Formal Approach Of The Interoperability Of C4IRS Operating Within A Coalition

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We observe currently that more and more nations are often involved in international coalitions to face at either a crisis or an emerging minor conflicts. These coalitions are formed for the purpose of increasing efficiency, by the coordinated action of military means and the gathering of their relating technical systems : networks, C4IRS. The merging of these systems generate situations at times technically new and complex.

The major problem we have to cope with is to make systems cooperated, most of the time **heterogeneous**; as a result of which, they present big deficiencies at interoperability level. One can object that it is always possible to solve this question by making gangways. In that case, one should be aware of what represents a temporary solution. What is more, this solution cannot be easily and reasonably generalized Which is necessary is to provide all systems entering in a cooperation with **interoperability mechanisms** in order to make these systems (inter)cooperated.

We intentionally use the verb i**ntercooperate** to highlight the new needs differing completely from the simple exchange messages, as they can arise from these following statements :

- To exchange knowledge, the validity of which is depending on time,
- To exchange know-how in operating process and methods application.
- To contribute to elaborate tasks belonging to dynamic processes.
- To share, in timely and appropriate conditions, useful knowledge for the evolution and the action of other

for mal approach basis

In our view, interoperability must be only considered as a **prerequisite of intercooperability**. In that scope, we will establish a clear distinction between three different domains that must be taken into account in such a approach. All systems which are put in relationship in the cooperation must have certain criteria and characteristics which are defined in these domains. What's more they are relevant of techniques and ways of modeling which are very different.

(1) (Inter)connectivity

That concerns essentially all necessary means to allow systems to communicate with each other, through a liaison and its relevant software mechanism. We will consider interconnectivity in our approach as a **prerequisite of interoperability**.

(2) Interoperability

If we consider now that C4IRS systems must exchange more than simple messages, i.e. knowledge, we address another problem, pertaining to the domain of interoperability. When we evoke this term, we must go beyond interconnectivity framework, because the exchange of knowledge supposes that we have symbolic representations to carry this knowledge. Moreover, C4IRS systems in the future will be called, to bring each other a mutual assistance (a requisite in the NATO definition of C3IS) in their cooperative actions to reach a common objective. In such a perspective, C4IRS systems must be in position to have a mutual comprehension of what they are doing, of what processes they are running, etc. At that point, we have to determine modalities allowing to get ''intelligence'' and how to interpret it, in the exchange mechanisms. In other words, it necessitates the need to **carry meaning**, in proper technical conditions, between cooperative systems. To sum up, we can characterize interoperability domain by the following points :

- A C3I system becomes interoperable when it can organize itself and enriches its exchanges within an **openness structure.**
- The precedent represents a necessary but not sufficient condition in an interoperable exchange; we need in addition to have a common vision of the universe in which systems are going to cooperate with the others .
- To take into account semantics in the mechanism of exchange.

(3) Intercooperability

This represents the final objective to reach, through the definition of a world, in which all (cooperative) systems are able to share all elements constituting their common activity in the cooperation, but also, to take systematically advantage of everything that is appealing to intelligent behavior.

Elements of the approach

We begin by introducing a concept of **openness context** to emphasize the semantic point which will be attached to themes of cooperation (evacuation, medical assistance, etc.) and cooperative systems operating in the coalition. We will define formally a context of openness by a triplet : (S, T, R), where : S, the set of the cooperative systems, the set of the themes specified in the cooperation, R is a binary relation : $R \subset S \times T$.

We next define a notion of **interoperable group** : subset of systems which are totally related to subsets of themes. Therefore it is possible to get symbolic representation (with lattices) of the openness structure of the cooperation (or coalition).

We consider afterwards that an (interoperable) action must be assessed with 3 fuzzy measures : possibility, necessity, credibility.

We define, in a prepositional calculus view, an interoperable competence relation to state if system is able to say if such an action is normally interoperable in a fixed system's world, fixed by the coalition. That enables us to get successively vectors and matrices of interoperability. They represent an interesting point insofar they give a visibility about the feasible and credible interoperability.

In the intercooperability domain, we go beyond the system's interpretation regarding actions and to see how any systems can interpret the other systems' ability for interoperating on actions. What one can summarize simplistically : (1) interoperability (S^i) $\rightarrow$ system S^i interprets [S^i (interoperability) / {action(s)}], $\forall$ i $\in$ [1, n], (2) intercooperability (S^i) $\rightarrow$ systems $\{S^k\}$ interpret [(S^i) interoperability /{action(s)}], $\forall$ i, k $\in$ [1, n]. We define a relation of intercooperability competence in the same way we do for the interoperability competence We consider that a system has a competence in intercooperability when, it is able to « judge » the ability of adjoining (cooperative) systems, to interoperate on a set of actions, in a time window θ, fixed by a mission.

In applying this relation we get successively vectors and matrices of intercooperability. The two kinds of matrices present very interesting points because they entitle us to determine parameters which highlight some aspects about interoperability mechanisms like formalization of a consensual point of view.