

**17th ICCRTS
“Operationalizing C2 Agility”**

Title of Paper

**Information Sharing Framework for Agile Command and Control in Complex Inter-domain
Collaboration Environment**

Topic(s)

Primary: Topic 8: Networks and Networking
Alternative: Topic 4: Collaboration, Shared Awareness, and Decision Making
Alternative: Topic 3: Data, Information and Knowledge

Name of Author

Rauno Kuusisto

Professor, Head of Division, Finnish Defense Forces Technical Research Center,
P.O.Box 10 FI-11311 Riihimaki, Finland
rauno.kuusisto@mil.fi

Professor, Department of Mathematical Information Technology, University of Jyvaskyla,
P.O.Box 35 FI-40014 University of Jyvaskyla, Finland
rauno.k.kuusisto@jyu.fi

Adjunct Professor, Department of Tactics, National Defense University,
P.O.Box 7, FI-00861 Helsinki, Finland
rauno.kuusisto@mil.fi

Point of Contact

Rauno Kuusisto

Professor, Head of Division, Finnish Defense Forces Technical Research Center,
P.O.Box 10 FI-11311 Riihimaki, Finland
rauno.kuusisto@mil.fi

**Information Sharing Framework for Agile Command and Control in Complex Inter-domain
Collaboration Environment**

Abstract

The access to the global commons consisting of the high seas, international airspace, outer space and cyber space is essential to be ensured to guarantee the secure development of global welfare and stability. Access management is complex challenge. One of the cornerstones of access management is ability to exchange relevant information compared to the situation dealt with.

This paper presents a theoretically-practically motivated framework to help to construct well-functioning information exchange practices and tools. The paper is based on long-term research work of information exchange requirements supporting management and collaboration. Presented construction is based on several theories dealing with communication, management, organizations and cognition. The theory of complex adaptive systems acts as a collecting theory against which the analysis is made. Conclusions are based on empirical research conducted in several practical cases during the last decade. The final suggestion as an information exchange framework for agile command and control in complex inter-domain collaboration environment takes account not only the common interest of the collaborating actors, but also the different roles of various actors, the phase of operation, cooperation maturity level, and the level (strategic ... operating) of the conducted activity. All these issues are collected under the same framework construction.

Introduction

Collaboration and networking demands are increasing. Lots of organizational communicative activities have moved into technical networks. Cyber domain has become vital unifying element for the comprehensive functionality of the inter-woven global commons network. One of the cornerstones to assure access to the global commons is good practices of exchanging relevant information. A great deal of information exchange takes place on or via cyber domain. Cyber enhanced information exchange environment differs from traditional ones. Information releasing and spreading is easier than before. Contacts between various actors are faster to form but they may remain non-personal. Feedback may lack. This sets certain requirements to construct practices and solutions to support command and control in complex inter-domain collaboration environment.

The working environment of organizations has changed due to the extensive use of information technology. Organizations are more or less interrelated to each other's and lots of activities are executed using technical tools and networks. Relationships are changing more or less frequently making working environment challenging. New relationships are constructed while others are in execution phase containing planning and decision-making. Those phases differ from each other's thus requiring different types of information exchanged. Organizations are interdependent with each other's. This realizes via certain cross-organizational and non-organization specific processes. Various actors have common interests concerning certain objectives in certain situations. Information technology glues these actors together in two ways. It enables collaboration and the use of non-organizational specific services, and it enables somewhat free information publishing and gathering. The organization independent information domain makes inter-organizational relationships complex and emergent by nature. This emergence cannot be controlled, but the content of mutually available information can be structurized to some degree by using relevant processes and technological tools.

The leading idea to present a comprehensive construction for information sharing and assurance in a complex environment is based on following general hypotheses:

- All vital functions of societies and various globally functioning organizations are dependent on cyber-space.
- All operations on the common domain require various kinds of information sharing activities.
- When seeking cooperation with various actors there will be no overtaking authority to take a role over collaborative parties, because that would be inappropriate and counterproductive.
- Comprehensive information sharing framework will enhance the overall understanding about producing and distributing relevant information in various situations.

Information domain can be divided in two main areas. First one is the contents of the information. Content is typically defined by requirements of doing something. Content is related to subject of particular interest. The other main area is the information framework. (Von Solms 2000) This can be referred as the universal level of the information domain. This universal level describes the information phenomena of the situation under concern. It defines general information exchange features of getting together and dealing with challenges no matter what they are. This universal framework can be illustrated, like it is done in this study, with a human oriented information categorization model. The model acts as a frame of reference to typify information requirements in different phases of networking activity. The model is an approach to the ontology of human information handling in a context of a complex adaptive social system (Holland 1996). Theoretical basis for modeling this human information exchange is based on philosophy of communication and cognition, theory of knowledge management, sociology, and decision-support systems.

The research question of the paper is: “In what manner can various approaches of the information exchange and assurance be combined together to develop a comprehensive model to enhance the construction of information exchange solutions.” Approach to information is framework and universally oriented pursuing to increase understanding about information exchange situations offering user focused approach to develop dynamic knowledge discovery solutions. The scientific approach is hermeneutical supported by validating empirical results. The research approach is cross-disciplinary. Research strategy is constructive pursuing to develop a generic model for practical purposes.

1. Theoretical background

1.1 Complex adaptive systems (CAS)

The theory of complex adaptive systems (CAS) by (Holland 1996) aims at to explain the chaotic nature of multi-actor interactive system on the viewpoint of one actor. The CAS theory seeks understanding of the adaptive behavior of an entity in its acting environment by categorizing its basic features. CAS theory divides these basic elements in four properties and three mechanisms. Very brief description of those is given below. More detailed information is available e.g. from (Kuusisto 2009).

1. Aggregation is a property of an entity. It defines that an entity seeks to categorize same kind of things in same kinds of classes, like vehicles, organizations, plants, animals, etc and after this classification treat the members of those classes as equivalent.
2. Tagging is a mechanism that gives a descriptive symbol (name) for an aggregate.
3. Nonlinearity is property that expresses that the outcome of the whole is not the sum of its parts.
4. Flow is property that tells what transfers between building blocks. Flow can be information, material, radiation or symbol.
5. Diversity is property that tells that wholeness contains certain (various) amount certain (different) kinds of nodes that have suitable role in that wholeness.
6. Internal modeling (or schema) is mechanism that causes certain behavior of an entity, when certain stimulus occurs.
7. Building blocks form the mechanism that enables to construct models in a simple way. (Holland 1996, 10-40)

A CAS entity is depicted in Figure 1.

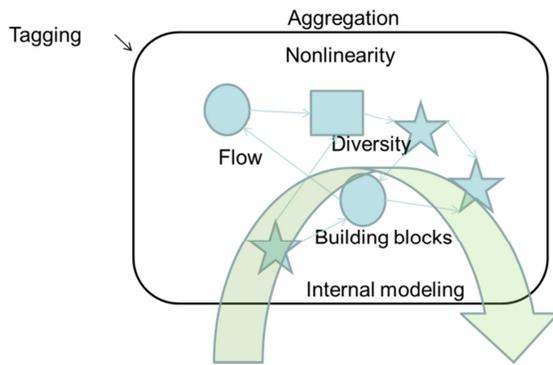


Figure 1: A CAS entity

The world can be considered as a complex system of complex systems. It is neither random nor accidental. It is a collection of systems' elements with certain kinds of universal features and the continuum of their interrelations. This makes the world act in a non-deterministic way. This apparently fuzzy behavior becomes understandable if we perceive the system at the right structural level. (See Ball 2004, Kauffmann 1995, Moffat 2003)

Complex adaptive systems theory describes fundamental phenomena of interacting community on the viewpoint of one entity. When this theory is applied to human communication activities, the next often revealing features can be stated as hypotheses.

1. People like to categorize the exchanged information. Typically information is categorized by content and it is defined by subject of interest. Information exchange strategies are based on these content based aggregations. The behavior of the wholeness is judged on behalf of aggregation of those content based information categorization models.
2. Social communication networks are defined by subject of interest. The name – tag – of interest guides people to form networks with such people, who express same kind of tags. Communication networks are based on similarity in content.
3. The outcome of nonlinear interacting system is emergent thus being out of individual control. This emergence is frequently attempted to tame with complicated information categorization models and precise procedures.
4. Information flow between various interactive entities is attempted to facilitate or moderate to make it controllable. The flow is controlled by content and amount. Second order effects are typically not taken account.
5. Diversity of actors in networked communication situations is wide and complex. Diversity can be organization structure, information handling role, interaction phase or information content based. Typically diversity is seen case by case without taking account the comprehensive wholeness. Universal phenomena of diversity are seldom taken account.
6. Internal models are based on existing experiences, competence and valuations of an entity and they are evolved by incoming perceptions. The evolution of internal models is relatively slow thus making novel communication situations with unseen parties somewhat challenging.
7. Because of the content based strategy of information exchange the building blocks of creating common models for releasing and receiving relevant information will be different amongst different communicative actors. This makes communication challenging, while different actors are speaking on different context.

The above statements represent typical practical level presentation about on information exchange situations between human individuals. However, this paper seeks to present some new approaches

to interpret CAS at communication situation and context level instead of communication between human individuals. Aggregation will be shifted from dialogue content to dialogue situation.

1.2 Information sharing strategies

Creating understanding is difficult. The world outside the subject may reveal itself as digital. It is right or wrong, good or bad; I either accept it or I reject it. According to Habermas (1984, 1989), at least one common item between the communicative parties shall exist to launch communicative process. This process is essential to get common activities in realization. Various information sharing strategies may be chosen to create this understanding, acceptance and cooperation. Following information releasing strategies can be expressed:

1. I share everything.
2. I share nothing.
3. I share to suitable degree by rationing out with nominated (subjective) criteria.
4. I share to suitable degree by releasing relevant type of information content related to criteria defined by working environment and situation.

More detailed description of information sharing strategies can be found from (Kuusisto 2009). Strategies 1, 2 and 3 are more or less content based strategies that are based on fundamental assumption that right kind of content of shared information is main judgment criteria. Strategy 4 is framework based strategy that assumes that certain situations with certain kinds of actors form the framework that defines information exchange requirements. This strategy is network and inter-working oriented. It takes account both subjective information releasing criteria and objective collaborative parties viewpoints. It focuses to the communication situation instead of communicated content thus pursuing to create situation and context based communication forums to enhance the maturity of cooperative communication. Strategy 4 relies on the understanding of the universal fundamentals of communicative situations.

Complex, comprehensive framework based information exchange strategy is based on rather simple logic of perceiving complex information exchange systems as follows. "I cannot exactly know the specified content information needs of my partners, but I can know the overall features of the working environment and the situation, where my partners are. If I know this, and I know what types of information (what kind of information exchange profile) is required to handle this kind of situation I can guide (and maybe control) my information publishing towards to release situation bound relevant kind of information and avoid to release unnecessary information." This requires that commonly accepted strategy based on common vision exists. Further on, this requires that situation understanding exists. In this study, it is assumed that above described information sharing strategy 4 will function in more sufficient way in networked environment than the other ones. More information about this is in (Kuusisto 2009).

An example of a supporting structure for various actors to adopt complex information sharing strategy is described in (Kuusisto 2008b) as a generic reference of collaboration support system (CSS). This particular CSS is assumed to be an information releasing and exchange forum for various organizations that are working on the same operational area. It gives a new viewpoint to collaboration field by expanding the collaboration situation to an environment, where divergently view-pointed and oriented organizations will seek and establish collaborative relationships instead of organizing cooperative situations with relatively equally based organizations or parts of one particular organization. This CSS information sharing architecture is depicted in figure 2.

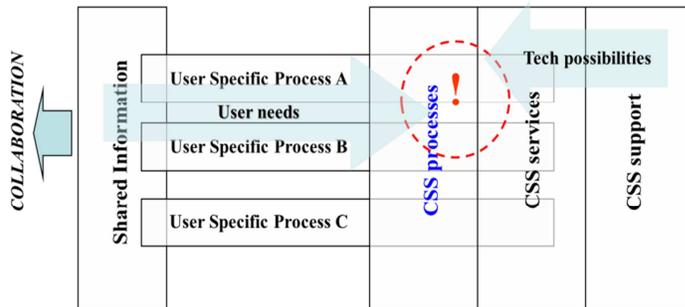


Figure 2: CSS information sharing architecture. (Kuusisto 2008b)

Using complex information releasing strategy, a new set of CAS-feature based hypotheses can be set to shift from content based thinking to framework based thinking in information sharing.

1. Aggregation shall be done on the basis of collaboration context and situation instead of communicated information content. Second order aggregation describes in that case the nature of cooperation instead of the meaning of each collaborative party.
2. Tagging is formed around the four-dimensional matrix defined by the role of information handler, phase of collaboration, level of organization and the interest of organization. Tagging supports context and situation based aggregation.
3. Nonlinearity is not tamed. Information exchange processes are meant to support various parties to deliver such information that will be effective in tagged situations.
4. Information flows are controlled by the demands of collaboration context and situation instead of one or several parties' agreements of releasable information. Each collaborating party releases such information that is relevant for tagged collaboration aggregation, not their core business. Core business information flow is meant for each party's internal use.
5. Diversity is not controlled or forced. Critical mass of various actors guarantees that all relevant acts will be done. Processes are used to encourage big enough amount of actors to involve to each tagged aggregation to guarantee critical mass.
6. Individual tacit internal models are not tried to harmonize. Tagged context and situation based aggregation's overt internal models shall be communicated in continuous dialogue. That guarantees that all individual actors involved to tagged situation have same understanding about the situation and the direction of the development of the comprehensive completeness. This means that situation understanding shall be created in continuous future oriented dialogue process amongst co-operating parties.
7. Building blocks are situations instead of organizations or other actors. The outcome of the comprehensive context will be constructed as a system of situations rather that system of actors. A shift from physical structures world towards the space of information can clearly be seen.

1.3 Information exchange model

Actors' interests to information can be categorized in several ways, e.g. on time axis, based on information content, based on the role of a particular actor or based on the phase of activity. Information interests differ from one situation to another and also from one actor to another. All these interest viewpoints exist during the situation where actors are involved. A unified and abstract enough structure of describing information shall be needed to get an idea, what type of information various networking situations may require.

Theory for deepening the understanding about complex information exchange situations originates to complex adaptive systems. (Holland 1996, Kauffman 1995, Ball 2004) In this paper, the human information exchange framework is based on communication philosophy (Habermas 1984, 1989), sociology (Parsons 1951, Luhmann 1999), cognition philosophy (Bergson 1911, Damasio 1999, Merleau-Ponty 1968), organizational culture (Schein 1992, Hofstede 1984), knowledge management (Polanyi 1966, Maier 2002, Nonaka&Takeuchi 1995, Awad&Ghaziri 2004) and decision support systems (Turban et.al 2005, Marakas 2003). Empirical material is collected during national and international inter-organizational cooperation exercises between 2005 and 2008. Individual results of those studies have been published on academic conferences and research reports (Kuusisto and Kuusisto et.al. from 2006 to 2008). In this paper, information exchange situations will be approached via the theoretical-practical motivated framework described in those papers.

This high-level abstraction of human information handling ontology is depicted in Table 1. Rows describe the temporality and abstraction degree of information. Information at the upper row is relatively most abstract, future oriented and its effects are long-lasting. The lowest level contains information that updates fast, is concrete and is observable as immediate events. The column on the left contains cultural information described by Schein (1980 & 1992). The next column on the left contains actors' internal information. The next right contains information of expressed conclusions made by the actor. The column on the right describes information that comes from outside of an actor or is remarkably affected by the world outside the actor itself. More detailed description of the model is in (Kuusisto 2008b and Kuusisto 2010). This ontology of human information handling structure is used to analyze various and different information sharing and information exploitation situations.

Table 1: The high-level abstraction of human information handling ontology

Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions	Mission, vision	Decision	Task
Socially true values	Means	Alternatives to act	Foreseen end states
Physically true values	Resources	Possibilities to act	Anticipated futures
Social artefacts	Action patterns	Restrictions	Environment
Physical artefacts	Features	Event model	Events

This model has been successfully used in information exchange research and it has been tested on international scientific forum. The model expresses a universal tagged aggregation to understand information flows of an active entity in a diverse and nonlinear networked environment and position entity's information exchange situation into a structured schema. This is essential, because comprehensive social system is emergent, dynamic and complex. Further on deep pondering about information strategy that can be as optimal as possible for smooth acting in that kind of working environment is required.

2. Approaches for information sharing

2.1 Common interest, organizational level

Organizations have different structures. However, organizations are formed and operated by human beings, who exchange information in a human way. That makes all organizations – despite their different structures – act among similar principles.

Information content is one of the criteria taken account when constructing information exchange systems and practices. In this paper we are not concentrating that viewpoint, because information content-based approaches are frequently handled while constructed various decision-support systems. Obviously, the content of exchanged information shall be such that collaborating parties can feel it to be relevant for their own or commonly conducted activities.

According to the operating level of an organization or its part (strategic, operational, tactical, operating), the nature of the information content obviously varies. Strategic management deals with completely different content issues than operators on the field. This means that information content shall be taken account when designing various kinds of technological support systems for organizations. This does not mean that information content is the only criteria for this design and construction process. Also, this does not mean that the generic information interest profile of certain kinds of actors in organizations is different. Decision-makers are interested in same type of information despite on what level they are in the organization. That is the phenomena we are delving in during following chapters.

2.2 Role of an actor

Several various inter-authority collaborative exercises and experiments were studied during 2005 – 08. Information interest of various actors and situations were studied by using the information exchange meta-model (Table 1) as a framework and content analysis (Krippendorff 1980) as a method. It was find out that information interest of an actor varies related to the role of an actor and the phase of the activity. It was found that information interest profiles formed in very different way in these various cases. More detailed description of those studies and their results are found from (Kuusisto, et. al 2006a, 2006b, 2007, Kuusisto 2008a, 2008b, 2009, 2010).

The information interest depends on the task or purpose of the actor in an organization. According to conducted research, four various typical roles of actors were found. (e.g. Kuusisto 2008a) Those roles were: situation follower, Information analyst, planner and decision-maker. The information interest profile of those different roles differs rather drastically from each other's. A much generalized depiction of this disparity of the information interest between various roles is in Figure 3. Figure shows highlighted those information categories that seem to be mostly under the keen interest of the actors. It shall be noticed that this description does not give complete explanation about the variance of the various roles information exchange profiles. This description depicts the phenomenon.

Decision-maker	Values, Competence	Internal facts	Conclusions	External facts
	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
Planner	Physical artefacts	Features	Event model	Events
	Values, Competence	Internal facts	Conclusions	External facts
	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
Information analyst	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events
	Values, Competence	Internal facts	Conclusions	External facts
	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
Situation follower	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events
	Values, Competence	Internal facts	Conclusions	External facts
	Basic assumptions	Mission, vision	Decision	Task
Situation follower	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events

Figure 3: The disparity of information interest of various roles of an actor.

2.3 The phase of activity

According to what is going on in the organization or between organizations, the information interest profile will vary. Four different phases of activity was recognized in previous studies (see e.g. Kuusisto 2008b). Those are: Searching for cooperation party, Information preparing for the mission planning, planning the mission and executing the mission. A much generalized and brief conclusion about the information exchange profiles is depicted in Table 2. Again, it shall be remembered that this depiction does not give complete explanation about the variance of the various situations information exchange profiles. This description depicts the phenomenon.

Table 2: The variance of information interests between different situations

<i>Searching cooperation party</i>			
Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions XX	Mission, vision XX	Decision	Task X
Socially true values X	Means XX	Alternatives to act	Foreseen end states
Physically true values X	Resources XX	Possibilities to act	Anticipated futures
Social artefacts	Action patterns XX	Restrictions	Environment
Physical artefacts X	Features XX	Event model	Events

<i>Information preparing for the mission planning</i>			
Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions	Mission, vision	Decision XX	Task
Socially true values	Means XX	Alternatives to act	Foreseen end states
Physically true values	Resources XX	Possibilities to act X	Anticipated futures X
Social artefacts	Action patterns X	Restrictions XX	Environment
Physical artefacts	Features	Event model X	Events XX
<i>Planning the mission</i>			
Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions	Mission, vision	Decision	Task
Socially true values	Means XX	Alternatives to act XX	Foreseen end states X
Physically true values	Resources XX	Possibilities to act XX	Anticipated futures X
Social artefacts	Action patterns	Restrictions XX	Environment X
Physical artefacts	Features	Event model	Events
<i>Executing the mission</i>			
Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions	Mission, vision	Decision XX	Task X
Socially true values	Means X	Alternatives to act	Foreseen end states
Physically true values	Resources XX	Possibilities to act	Anticipated futures
Social artefacts	Action patterns XX	Restrictions	Environment X
Physical artefacts	Features XX	Event model X	Events XX

The most important information in network foundation phase will concentrate to every actor internal facts added with values and competence information. (See Table 1.) In addition, information about all working environment features and issues was found crucial to successfully work on the area.

In tactical planning situation, information in the middle of the model comes important in addition to situation follow-up and decision information releasing. During briefings, discussions raise up mainly about available means and resources and about possibilities and alternatives to act, as well mutual restrictions for activities. In the case of small group decision-making discussion, the general information releasing profile was quite equal to the one with briefings. What comes into the discussed information categories, still the means and resources items were found to be important, but discussion about alternatives to act moved towards to anticipate the future and to evaluate the possible end-states of overall activity. Discussing about mutual future orients parties to work together more longer periods than to only deal with the emerging issues.

If time is critical, e.g. decisions and choices are done in quickly changing situations, some of the information categories seem to emphasize more important than others (Kuusisto 2005). This phenomenon is depicted in Table 3. It seems that such information that leads to the final decisions required by mission and task becomes more important when time to make decisions gets reduced. Resources, alternatives and futures expectations will rise under interest. The result is rather obvious.

Table 3: Time criticality of the required information

Values, Competence	Internal facts	Conclusions	External facts
Basic assumptions	<u>Mission, vision</u>	Decision	<u>Task</u>
Socially true values	Means	<u>Alternatives to act</u>	<u>Foreseen end states</u>
Physically true values	<u>Resources</u>	Possibilities to act	<u>Anticipated futures</u>
Social artefacts	Action patterns	Restrictions	Environment
Physical artefacts	Features	Event model	Events

2.4 Cooperation maturity

According to Alberts & Hayes (2007) management (or interaction) maturity transformation is described with five-phased model, where level of interaction maturity describes the level of operational maturity. Interaction maturity levels are (from less interactive to most interactive): Conflicted, de-conflicted, coordinated, collaborative and agile. (Alberts & Hayes 2007, 164) The phenomena of those levels are described (Alberts & Hayes 2007, 165-179. The command and control (C2) maturity model has been under development in NATO working group from the beginning of the year 2006. The process has its motivation in discovered need to develop command and control practises in socio-technically networked cooperation environments.

It was observed that information exchange meta-model applied to the C2 maturity model and analyzed real-life collaboration situations information exchange profiles were not completely equal. However, it was very interesting to find out that uniqueness between these two situations was observable. Referred to that, following hypothesis can be postulated: “The information exchange profiles concerning de-conflicted, coordinated and collaborative activity situations can be formulated in a way that is expressed in figure 4.” Because the information refining process progresses from the bottom of the model towards the final decision, and from sides toward the conclusions category, it is logical to make assumption that the higher the required collaboration maturity level is the higher and broader both the released and discussed information will disperse over the information exchange meta-model. Empirical results support this hypothesis. The judgment and critics for that approach is given more detailed in (Kuusisto 2008b). Information concerning the situation under interest is exchanged in different intensity according to the maturity level of cooperation. Figure 3 depicts the general phenomena of this information exchange modeled by the information exchange meta-model described in chapter 1.3. Information is changed about those categories that are shaded in figure 3. Those categories that are surrounded by dotted line are openly discussed between collaborative parties. Conflicted maturity level is not described, because no information is exchanged. On the agile level everything is discussed, so that level is also not described.

De-Conflicted	Values, Competence	Internal facts	Conclusions	External facts
Situation is followed together	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events
Coordinated	Values, Competence	Internal facts	Conclusions	External facts
Situation is followed together and plans are made jointly	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events
Collaborative	Values, Competence	Internal facts	Conclusions	External facts
In addition, information is analysed and decisions are made together	Basic assumptions	Mission, vision	Decision	Task
	Socially true values	Means	Alternatives to act	Foreseen end states
	Physically true values	Resources	Possibilities to act	Anticipated futures
	Social artefacts	Action patterns	Restrictions	Environment
	Physical artefacts	Features	Event model	Events

Figure 4: Information exchange requirements on various cooperation maturity levels.

Properly functioning collaboration support systems will help organizations to orient to more collaborative, coordinated or agile working principles. With a good methodology the on-line evaluation of the maturity level of collaboration procedures of organizations can be performed. That will help to evaluate and develop both organization related processes, collaboration system processes and inter-organizational processes. Further on this will help organizations to move towards the edge and gain good performance of effects.

2.5 Conclusive findings

As a conclusion it can be argued that improvement of harmonizing the efforts on the field would need a concept that provides as good a system as possible to improve the potential of information sharing of the information of the working environment and the features and action patterns of all actors in emerging and non-lead networking communication and acting network.

We can postulate that different kind of usage situations require different kind of emphasis concerning the type of the information required to be exchanged. Further on, we can form a hypothesis that different phases of collaboration require different kinds of user supporting processes. The processes shall be such that they guide the user to use the relevant services and release relevant type of information compared to this nominated collaboration phase. It seems that whether conducting operations or activities the sharing of certain information categories between interacting parties is beneficial. This is consistent with Habermas's theory of communicative action (1984, 1989). He claims that to start communication, at least one common item must exist between interacting parties. Interaction and its development are based on this common item. The implication is that to conduct interaction between two or more actors, one or multiple common categories of information must be present. To gain mutual understanding, or to protect one's own information space, interacting parties require common information flows.

Information exploitation profiles differ in the cases of making decisions, and preliminary planning work, the decision-making itself, as well as establishing collaboration relationships, managing various collaboration situations and providing information management and other support. To re-iterate from above, at least one information category must be common between those functions. Information flows pertaining to action alternatives should be managed well, because they join planning and decision-making functions. In general this means that organizations should understand what types information are important for the activities between organizations. This can be used to produce and develop inter-organizational working procedures. Workflows should support information exchange procedures across organizational boundaries to assure the information flow priorities, and to take into account the temporal demands of information exchange. Organizations should gain understanding about information exchange requirements to be able to fulfill the challenges that they face when interacting with other organizations or actors. Commonly used processes shall in collaboration support situation act as a creator of “common virtual organization”.

Information exchange profiles for cooperation shall be determined to optimize interactivity. This interactivity may be directed to the direction of superior, subordinate or peer levels. Those organizations or parts of organizations that are working with the same kinds of issues should have common information exchange profiles. Cooperation can be enhanced when information content priorities and time frames of updating content are consistent across various, collaborating, inter-organizational actors. It can be concluded that to develop inter-organizational working processes, it is essential to identify, develop and exploit interworking information exchange profiles. In crisis management, this means that all of the interacting actors should have shared information flows.

Information content is the traditional way to categorize the needs of the information system user. That is a very good approach, when building up e.g. decision support systems. When collaboration support is dealt with, the user specific information content is no longer the primary engine to drive system development. In that case the phase of collaboration will be important, as well as the role of an individual member of an organization.

Information interests of various actors vary remarkably in time, space and content. Three different classification criteria can be pointed out:

- Information content
- Organizational level
- The role of an actor
- The phase of operation
- Collaboration maturity level

As a conclusion it can be argued that improvement of harmonizing the efforts on the field would need a concept that provides as good a system as possible to improve the potential of information sharing of the information of the working environment and the features and action patterns of all actors in emerging and non-lead networking communication and acting network. Information sharing system shall provide a discussion forum and it shall fulfill the demands of good practices of information and knowledge management. The forum shall contain content of areas of interest of various actors, as well.

Information using profiles differ in the cases of making decisions, and preliminary planning work, the decision-making itself, as well as establishing collaboration relationships, managing various collaboration situations and providing information management and other support. To re-iterate from above, at least one information category must be common between those functions. Information flows pertaining to action alternatives should be managed well, because they join

planning and decision-making functions. In general this means that organizations should understand what types of information are important for the activities between organizations. Workflows should support information exchange procedures across organizational boundaries to assure the information flow priorities, and to take into account the temporal demands of information exchange. Organizations should gain understanding about information exchange requirements to be able to fulfill the challenges that they face when interacting with other organizations or actors.

Information exchange profiles for cooperation shall be determined to optimize interactivity. This interactivity may be directed to the direction of superior, subordinate or peer levels. Those organizations or parts of organizations that are working with the same kinds of issues should have common information exchange profiles. Cooperation can be enhanced when information content priorities and time frames of updating content are consistent across various, collaborating, inter-organizational actors. It can be concluded that it is essential to identify, develop and exploit inter-working information exchange profiles.

Collaboration relationships are building up in a complex way, where structuring principles depend on the organizational structural level, the mission of an organization, the phase of the collaboration process, and the role of the member in an organization. First two determining the relevant information content and latter two ones obey the framework of the relevant type of information. It is crucial to find out and understand also what type (not only the content) of information shall be put available for others in collaborative network. This typifying requires an internal model of entity's information exchange. This model shall be universal, i.e. equivalent despite of the parameters of the information exchanging node (actor). Parameters are here understood as the position in the organization, role in the organization, phase of activity and task-oriented information interest.

Research results concluded above give a steering hunch to ponder that novel idea shall be produced to rethink information exchange strategies in a new way. It is obvious that traditional ways to steer information exchange are not so optimal in emergent networked environment.

When setting the information handling ontology (table 1) in different shape and connecting both the phases of operation and the various roles of acting entities into that, we can formulate a comprehensive expression about common information needs. This depiction reveals not only the individual case by case information needs but also those common interest areas that will glue together actors with different roles and those information issues that will lead the organization from one activity phase to another. This depiction will help to understand to which kind of information issues organizations shall concentrate to guarantee smooth operating and cooperation both internally and between other organizations.

Let us take some examples. In the phase of searching cooperation possibilities, a situation follower searches information about the features of possible collaboration parties. At the same phase, decision-makers are interested in the information about the basic assumptions (basic values) and the mission and vision of the possible partners. He or she is also interested in how this possible partner will reach its goals (means) and to some degree about its task and published values, as well. Another example reveals that in mission planning phase, the common information interest of the planner and decision-maker is in means, alternatives to act and foreseen end-states. Those actors will exchange information about where to organizations most probably ending, in what ways it will end there and what are the actions to take to reach that end-state. It shall be remembered that the depiction in figure 5 is very brief and generalized. It does not give explicitly correct answers, but gives again a good view into the complex phenomena of information exchange situations.

When maturity level abstractions (Figure 4) are connected to the model depicted in Figure 5, we can reach again a new level of understanding about the demands of constructing information exchange systems. Let us assume that collaboration is on de-conflicted level. On that level, discussed information category is “restrictions”. Restrictions tell those situational and organizational borders inside which own activity is possible and relevant. According to the combinatory model in Figure 5, this means that information analysts of all participating organizations shall be connected together to discuss during the complete mission planning preparation and planning process.

	Partnerizing	Planning prepared	Planning	Execution
Decision maker	Basic assumptions	XX		
	Mission, vision	XX		
	Decision		XX	XX
	Task	X		X
Planner	Socially true values	X		
	Means	XX	XX	X
	Alternatives to act			XX
	Foreseen end states			X
Analyzer	Physically true values	X		
	Resources	XX	XX	XX
	Possibilities to act		X	XX
	Anticipated futures		X	X
Situation follower	Social artefacts			
	Action patterns	XX	X	XX
	Restrictions		XX	XX
	Environment			X
	Physical artefacts			
	Features	XX		XX
	Event model		X	X
	Events		XX	XX

Figure 5: Combination of role- and activity-phase related information interest profiles.

3. Information sharing framework

Information sharing in cooperation situations is somewhat complex by nature, as we have noticed above. Compared to the information sharing strategy that was selected as the one to be obeyed earlier in section 1.2, we can postulate that there shall be a common process layer to enable information sharing between very various actors in various situations. This process layer shall support information exchange despite various users’ different ways to act and different kinds of information content interests. This process layer shall not harmonize the ways to act of collaborating parties but enable smooth information flow. The process layer shall support communication hypotheses set at the end of chapter 1.2. Figure 6 depicts that. Common information sharing process shall support differently acting organizations to fulfill their common interest taking account the activity level of cooperating organizations (operating ... strategic), phase of cooperation and roles of cooperating entities at the required cooperation maturity level.

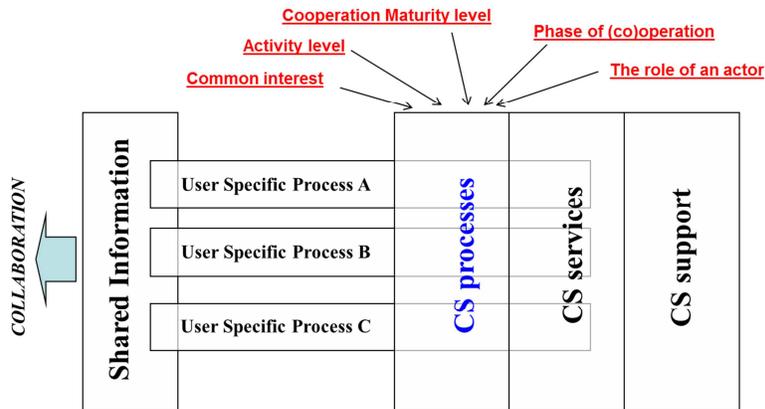


Figure 6: Issues taking account to construct well-functioning collaboration information sharing system

How to construct such a process layer? Figure 7 gives some guidelines for that. It describes the information sharing framework for agile command and control in complex inter-domain collaboration environment. The framework contains the structure of collaboration situation, activities of various collaboration cases and information that is relevant to share during collaboration. The model is a matrix, where information sharing takes place in the crossings of structure and activity. Information sharing requirements are modeled by using the comprehensive model depicted in figure 5.

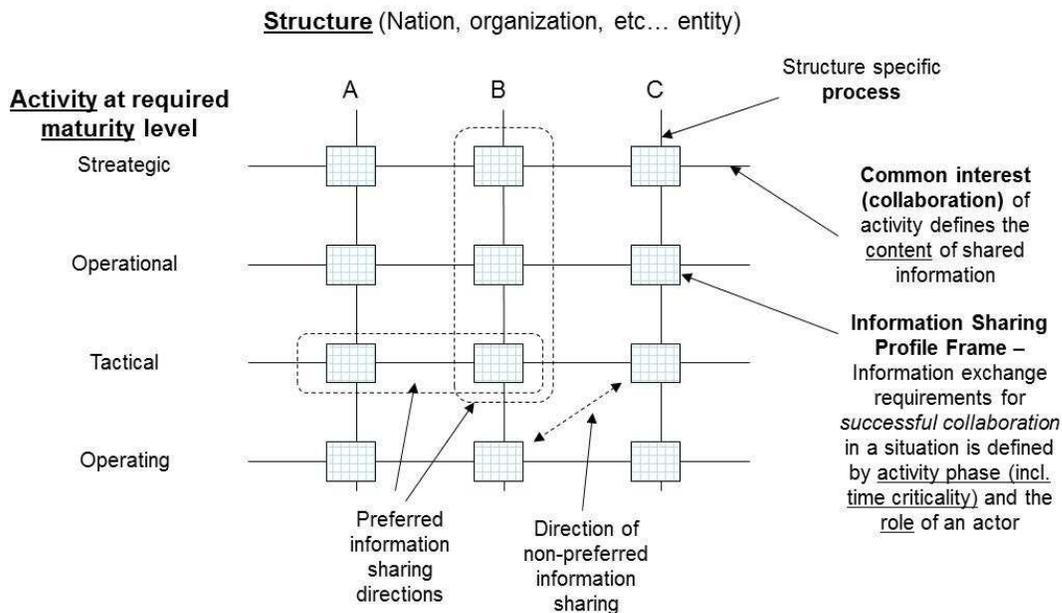


Figure 7: Information sharing framework for agile command and control in complex inter-domain collaboration environment.

Structure determines those entities that are involved to certain kind of collaborative activity. The entities may be coalitions, nations, organizations, etc. The entities need not to be same kinds of. A variety of entities working together may exist in that model. Only determining issue is that those

entities shall have some common interest of working together. This common interest defines the content of exchanged information. Those together working entities will be connected together at a certain operating level. Strategic levels are connected to strategic levels and tactical levels to tactical. Organizations are working as organizations without trying to supervise or master other organizations sub-parts. Communication between organizations takes place on peer-level. Communication inside organizations takes place how the organization has it determined. Every organization obeys its own practices. Collaboration is conducted at required maturity level. The phase of activity, the role of an actor and the required maturity level define the type of exchanged information. The type of information is not dependent of the common interest of cooperating parties but the overall situation to be dealt with.

4. Discussion

An information sharing framework for agile command and control in complex inter-domain collaboration environment was presented. It takes account not only the content of information but before all, the entire context, where information exchange situation takes place. This framework model helps to construct better functioning situation based information exchange and situation awareness systems in ever evolving and complex collaboration environment consisting of global commons glued together via cyber space.

It shall be taken account that the data presented in this paper is not accurate as a data itself. The meaning of the data was to demonstrate the complex nature of the information exchange requirements in the multi-actor, networked working environment. Lots of generalization of the data was made to refine the nature of the fundamental phenomena of assuring the information required for comprehensive situation awareness and successful cooperation in complex inter-domain environment.

Lots of research work needs still be done, before we can confirm all those hypotheses presented in this report. However, the basic features and relevant phenomena of releasing the right kind of information for cooperation were documented. Research shall be continued in a more detailed way to get various information exchange situations requirements confirmed in more precise way.

REFERENCES:

Alberts, D.S. & Hayes, R.E. (2007), *Planning: Complex Endeavors*, CCRP, USA.

Awad, E., & Ghaziri, H. (2004). *Knowledge Management*. Upper Saddle River, NJ: Prentice Hall.

Ball, P. (2004). *Critical Mass: how one thing leads to another*. London, UK, Sydney, Australia, Auckland, New Zeland: Arrow Books .

Bergson, H. (1911). *Creative Evolution*, Lanham, MD: Henry Holt and Company, University Press of America, TM Inc.

Damasio, A. (1999). *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*, New York: Harcourt Brace.

Kauffman, S (1995). *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*. New York, Oxford: Oxford University Press.

- Habermas, J. (1984). *The Theory of Communicative Action, Volume 1: Reason and the Rationalization of Society*. Translated by Thomas McCarthy. Boston: Beacon Press.
- Habermas, J. (1989). *The Theory of Communicative Action, Volume 2: Lifeworld and System: A Critique of Functionalist Reason*. Translated by Thomas McCarthy. Boston: Beacon Press.
- Hofstede, G. (1984). *Culture's Consequences: International Differences in Work-Related Values*. Beverly Hills, California: Sage Publications.
- Holland, J.H. (1996). *Hidden Order: How Adaptation Builds Complexity*. Cambridge, MA: Perseus Books.
- Kauffman, S (1995), *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*, Oxford University Press.
- Krippendorff, K. (1980). *Content Analysis: An Introduction to Its Methodology*. Newbury Park, California: Sage.
- Kuusisto, R. (2005). *From Common Operational Picture to Precision Management. Managerial Information Flows in Crisis Management Network*. Publications of the Ministry of Transport and Communications 81/2005, <http://www.lvm.fi/web/fi/julkaisu/-/view/820682>, (In Finnish)
- Kuusisto, R. (2006). Flowing of Information in Decision Systems, *Proceedings of the Thirty-Ninth Annual Hawaii International Conference on System Sciences, (HICSS-39)* Kauai, Hawaii, USA, January 4 – 7, 2006, Abstract on page 148, Full paper published on electronic proceedings and on: <http://csdl2.computer.org/comp/proceedings/hicss/2006/2507/07/250770148b.pdf>, pp: no page numbers.
- Kuusisto, T. & Kuusisto, R. (2006). System Modeling Approach to Network-Enabled Defense, *Proceedings of 2006 Command and Control Research and Technology Symposium (CCRTS)*, San Diego, USA, June 20-22, 2006, pp: no page numbers.
- Kuusisto, T., Kuusisto, R., Lund, O.-P. & Mikkola, T. (2006a). Information Flow Aspect on the High-Level Tactical Managing, *Proceedings of International Conference on i-Warfare and Security*, Monterey, 15-16 March, 2006, Baltimore, USA, pp: 131-136.
- Kuusisto, T., Kuusisto, R. & Seppänen, H. (2006b). Geographic Information Management in Brigade Level Decision-Making, *Proceedings of the 5th European Conference on Information Warfare and Security*, Helsinki, Finland, pp: 151-159.
- Kuusisto, R, Huttunen, M (2006). "The Emerging Combination of the Principles of War in the Networked IW Environment, *ECIW 2006*, Helsinki, June 2006, Finland.
- Kuusisto, T., Kuusisto, R., Nissen, M. (2007). "Information Flow Aspects of Inter-organizational Crisis Management", *Journal of Information Warfare*. 6(2), 39-51.
- Kuusisto, R. (2008a) "*SHIFT*" *Theoretically-Practically Motivated Framework: Information Exchange Viewpoint on Developing Collaboration Support Systems*, Finnish Defence University, Department of Tactics and Operation Art, Series 3, No 1, Helsinki 2008: Edita Prima Oy.

Kuusisto, R. (2008b). "Analyzing the Command and Control Maturity Levels of Collaborating Organizations", *Proceedings of 13th International Command and Control Research and Technology Symposium (13th ICCRTS)*, Bellevue, WA, June 17-19.

Kuusisto, R. "Choosing Information Sharing Strategy on Collaboration Networks", in *proc of 14th International Command and Control research and technology Symposium (14th ICCRST)*, USA, June 2009.

Kuusisto, R. (2010): "User Approach to Knowledge Discovery in Networked Environment", in Syväjärvi, A and Stenvall, K (eds.) *Data Mining in Public and Private Sectors: Organizational and Government Applications*, © IGI Global, Hershey, New York.

Luhmann, N. (1999). *Ökologische Kommunikation, 3. Auflage*. Opladen/Wiesbaden: Westdeutcher Verlag.

Maier, R. (2002). *Knowledge Management Systems. Information and Communication Technologies for Knowledge Management*. Berlin, Heidelberg, New York: Springer-Verlag.

Marakas, G.M. (2003). *Decision Support Systems In the 21st Century*, New Jersey, USA: Prentice Hall.

Merleau-Ponty, M. (1968). *The Visible and Invisible*. Evanston, IL: Northwest University Press.

Moffat, J. (2003), *Complexity Theory and Network Centric Warfare*, CCRP, USA

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company*. New York, New York: Oxford University Press.

Parsons, T. (1951). *The Social System*. London: Free press of Glencoe.

Polanyi, M. (1966). *The Tacit Dimension*. Cox & Wyman Ltd, London, Fakenham, Reading: Cox & Wyman Ltd.

Schein, E.H. (1980). *Organizational Psychology (3rd ed.)*. Englewood Cliffs, N.J., Prentice-Hall (first published 1965, 2nd ed. 1970).

Schein, E.H. (1992). *Organizational Culture and Leadership, (2nd ed)*. San Francisco, USA: Jossey-Bass.

Turban, E., Aronson, J.E., Liang, T-P (2005). *Decision Support Systems and Intelligence Systems*. New Jersey, USA: Pearson prentice Hall.

Von Solms, B. (2000). Information Security - The Third Wave? *Computers and Security*, 19(7), 615-620.