Changes in the Military Information Interoperability Environment

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Abstract
The present paper focuses on the IT interoperability environments as well as on IT systems related to the IT environment, such as those devices that are indirect, without human interaction, information exchange relation with the given system.

We set forth to categorize, classify and analyse the IT interoperability systems and to find their applicability in the field of military action. In the changing international security environment, and as a consequence of changes in nature of military operations, and structure of forces, the traditional interoperability solution is less and less appropriate.

Introduction
Prior to the NATO Prague Summit NATO defence ministers, as a preparation of Prague Capability Commitment, identified four key operational capability areas. These included the improvements in interoperability of deployed forces\(^1\). Operational interoperability is a mutual capability of actors to ensure a successful and efficient cooperation that requires appropriate level of interoperability on different functional areas (such as command and control, intelligence, logistics, etc.). All functional area interoperabilities are based on information interoperability, and technical interoperability\(^2\).

An essential condition of ensuring all the interoperability types mentioned above is interoperability of military IT systems. According to the basic NATO document on this topic “Common-funded NATO C3 systems must be fully interoperable and must inter-operate with national systems. Likewise, national systems of members and Partners must inter-operate to enable forces to operate together effectively. NATO, therefore, needs considerably improved interoperability across all levels of the NATO C3 System for the support of functions ranging from political consultation to tactical battlefield operations”\(^3\).

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\(^1\) The Prague Summit and NATO’s Transformation. A Readers Guide – NATO, 2003, p.27


\(^3\) Draft NATO Policy for C3 Systems Interoperability – NATO, 2003, p.5
In practice, interoperability between/among military IT systems first appeared in case of actors working on similar functional, or professional areas, and being in a permanent, and close cooperation. Traditional IT systems’ interoperability solutions, based on standardized protocols and intermediary representations (bit- and character-oriented message formats, common data models), were developed in support of these kind of cooperation. In the changing international security environment, and as a consequence of changes in nature of military operations, and structure of forces, the traditional interoperability solution is less and less appropriate.

Military IT systems must be interoperable no longer only in a limited cooperation area, but in a dynamically changing environment. This requires a new actor-oriented approach of interoperability, and theoretic studies of the concept, and characteristics of interoperability environment. Moreover it is necessary to analyze changes in the interoperability environment of military IT systems.

This publication summarizes basics of information interoperability, and IT interoperability, introduces concepts of actor-oriented interoperability, and interoperability environment, identifies basic types of interoperability environments, and their main characteristics, analyses the changes in the military cooperation environment from the point of view of information interoperability, and finally presents appearance of these changes in the semantic, syntactic, and physical level of the infosphere.

**Community of interest oriented, and actor oriented approaches of interoperability, interoperability environments**

Concept of interoperability, and information interoperability is essentially a relational concept. According to the commonly accepted understanding a specific actor, system, device can not be interoperable in itself, but only related to a well-defined group of actors, systems, devices, in cooperation (inter-operation) with them. So information interoperability is a mutual capability of different actors necessary to ensure exchange of common understanding of information needed for their successful cooperation. Information needs of cooperation are expressed in form of information exchange requirements that define: what kind of information need to be exchanged, between what actors, and in what ways (on what carriers, in what quantity, and quality).

Information exchange between/among cooperating actors can be done with the help of intermediary representations. To ensure efficient cooperation, and meaning-preserving information exchange, it is necessary to select, or develop intermediary representations, and to determine an agreed, common understanding of these representations. So interoperability of a specific actor regarding a given community of interest
means, that he/she is able to use the intermediary representation(s) of the given community, in other words he/she can send information, messages, questions, or receive information, messages, replies with appropriate contents, and in appropriate formats, as if he/she could speak the “language” used in the given community.

Information exchange is possible between people, between people and IT systems, and between IT systems. Traditional information exchange between people implicitly includes information interoperability, that is handling, and elimination of conceptual, or representational differences between affected partners. This is accomplished by people exchanging information themselves, based on their knowledge, and capabilities. They transform their own, acquired, or created information to the intermediary representation (spoken language, written text, drawing, sign group, gestures, etc.), they interpret the given message, carrier content received, and as a result they develop (in fact new) information, that is from the point of view of cooperation similar enough to the information sent.

From the point of view of interoperability between actors, information exchange without human assistance (machine to machine = M2M) between the actors’ IT systems is of a continually growing importance. During exchange, and if necessary, transformation of data stored, handled in IT systems, it is necessary to ensure, that source and target data carry the same meaning, or to be more precise similar enough meaning for cooperation, for all the concerned actors.

So IT interoperability is a mutual capability of IT systems, devices, applications to – if necessary after intermediary transformations – receive, exchange data, preserving the meaning assigned to data by the primary user community. In case of IT systems interoperability is usually described not in respect of an explicit community of cooperating actors, but rather in connection with a given intermediary representation in form of “*-compliant”4.

Questions of interoperability could be studied not only from the point of view of a given community of interest, but from the point of view of the individual cooperation objects. Community of interest oriented approach deals with cooperating objects, the cooperation between them, and the interoperability requirements and solutions during this cooperation. It leaves objects not interested in the cooperation, and other communities, and areas of interest out of consideration. On the contrary actor oriented approach concentrates on the questions of interoperability between a given object and all of his/her cooperating objects, irrespective of the fact, that

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4 For example MIP-compliant, or AWCIES compliant
the given object is in connection with one, or more communities of interest.

In our days questions of information interoperability, and interoperability of IT systems are primarily discussed, and handled in a community of interest oriented approach. But this approach provides solutions for actors, and their IT systems only in an increasingly limited manner. It is basically appropriate only for those systems, that are in permanent connection with IT systems of a well defined, essentially invariable community of interest, and they have practically no information exchange relations with systems outside of the given community of interest. Quantity of such systems is less and less, since information exchange relations between IT systems are determined by relations between actors of infosphere, and the number of their IT systems. In the Information Age information exchange relations between individual actors is remarkably increased, and the application of IT systems, and devices become general.

Interoperability problems of a given IT system and useful solutions determined by characteristics of its IT interoperability environment. To discuss these questions we should define concepts of information interoperability environment, and IT interoperability environment.

Taking the common understanding of the concept of environment as a starting point, information interoperability environment is based on the interoperability relationships of actors, and components of infosphere. Since information interoperability is a mutual capability of actors to exchange information preserving the common understanding, interoperability relations are essentially the same as information exchange relations, because practically in case of all information exchange relation there could arise interoperability problems.

Information interoperability environment can be interpreted from the point of view of a given actor, a group of actors, or in general sense. The basic concept is the information interoperability environment of an actor: the group of those actors with whom the given actor exchanges information, or whose information he/she acquires, and exploits (with or without their permission), and finally the IT systems, devices possessed, and the information handled by these actors.

Information interoperability of a group of actors is the complex of the information interoperability environments of actors forming the group, that is to say all actors, their IT systems, devices, and information, that are in information exchange relation with some member of the group. So we can
talk about the information interoperability environment of an organization, an organizational system, or a mission oriented grouping – e.g. a given brigade, a given arm of an armed force, or forces executing a given military operation.

Information interoperability environment can also be interpreted in general sense. This global information interoperability environment is actually the same as the global information environment, since all actors of the infosphere, at least potentially, are in information exchange relation with other actor, or actors (practically there are not any isolated actors on the infosphere).

Among the information exchange relations, the relations between IT systems, devices without human interaction are a special group with special interoperability questions. So we can define the concept of the IT interoperability environment of a given IT system as all those IT systems (devices), that are in direct, without human interaction, information exchange relation with the given system. IT interoperability environment includes information, or rather data carrying these information, handled, or exchanged by the given systems. In the same way can be defined the IT interoperability environment of a group of IT systems, devices.

Information, and IT interoperability environments can be classified into three types, these are the elementary, combined, and dynamic environments.

The main characteristic of elementary interoperability environment is that information exchange relations of the given IT system are related to a well defined, permanent, close, functional area cooperation. So interoperability objectives of the given system aimed at developing, and maintaining interoperability with IT systems of members of a well defined community of interest. In the given cooperation group, conditions of IT interoperability can be created by preliminary agreements, the intermediary representation (“common language”) can be developed, so the appropriate interoperability solution can be realized and continuously maintained.

The speciality of combined interoperability environment is that the given IT system is in connection with more IT systems, that are members of more previously known community of interest, and these communities develop their interoperability solutions independently of each other, or only a partially coordinated way. Number of these communities is usually few, rarely greater than 2-5. These IT systems know, and use intermediary representations of more communities of interest (“they speak several languages”). Conditions of interoperability in this case can also be created in
advance, the combined interoperability solution for the given system can be previously developed, and continuously maintained too.

In case of dynamic interoperability environment, the given system is in information exchange relation with IT systems of more communities of interest, but the number of communities is significantly higher than in case of combined interoperability environments, and their list is dynamically changing, because some of them appear only in connection with the particular mission (operation). So in contrast with the previous two types, conditions of interoperability can be only partially created in advance, only on the previously known cooperation areas. Interoperability solutions in the dynamically appearing cooperation areas, and relations must be finished, and tailored to the given situation in the course of operations, in the period of preparation, or execution.

The changed cooperation, and interoperability environment

The beginning of the XXI. century is characterized by significant changes in the international security environment, the nature of military operations, the missions, and structure of military forces executing operations, and in doctrinal principles. These changes have definite influence on requirements of interoperability between military IT systems, and on possible ways, and methods of ensuring interoperability. In the following we will analyze and summarize the most important changes has happened (or will probably happen), and their consequences. For this purpose we will take the common vision of the two NATO strategic commanders as basis.

One of the basic element of the allied commanders’ strategic vision is the holistic approach of military operations, and the extension of their relations to other – informational, economical, social, legal, and diplomatic – activities. This involves significant extension in, and continuous development, and changes of information used in preparation and execution of operations.

Other significant element of strategic vision is the change in structure of forces executing military operations, the extension of the circle of cooperation partners, and the evolving dominance of multilaterality. Military operations of our age are planned and executed in a joint, combined-allied, and even coalition-framework, usually established for the given mission, and based on occasional national offerings. Moreover to fulfill their mission the executing forces must establish close cooperation

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5 Strategic Vision: The Military Challenge (By NATO Strategic Commanders) – NATO, 2004
with other, non-military – international, governmental, non-governmental, and civil – organizations\textsuperscript{7}.

From the changes, and characteristics presented before it follows that a given military organization, and its IT system(s) should exchange information with a lot of such other organization and IT system, with whom previously it had no, or only partially had opportunity to come to an agreement, and to create the necessary conditions of information, or IT interoperability. The range of potential cooperation partners spans from the units of the own arm, or own armed force, through the allied, or coalition organizations, to most diverse organizations. At the same time this scale demonstrates the differences in interests, in the closeness of cooperation, in the level of autonomy, and as a consequence in the amount, and characteristics of information exchange relations.

The strategic vision emphasizes the role of information superiority, as a fundamental factor, and the dependence of organizational success on the extensive, and efficient application of information, information processes, information systems, and the services provided by information technology. In the document particularly points out the role, and significance of information (in the first place intelligence) sharing, and creation of situational awareness \textsuperscript{8}. The consequence of this statement is the continuous development in the exploitation of IT systems, applications, and information handled by them, and in the amount of information exchanged between IT systems of different actors.

Finally one of the most stressed component of the NATO commanders' strategic vision is the emerging network oriented approach, that plays a significant role in doctrinal ideas or our age, and its NATO concept, the network enabled capability.\textsuperscript{9} Both on organizational, and system level this approach essentially requires an ability to interconnect with other components on a mission-oriented way, to synergically complement each others capabilities, and an ability to efficiently adjust, adapt, and self-reconfigure to a dynamically changing environment.

According to commonly accepted understanding, network centric force is based on the networking of sensors, gathering information; systems, and devices used in mission execution, exploiting information; and command and control systems, and tools supporting organizational level information processing (analysis, evaluation, and decision). This extremely increases information (data) exchange requirements mainly on

\textsuperscript{8} Ibidem. Points 14., 18., 31.
\textsuperscript{9} Strategic Vision: The Military Challenge. Points 29., 32.
the level of technical systems, and devices. According to network oriented approach a given IT system should be able to exchange (or acquire) information with (from) existing, and newly appearing systems of a cooperative, neutral, and even adversary actors of infosphere.

As a summary it can be stated, that ideas formulated in the NATO strategic vision describe, outline, and prognose such an information interoperability environment, where:

– conditions of information, and IT interoperability should be ensured for a dynamically extending, and a mission-oriented way changing circle of actors of the international security sphere;
– amount of information handled by the individual actors, and exchanged between them is continuously increasing, its content is dynamically changing;
– more and more increasing part of information appears in IT systems, and is exchanged between them, and in a significant manner extends the amount of connections between IT systems.

All these facts naturally influence the quantity, content, and inner representations of information handled by military IT systems, and the quantity, content, and intermediary representations of information exchanged between IT systems.

From an informational point of view changes in interoperability environment can be classified into semantical level changes related to contents, and interpretations, and syntactical, and physical level changes, related to implementations. The former are basically in connection with the changes, and extensions in information, and information exchange requirements of cooperating partners, while the latter are connected partly to the representational requirements of information handled, or exchanged, and partly to the new results, opportunities have appeared in the means, and methods of information processing, and transmission.

Due to the continuous changes, and extensions in information, and information exchange requirements of cooperating partners, semantical level changes are natural phenomena of any application area. In consequence of changes in the activities, and the development of the given functional areas new, previously not used types of information (textual, map-related, visual, audio, sensor, multimedia, etc.), and in case of “data-like” information new object types, property types, relation types, and property values are needed, or existing ones should be modified.

The set of information handled by individual actors can also be changed, extended due to the changes in the group of actors. New actors'
joining the cooperation usually involves appearance of new information, different in contents, or interpretation. The development of information exchange requirements can be the result of a closer cooperation between actors. In this case not only the set of information handled by the individual actors extends due to different reasons, but a higher proportion of them are exchanged.

Changes, and extensions in the set, and contents of information can be experienced on two levels: first in the information handled by the individual actors in general, and secondly in the information handled by their IT systems. The amount of information exchanged between IT systems extends first of all depending on the extension of information handled by these IT systems. So information exchanged in traditional ways earlier, sometime will usually be exchanged between IT systems (too).

When a change in contents of information covers only a narrower part of community of interest, or does not affects IT systems, it has no significant impact on interoperability, and does not require modification of the intermediary representation. But even in this case it can happen, that actors involved in changes, in order to enhance operation, and cooperation, would like to exchange new, or modified information among each other. Conditions of interoperability for a narrower community must be created in the same way as for the whole community of interest.

Semantical level changes, modifications in intermediary representations used in information exchange are necessary only when changes in information handled by individual actors exceed a critical level. Intermediary representations – although they would be capable to support information exchange between any two actors – due to difficulties of preliminary agreements, and preparations, usually support only exchange of information commonly used by all, or significant part of the community of interest.

Changes in syntactical, and physical level representations practically does not affect the content of information processing, and information exchange, they are usually “transparent” for the actors taking part in cooperation. Such changes take place when a new document format, database format, dialogue protocol, message format, physical storage, or transmission format (mode) more successfully, more efficiently, more securely, or more economically supports the information exchange between IT systems. Appearance of new formats could arise from application demands, or from new results of information technology development.

Semantical, syntactical, and physical level changes in the interoperability environment are also characterizing the military domain.
In order to demonstrate this, see some example of changes, and their consequences in the international security area, in the nature of military operations, in doctrinal ideas, or in military technology at the end of the previous century, and at the beginning of the 21st century. Due to appearance, and growing significance of military operations other than war a lot of new information (name of international security organization responsible for a peace operation, authorized duration of peacekeeping operation, etc.) should be handled, and exchanged. Changes in doctrines, and other regulations require handling, and exchange of new types of information (e.g. pertaining to area of responsibility, host nation support, etc.). And finally appearance of new types of military technical systems, or their new characteristics may require handling of new information (e.g. electronic jam-resistance, non-lethal weapons characteristics, etc.).

Some examples of new syntactical, and physical level opportunities, or changes are the following: changes from the extensively used traditional character-oriented message formats (Message Text Formats) to Extended Markup Language (XML) based message formats, or change of special transmission formats, and modes to IP-based transmission. The change of character-oriented message formats to XML in the armed forces of the USA, then in the NATO has already begun in the 1990-s. Changes of the special transmission formats used in bit-oriented tactical data links (TADIL, LINK-xx) for lack of guaranteed transmission characteristics, and security solutions are not happened yet, but the development of information technology in the near future will probably create the necessary conditions.

Summary

Concept of interoperability, according to the commonly accepted understanding, is a mutual capability of different actors, systems, or devices necessary for successful cooperation. In the new Information Age one of the fundamental types of interoperability is information interoperability, and its increasingly important subtype is interoperability of IT systems (IT interoperability). Questions of interoperability could be studied not only from the point of view of a given community of interest, but from the point of view of the individual cooperation objects.

Due to the continuously developing IT support, the realization of information functions, and activities with the help of IT systems, and as a consequence the extension of connections between IT systems, the significance of actor oriented approach of interoperability has grown, and

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10 NATO C3 Agency XML Workshop, November, 1999
Introduction of concept of interoperability environment, and analysis of its characteristics has became necessary.

Interoperability environment of an IT system is the set of all those IT systems (devices), that are in direct, without human interaction, information exchange relation with the given system. Based on amount, and permanence of connections between systems we can distinguish the elementary interoperability environment (when information exchange relations of the given IT system are connected to a well defined, permanent, close, functional area cooperation), the combined interoperability environment (when the given IT system is in connection with IT systems of more, previously known community of interest), and the dynamic interoperability environment (when information exchange relations are dynamically changing, and some of them appear only in connection with the particular mission/operation).

In case of military IT systems, in our days, characteristics of their interoperability environment are basically depend on the significant changes in the international security environment, the nature of military operations, the missions, and structure of military forces executing operations, and in doctrinal principles. As a result, amount of information handled, and exchanged by IT systems, and amount of information exchange relations between systems are significantly increasing. Changes on the level of military application, and on the level of information activities result different semantic level changes (related to contents, and interpretations), and syntactical, and physical level changes (related to implementations) for IT systems, and these changes require development, and analysis of new interoperability solutions, and capabilities.

**Bibliography**