NECESSITY OF A MILITARY IT INTEROPERABILITY INFRASTRUCTURE

Sandor MUNK

Department of Informatics, Miklós Zrínyi National Defence University, Budapest, Hungary

Abstract: *In our world of globalisation the cooperation, and interoperability between/among different actors in every sphere (political, defence, economical, etc.) plays a more and more important role. In the changing international security environment the traditional interoperability solutions for military IT systems are less and less appropriate. In a dynamically changing environment, to cooperate with increasingly heterogeneous systems, new methods are necessary. An infrastructure-based approach provides a possible solution to ensure information interoperability.*

Keywords*: military informatics, military information environment, information interoperability, interoperability infrastructure.*

1. INTRODUCTION

In our world of globalisation the cooperation between/among different actors in every sphere (political, defence, economical, cultural, etc.) plays a more and more important role. On the basis of this grows continuously the importance of interoperability between these actors. In addition the evolution of Information Age has as a consequence the increasingly growing importance of information interoperability.

Nowadays successful and efficient activity, or operation of actors (individuals, organizations, systems) essentially unthinkable without extensive information exchange between actors, and without widespread use of different information sources, information services of the infosphere.

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 that in practice 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.

Traditional ways, and methods of creating, and maintaining information interoperability are less and less effective on the Information Age battle-sphere. In a dynamically changing environment, to cooperate with increasingly heterogeneous systems, new methods are

necessary. An infrastructure-based approach provides a possible solution to ensure information interoperability. This publication summarizes the basics of information interoperability, discusses some consequences of network centric warfare regarding information interoperability, and finally outlines a new, network centric approach of an interoperability layer, as a part of the information infrastructure.

2. MILITARY INTEROPERABILITY ENVIRONMENT AND ITS CHANGES

Concept of interoperability and information interoperability is essentially a relational concept. According to the commonly accepted understanding a specific actor, system, device cannot 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 needs 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.

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, and 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" (for example MIP-compliant, or AWCIES compliant).

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 [3].

One of the basic elements 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. [3, Points 11., 13., 18.] 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 multilateralism. 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 with other, non-military – international, governmental, non-governmental, and civil – organizations. [3, Points 17., 21., 22., 23.]

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. [3, Points 14., 18., 31.] 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. [3, Points 29., 32.] Both on organizational and system level this approach essentially requires an ability to interconnect with other components on a mission-oriented way, to synergic ally complement each other's 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 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 info sphere.

As a summary it can be stated, that ideas formulated in the NATO strategic vision describe, outline, and prognoses 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.

3. CONCEPT AND NECESSITY OF AN INTEROPERABILITY INFRASTRUCTURE

In case of cooperating information systems interconnected with other, heterogeneous systems, transformations between their inner representation and different intermediate representations (languages, message formats) today typically are realized by interface application components related to individual external representations (e.g. ADatP-3, Link-1, Link-16, ASTERIX interfaces). According to this solution, a new possibility of cooperation, a new intermediate representation requires the development, and implementation of a new interface component.

In a dynamically changing information environment the adaptation based on a continuous development neither sufficiently efficient, nor flexible, and in some cases even cannot be accomplished. Even a minor information system upgrade, limited in range and volume, requires a significant amount of time from the formulation of the requirements to the implementation of the new software or hardware version (solution). Moreover an additional time is necessary to do the modifications on all of the working implementations of the given system. What is more, in case of "legacy" systems usually it is not possible to upgrade the system, to extend it with new interface functionality.

An other disadvantage of interface components connected to individual intermediate representations, is that in case of similar, or identical data elements (e.g. date, time, spatial, quantity characteristics) the transformation between different representations should be repeatedly implemented in different components. This means that knowledge pieces (e.g. date, coordinate, or unit of measure transformation rules, and principles) used during transformations are hidden in the individual

interface components, so they are cannot be re-used.

Network centric approach, widely spreading in our days – that is, among others, characterized by the improved accessibility, autonomy, even detachment of different capabilities, and functions earlier strongly connected to, or inherently built into a "platform" – can be used in case of application components ensuring information interoperability, supporting information exchange among heterogeneous cooperating information systems.

The consequence of the separation of mediator application components from the individual information systems, applications is the implementation of an interoperability infrastructure that is situated between the individual systems, and the communication infrastructure, or constitutes part of an integrated info communication infrastructure. So autonomous application components, intended to resolve heterogeneity between different systems (mediators), belong to the group of so-called middleware components.

Information interoperability infrastructure, built on top of a traditional communication system, is a widely available unified system of personnel, devices and services that's purpose is to ensure information exchange based on common understanding, between cooperating IT systems.

Basic components of interoperability infrastructure are functional (application) components that implement interoperable transformations.

From the point of view of communication system, interoperability infrastructure is such a value-adder service layer that works built on top of traditional communication service layers. Basic purpose of communication systems, networks instead of traditional information transmission nowadays is more and more support of integrated functioning of a given organization, community of cooperation as a unified entity.

These systems, networks connect particular officials, and organizational units, and they should do this independently of the fact that "what language" the individual actors "speak",

what representations they use during information exchange.

Implementation of interoperability infrastructure will probably according to service-oriented architecture widely spreading nowadays. In this architecture different components implementing interoperable transformations appear as autonomous service-providers that can be used to build a complex transformation.

This kind of implementation, in case of missing interoperability sub functionality, makes possible to extend the infrastructure with application-side interoperability components, even to provide this functionality to other applications, and later to build into the infrastructure. All this ensures dynamic, application-requirement oriented extension of infrastructural services.

At the same time service oriented architecture requires implementation of service-advertisement, -registering, -seeking, and task decomposition/subtask planning functionalities that should also be part of the interoperability infrastructure.

Several components of an interoperability infrastructure are already available in form of independent applications, operation system functions, or functions of system development, and run-time platforms [*], only conditions of their wider availability should be ensured by placing their services at users' disposal in form of infrastructural services.

Components providing interoperability services can be operated in linking nodes of the communication system (routers, gateways, switches etc.), in autonomous infrastructural servers, or in application systems at their operation system, or middleware layers.

As it follows from the statements presented earlier, in case of traditional solutions a system has to know a number of different intermediate representation. Whereas in case of an infrastructure-based solution, a given system

can use its own, inner representation to send and receive messages, information.

Transformation between heterogeneous representations, and transmission of information is the task of the interoperability and communication infrastructure.

Because the application components making transformations are no longer parts of the individual information systems, in addition to the information exchanged, they have to get information (meta-information) about the representations used by the given systems.

Knowledge pieces necessary for understanding (interpretation) of data elements, data collection, originating from a given source are called a context. In this sense a context is a system of information (concepts, facts, assumptions, rules) necessary to understand (reproduce) the intended meaning of data elements, data collections belonging to a given information/knowledge representation. According to leading researchers of this topic, a context contains "meta data relating to its meaning, properties (such as source, quality, and precision), and organization" [4]. Contexts usually cannot be fully described, and formalized, because a correct interpretation of information requires the concepts, and rules of "common sense".

In case of traditional implementation of information interoperability, significant amount of context (meta) information needed for interpretation, and understanding is available only in documentations of the given system. Moreover in certain user communities there can be additional interpretation rules that are not recorded in any documentation. On the contrary, an autonomous interoperability layer requires a formalized description of different contexts.

Context descriptions play an interface role, but in contrast with traditional interface components (converters), they are independent of intermediate representations used for information exchange, and they should only have knowledge about the native representation of the system.

Another function of context descriptions is supporting inner representation autonomy of

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[*] For example document conversion (still and motion image conversion, audio conversion, textual document conversion, etc.) utilities, character set conversion functions, elementary data (e.g. numeric data) transformation functions.

the given system. Under appropriate conditions, assuming appropriate capabilities of the interoperability layer, inner representation of a given system, or some parts of it – with simultaneous modification of the context description – can be freely modified.

From the ideas, and suggestions outlined before it seems necessary, and promising to continue researches about a network centric interoperability layer. These should be, and can be coordinated with, among others, the principles, and solutions of the emerging component-based development, and web services architectures.

Military sciences should analyze specialties of military application, and should provide subject matter specific knowledge to develop, and implement useable, and useful interoperability solutions, products.

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