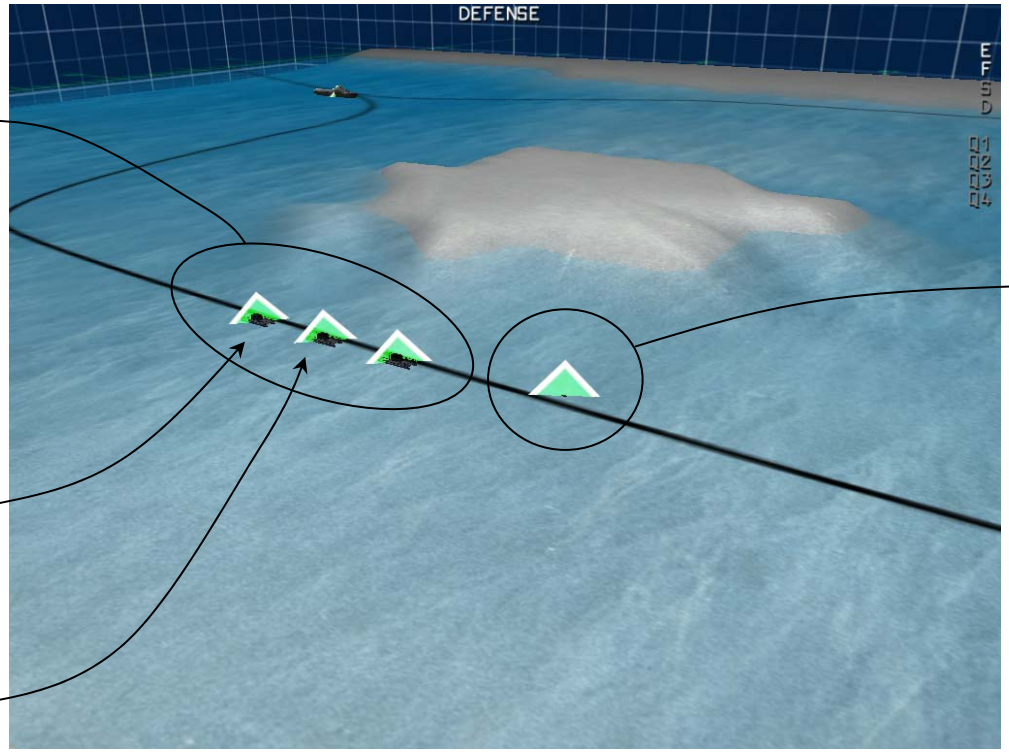


A group of self-propelled autonomous mine-sweepers (SAMs) have been activated and deployed by a transport vessel.

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

Self synchronisaton

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



A mine that assess signatures, waiting for a target.

Last SAM activate propulsor sound

Middle SAM activate engine sound

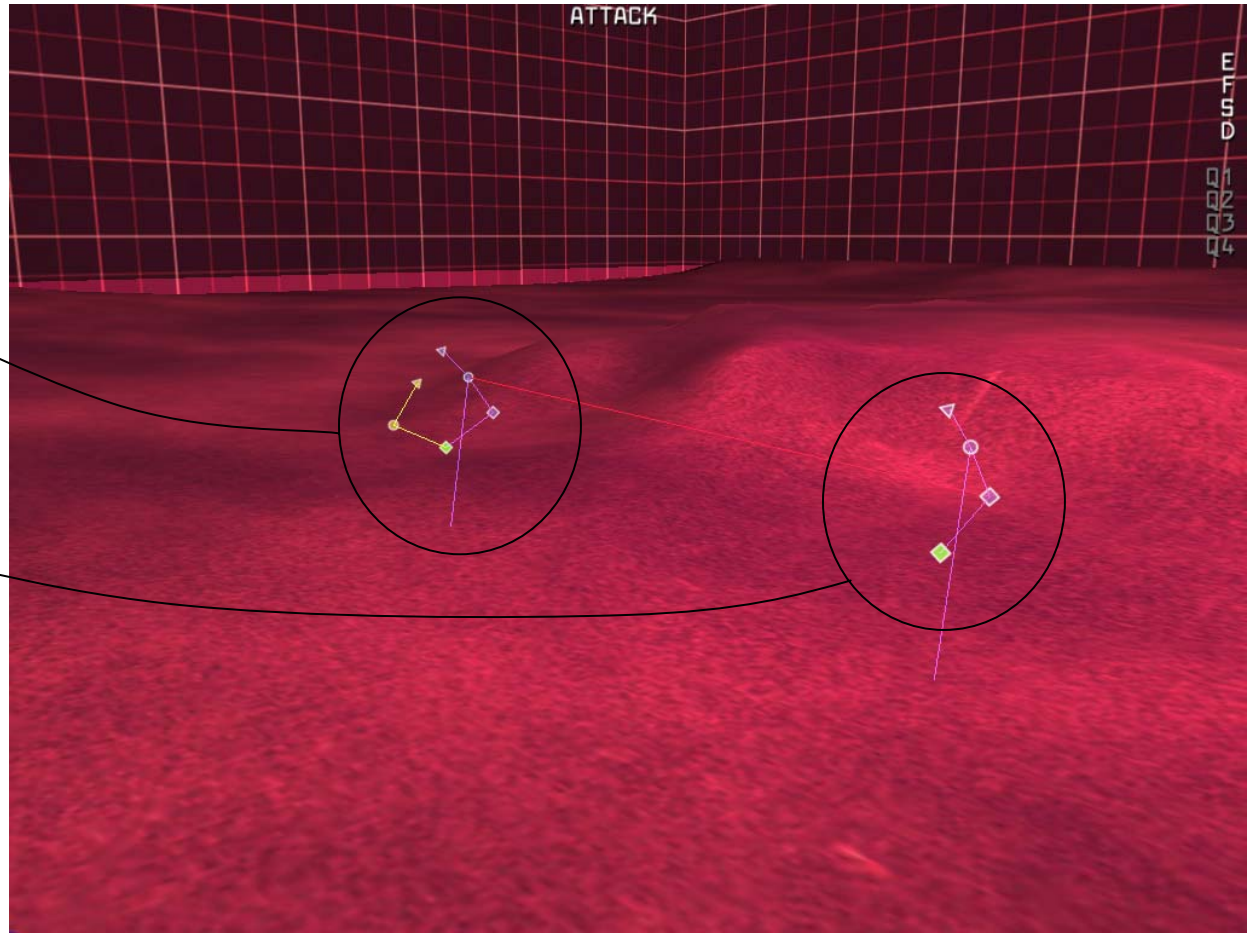
All SAMs activates magnetic signature

HDW/KOCKUMS

Concept creation (1)

The mines declaration of a signature

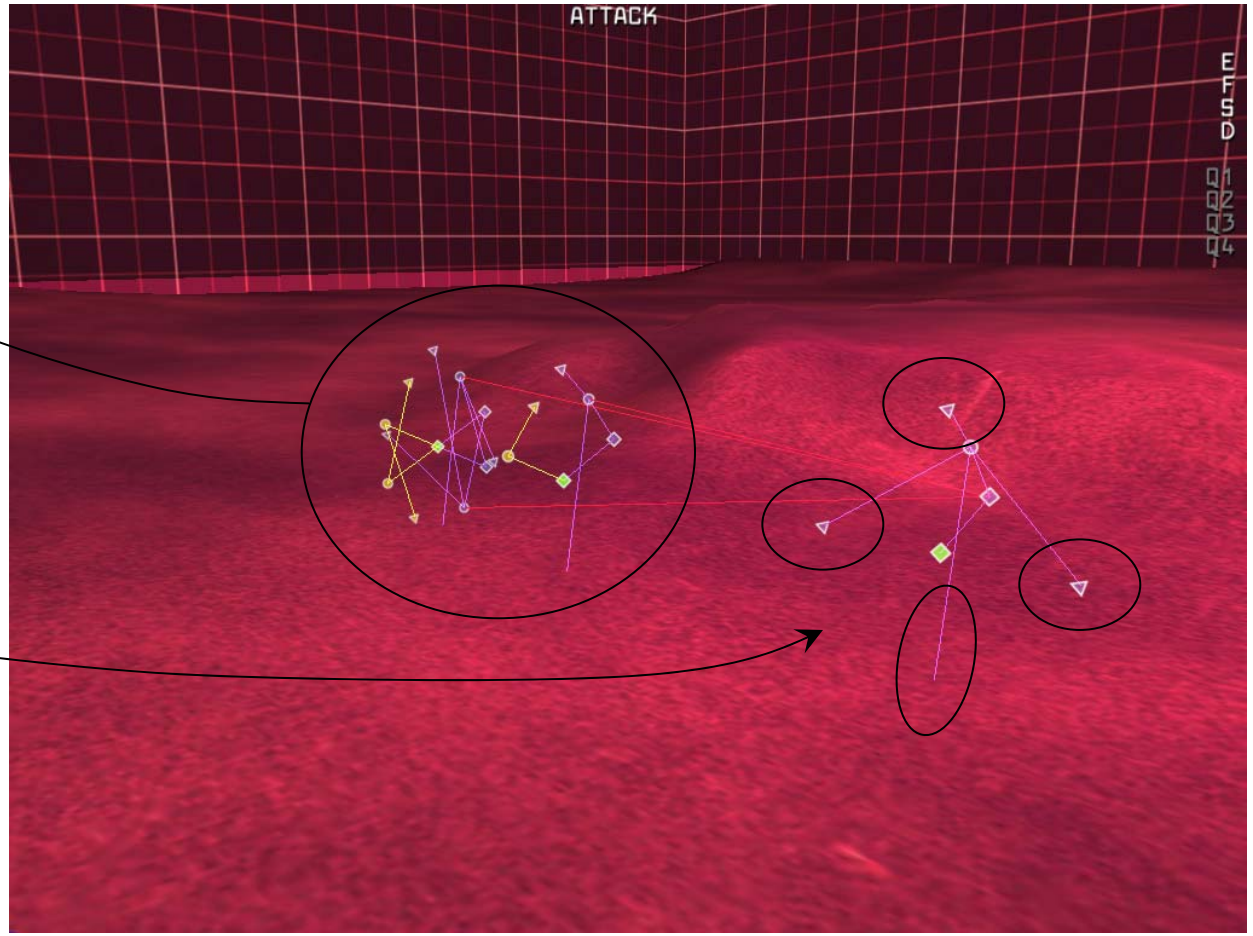
The mines declaration of itself



Concept creation (2)

Signatures from two SAMs

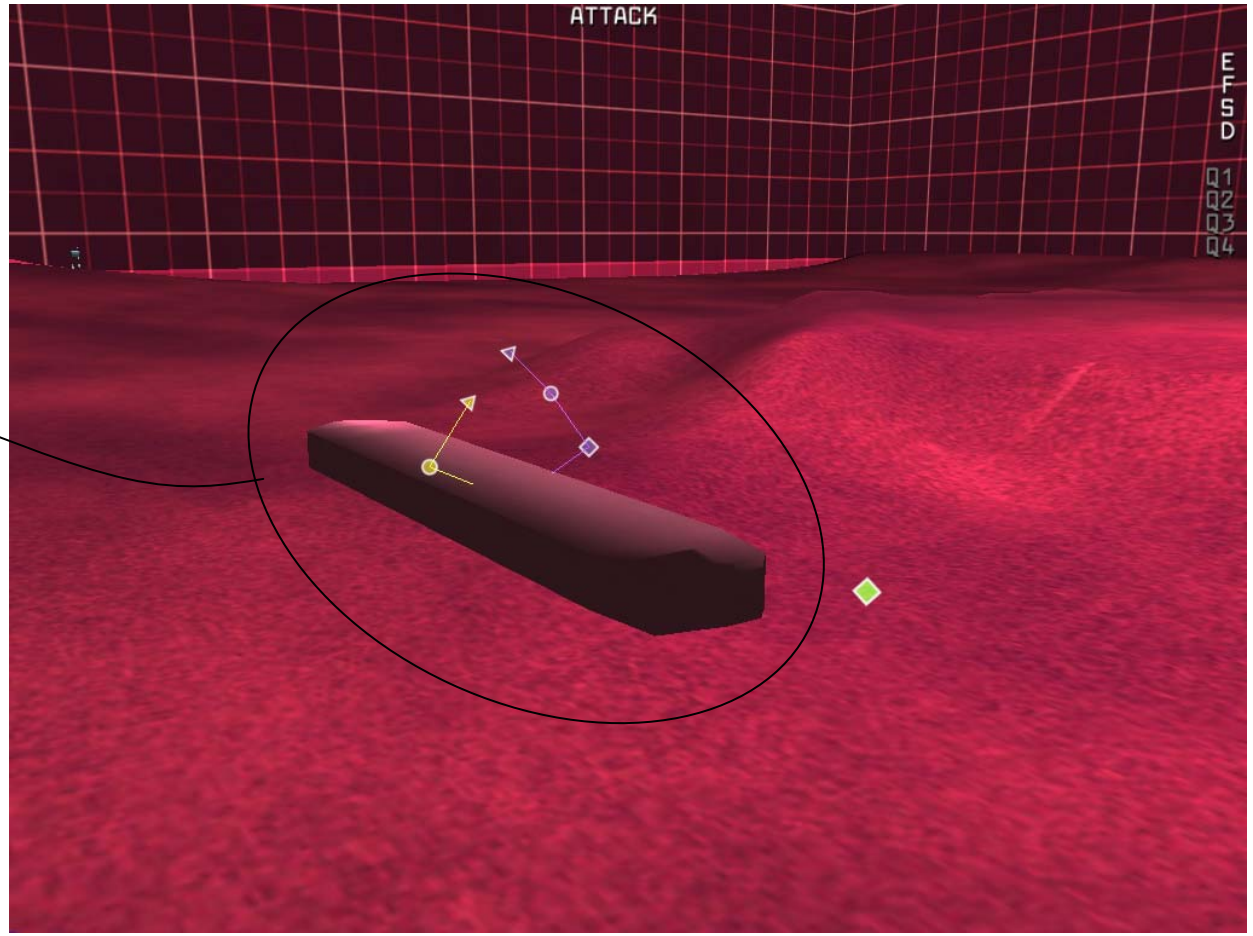
Four possible solutions to a pattern matcing problem (i.e., hypotheses), all unknowns.



Concept creation (3)

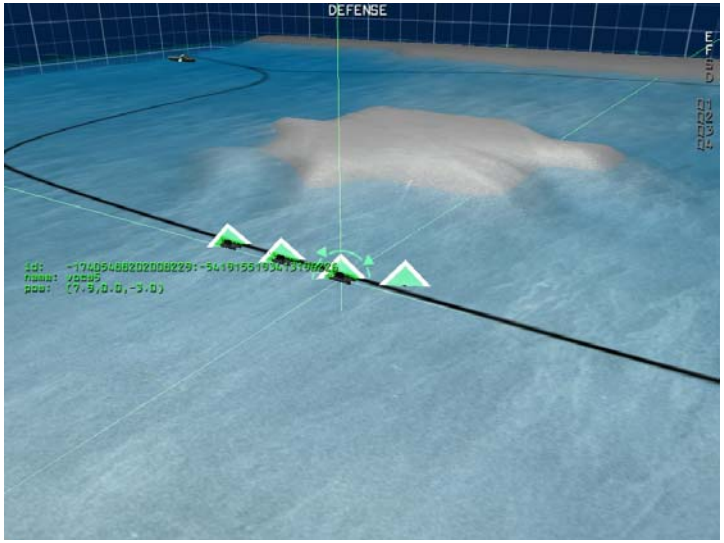
Six signatures at three different locations are classified as being one large vessel.

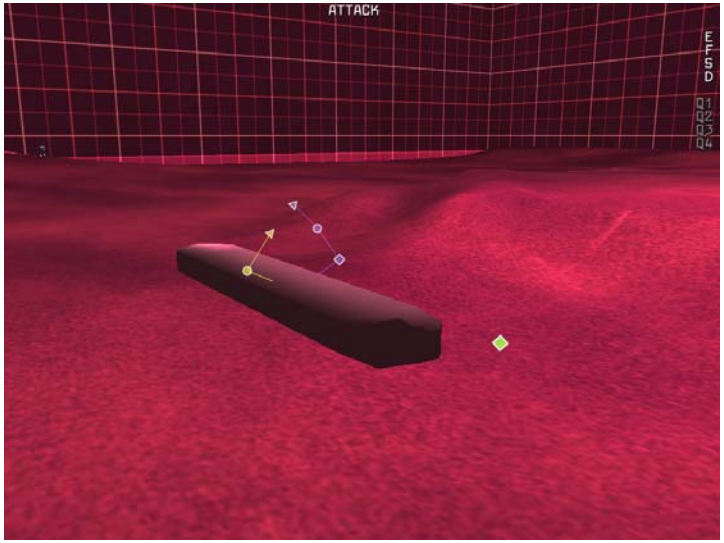
This is an example of information fusion.



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

Does this make sense?

The purpose of this paper is to investigate if/how these results are coherent with established NCW frameworks

- Introduce the architecture for Open Computational Systems (there is also a corresponding methodology)
- Compare the OCS to the domains of warfare
- Investigate the compliance of OCS to some requirements on networks and the GIG.

Open Computational Systems

Open systems are evolving over time in such a way that

- there is no real starting or stopping the system
- the operating circumstances are not known in advance

Computation and cognition are merging

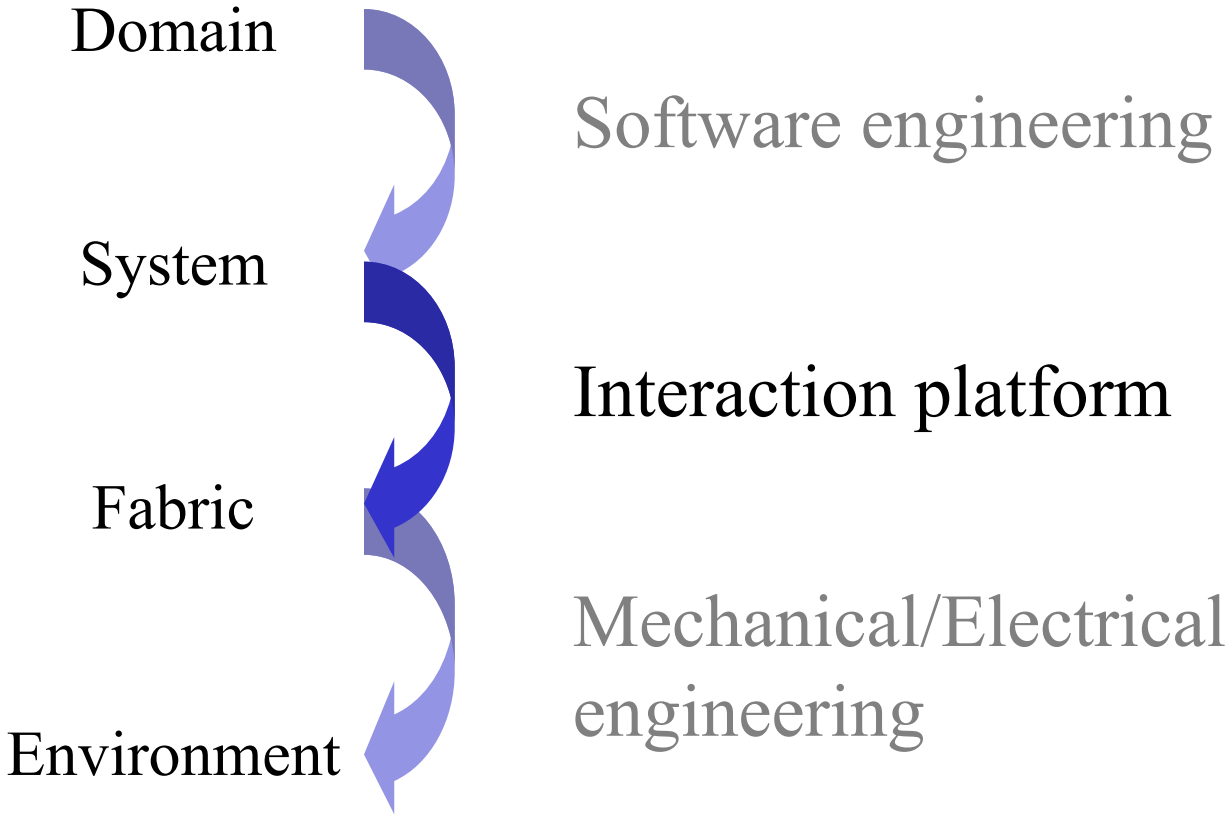
- there may be a significant amount of computers and software in the loop, enabling unmanned autonomy
- man-machine-system engineering is crucial

=> Once we know how to get connected, we have to learn how to maintain control

Architecture for open systems (1)

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.

Architecture for open systems (2)



Interaction platform

- Service oriented layered architecture for interacting entities: SOLACE
  - 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

- Distributed interaction system for complex entity relation networks: DISCERN
  - 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

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

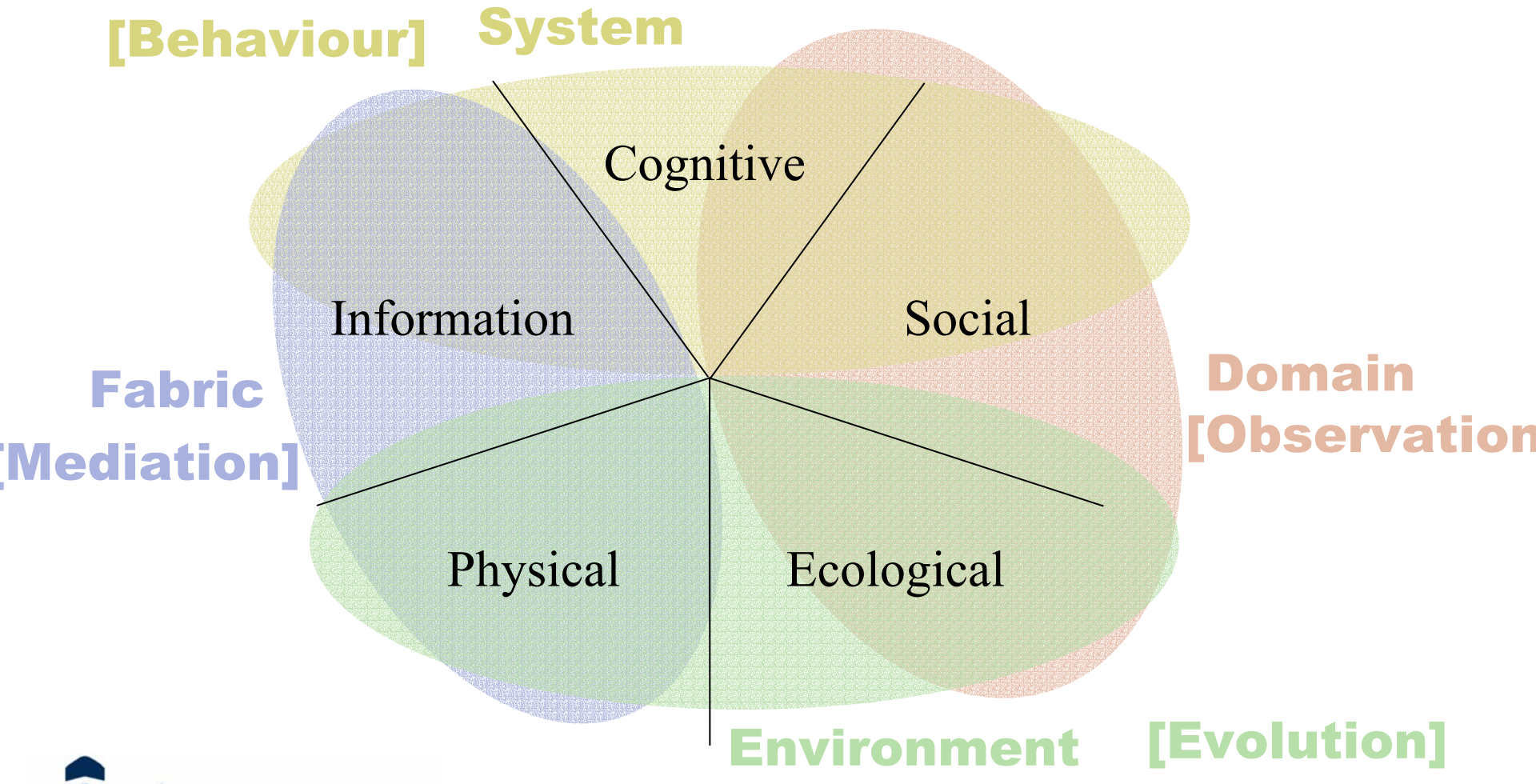
The Physical domain:
Strike, protect and manoeuvre; different environments

The case for the Ecological domain

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

=> The Ecological level relates the behaviour of (some) systems to the resulting effects on other systems and the physical world

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 will 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; it enables 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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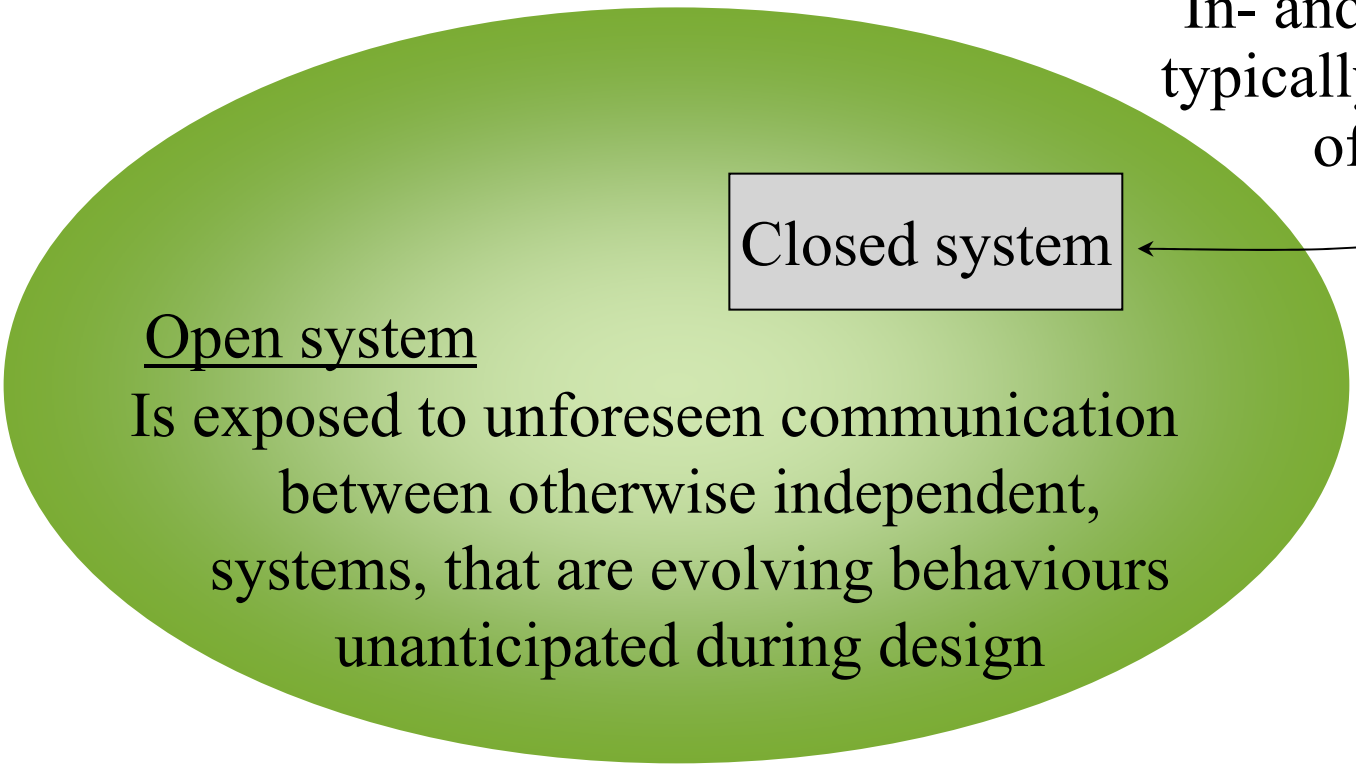
Current issues

- Allocation and distribution of cognitive tasks between men and machines (decision making, unmanned autonomity)
- Trade-offs between local capabilities and the need for communication (What can we do with available bandwith? How do we control disconnected nodes?)
- Dynamic network engineering (reconfiguration of task forces, on line maintenance of distributed capabilities)
- Task-based spatial/temporal grid-lock (granularity?)

NCW and NEC

- A difference more in praxis than in principle;
- Network Centric Warfare – NCW
  - Focus on technologies, how can they be used?
  - Often assuming command and control systems with high requirements on bandwidth
  - Often grounded in sensor-to-shooter loops
- Network Enabled Capabilities – NEC
  - Focus on missions and tasks; what capabilities do we need?
  - Assumes local capabilities and co-operation
  - Grounded in fexible low-lewel interaction between nodes

Closed and Open Systems



Ad hoc interaction and network establishment is needed

Engineering Challenges

- Open (evolutionary) systems impose continuously changing requirements
- Specific requirements are unknown at design time
- General requirements on the control of open systems:
  - the ability to observe (i) the properties of accessible participants of a network and (ii) their emergent behaviours
  - the ability to interact with various participants in the network in order to (i) provide specific guidance, and (ii) maintain performance

Trustworthy and Sustainable Operations in Marine Environments

- Purposes of TWOSOME:
  - to investigate the applicability of the DISCERN interaction tool
  - to investigate the usefulness of parallell visualisations
  - to investigate the presentation of results of information fusion
- Goals: to prove that adaptation and self-synchronisation could be achieved, leading to robust distributed systems
- Implementation:
  - TWOSOME runs as distributed processes on nine PC's and is controlled through e.g., two interaction tools
  - Graphics is developed for concrete and abstract entities and concepts
  - IP-compliant communications technology is assumed
  - Multiple levels of organisation and delegation is implemented

Distributed Interaction System for Complex Entity Relation Networks

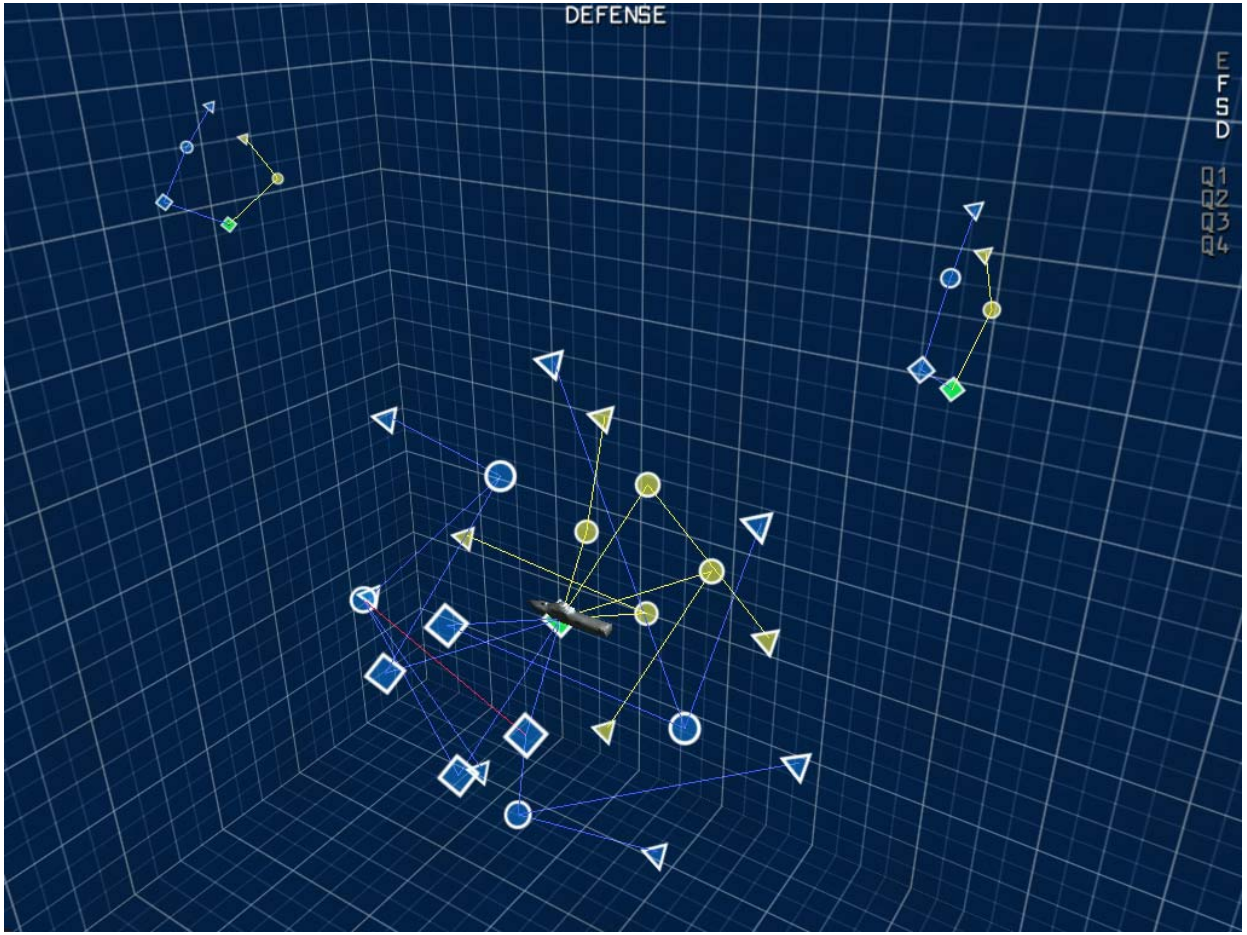
DISCERN provides 3D visualisation and interaction based on the information that can be made available through the network. It enables presentation of

- some geography in which we can observe the evolving behaviour of events (e.g., moving vessels),
- qualitative and/or abstract constructs (e.g., fabric level nodes, system level services and the available domains), and
- point-and-click service connections (e.g., the ability to open a direct text-based command interface to any available service in the network)

The world is not required

The number of symbols is increasing with system complexity

Removing the environment layer indicates non-geographical use



HDW/KOCKUMS

Topographic NCW maturity model

E Open evolutionary

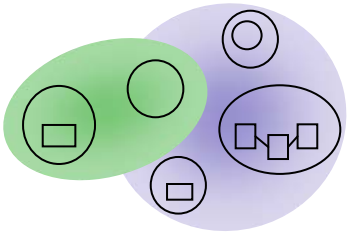
D Open asynchronous

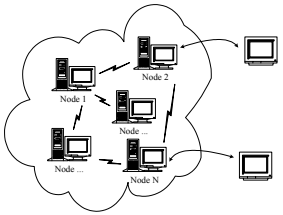
C Open distributed

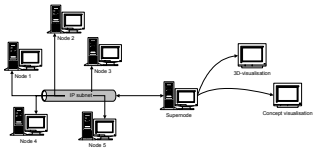
B Web services

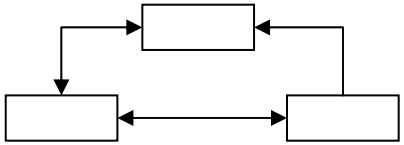
A Object brokering

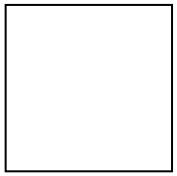
Baseline Applications

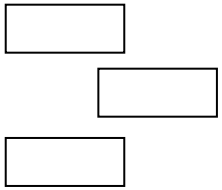




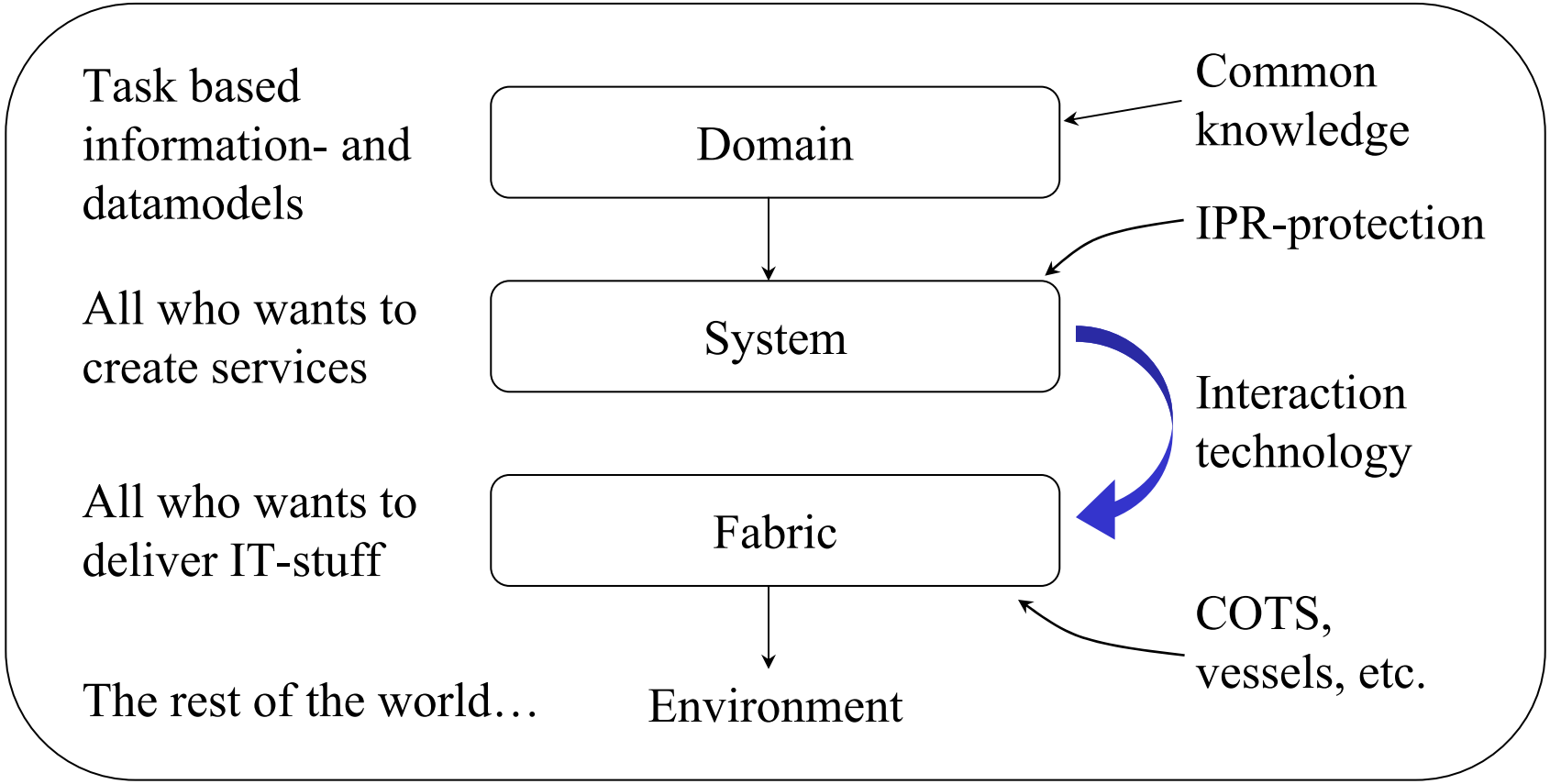




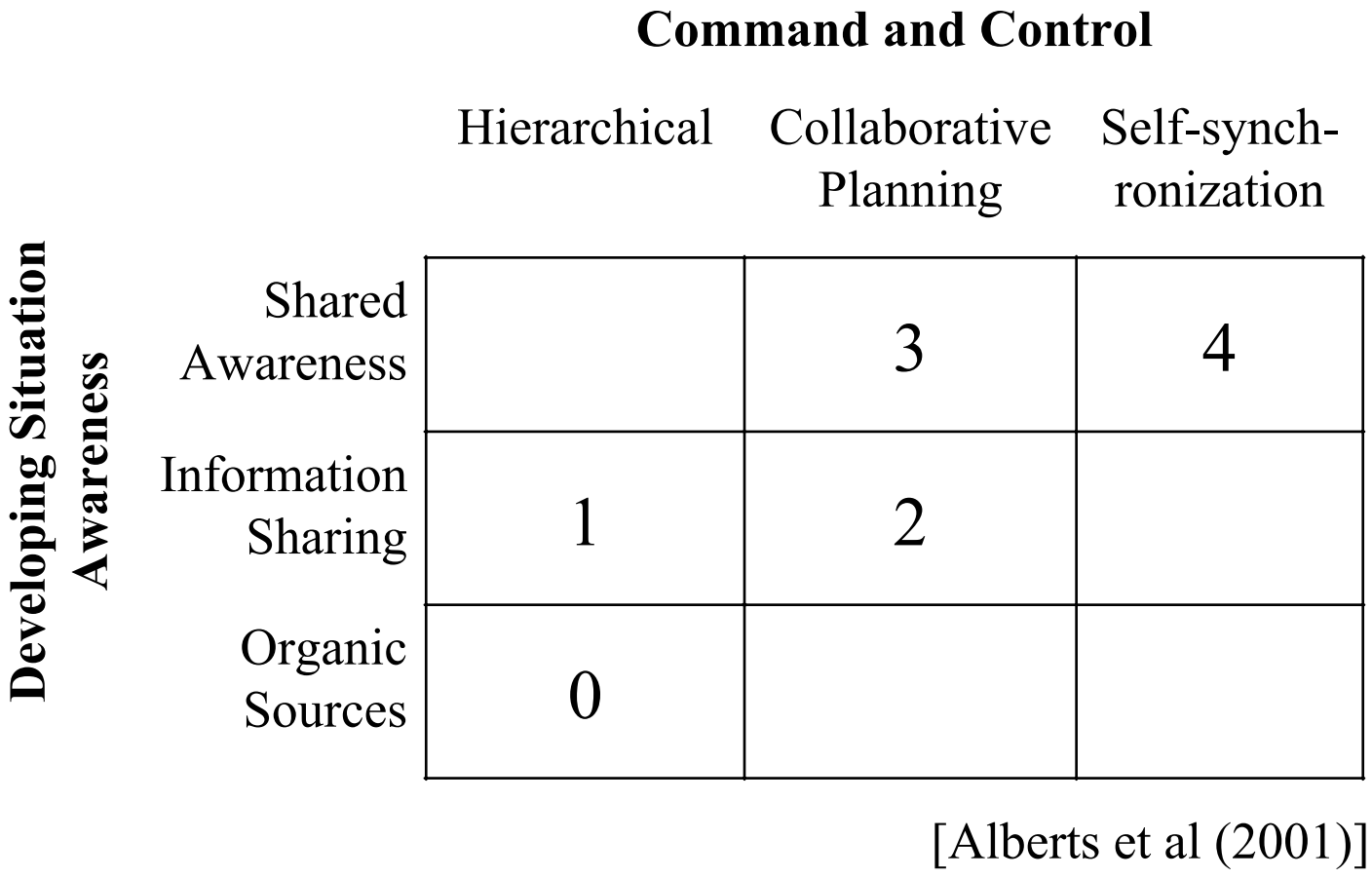




Organisational roles



The NCW Maturity-model



[Alberts et al (2001)]