A Message Exchange Protocol in Command and Control Systems Integration, using the JC3IEDM

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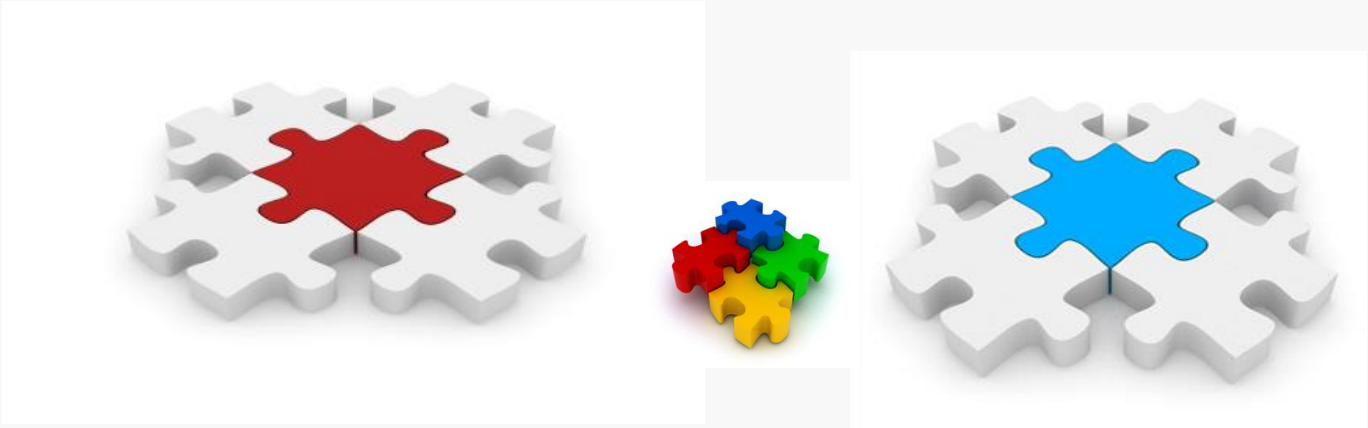
Summary

- **Introduction**
- **Objectives**
- **Partial Results**
- **Related Work**
- **Conclusions**
- **Future Work**
- **References**

Introduction

The Situational Awareness shared between military units is essential for The Joint Operations success.

- **This requires greater access to information, ensuring that the units in need of information have access to it;**
- **The operating environment focusing in rapid reaction requires more adaptable and efficient solutions for the exchange of information;**



Introduction

- **The definition of a protocol for exchanging messages is a complex task.**

- **For example, we have the Long-Range Identification and Tracking system (LRIT), where a multinational group took about five years to achieve stabilization at the Interface Data Exchange (IDE) protocols (IMO, 2012).**

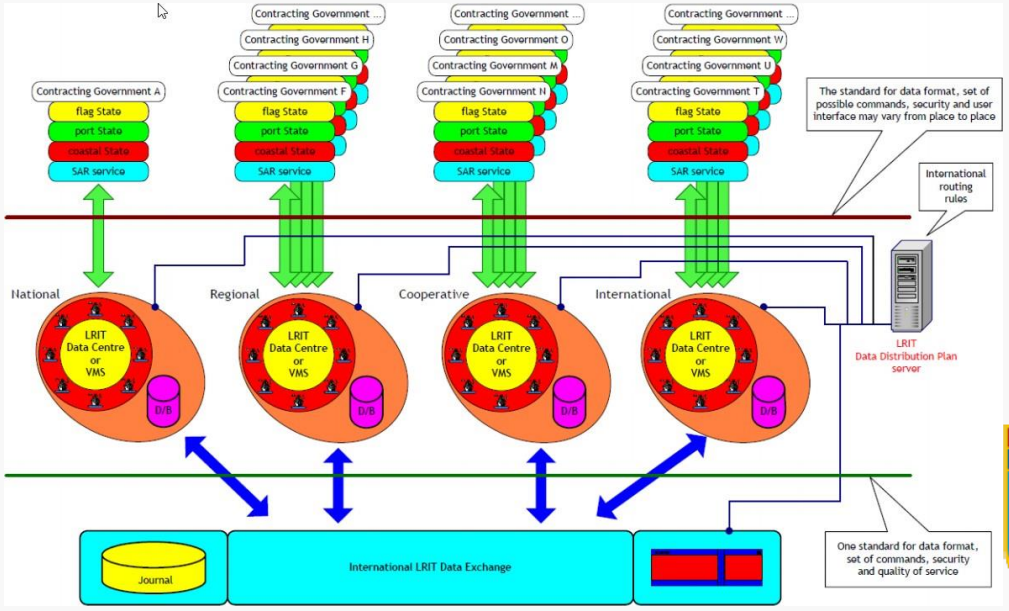


Figure 1. LRIT Architecture

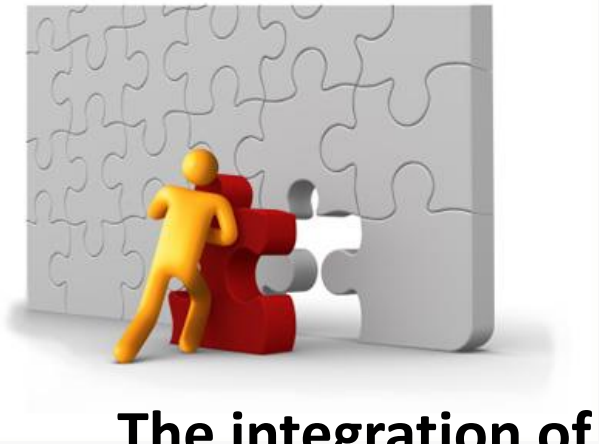
The Problem: C2 Systems Integration

Joint and multinational operations are complex and gather various military organizations operating as a Force.

Multinational forces may have differences in C2S, language, terminology, doctrine and standards of operation that may cause confusion.

The confusion increases the demand for information and also the level of uncertainty. The lower the level of the interface between various commands, the greater will be the uncertainty as well the demand for systems of C2S.

A Protocol for C2 Systems Integration



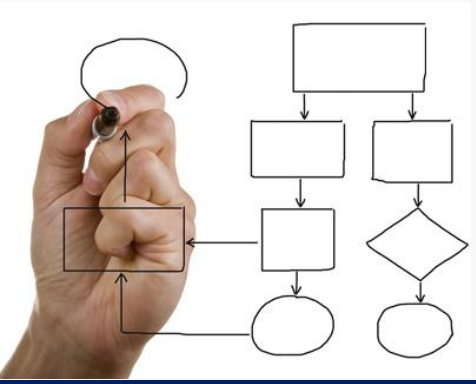
The integration of the Armed Forces Command and Control Systems, at the Operational level, using a generic protocol.

Propose a message exchange protocol to allow the integration between military C2 systems, using the concepts of JC3IEDM.

How to define a Protocol?

How to define a Protocol for Systems Integration?

- **Verify what are the Functional Requeriments;**
- **Define the Non Functional Requeriments;**
- **Verify what types of messages are necessary;**
- **Define the treatment giving to the messages;**



Needs for Protocol Development

- What are the Requirements?
- What are the types of messages?
- What will be the treatment of messages?

Integration Technologies

The study was based on field research (MoD) and C2 doctrine to assess the needs of exchanging information and restrictions during a Joint Operation (at operational level).

Study of technologies for systems integration:
- JC3IEDM (data model);
- Message Services (JMS);
- Web Services;
- CORBA;
- Microsoft .NET

Integration Technologies

Table 1. Comparing technologies for integration

Technology vs. Integration	CORBA	JAVA RMI	Web Services
Initial Project Difficulty	High	Low	Low
Interoperability (independence of language and platform)	High	Low	High
Expected Performance	Excellent *	Very Good *	Good **

*** Packets (message headers) are reading binary.**

**** Expected more overhead during packets reading.**

General View

- 2 views: "TOP-DOWN" (Protocol) and "BOTTOM-UP" (JC3IEDM);

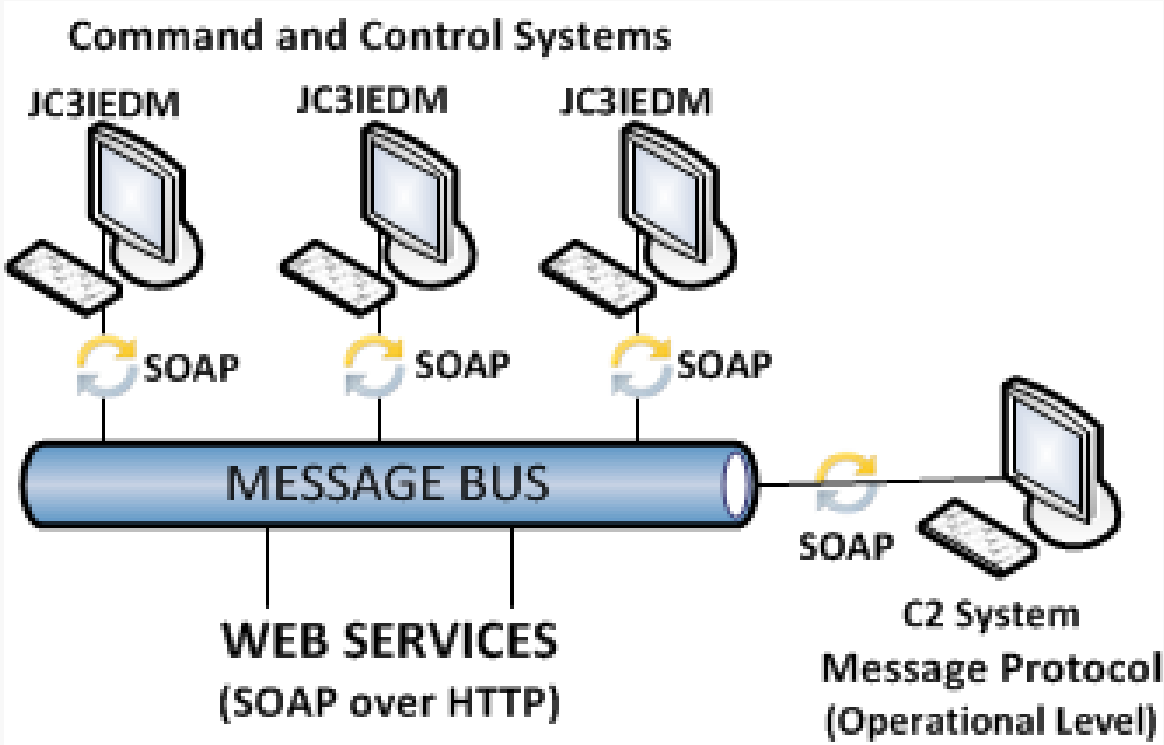


Figure 2. High Level Architecture

Types of Messages and Services

Types of Messages

- **Position per Unit Request (PositionRequest);**
- **Position per Area Request (AreaRequest);**
- **Position Report (PositionReport).**

Used Tecnologies

- **JAVA language;**
- **SOAP messages;**
- **Web Services.**

- The protocol proposes the handling of information. The data is treated as having value as sources of information.

The Data Model (JC3IEDM)

- The problem of representation of information for C2S has mature solutions, for example the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) (MIP).

- According to the Multilateral Interoperability Programme (MIP), Data interoperability requires a rigorous defined semantic vocabulary. The JC3IEDM is embedded in a structured context that defines the standard elements of information that compose the basis for interoperability between automated Command and Control Information Systems (C2IS), as long as can accommodate the model's information structure.

The Data Model (JC3IEDM)

The *Joint Consultation, Command and Control Information Exchange Data Model* (JC3IEDM) is used by NATO on Joint Operations for the C2 Systems integration on the Forces of the participating countries.

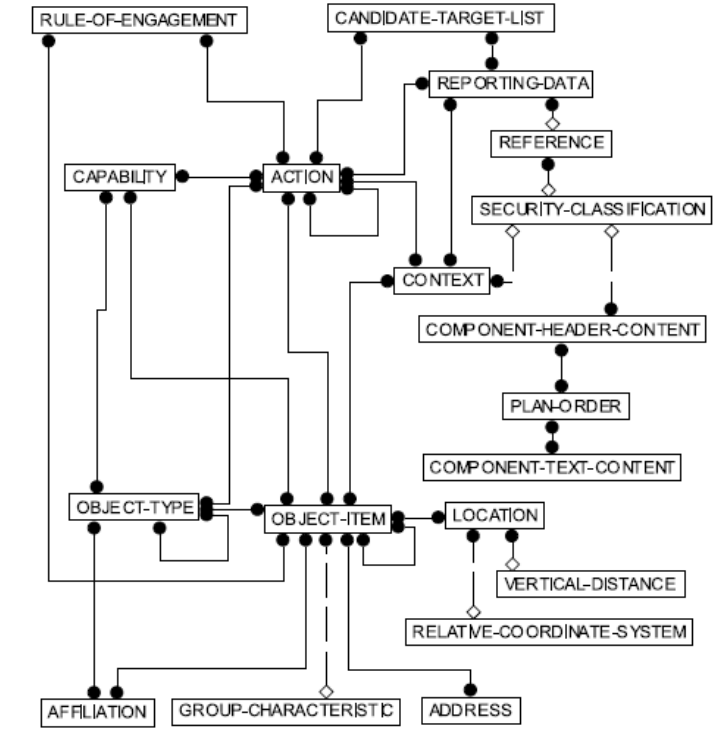
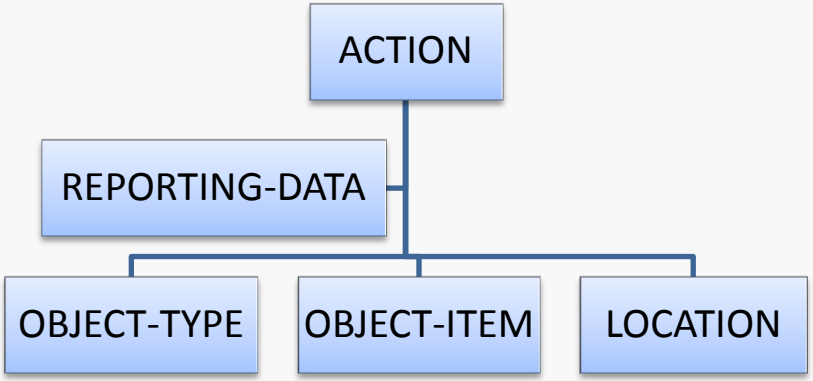


Figure 2. Independent Entities (MIP, 2012)

Selected Entities (JC3IEDM)

- ACTION
- LOCATION
- OBJECT-ITEM
- OBJECT-TYPE
- REPORTING-DATA



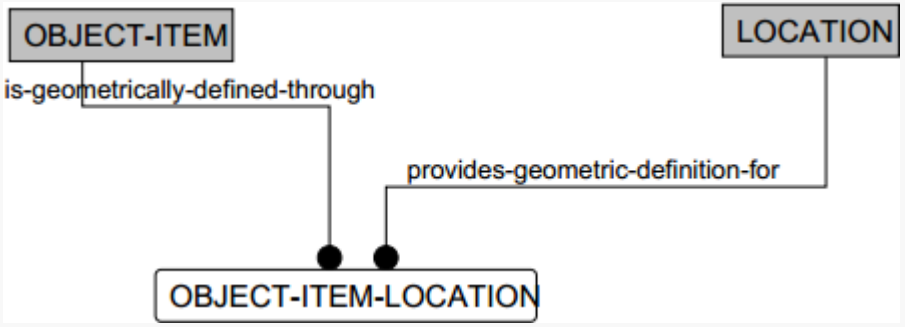


Figure 3. Example of the used part of the JC3IEDM

Source: https://mipsite.lsec.dnd.ca/Pages/Default.aspx

Partial Results

Non Functional Requirements

Type of Requirement	Description	Example
Timeliness	Urgency of the communication or integration between applications.	5 seconds.
Size	Size of data that the integration between applications must handle (related to volume). Big file sizes reflects on raising the expected overheads.	File size of up to 10Mbytes.
Resilience and Recovery	Resilience of the integration infrastructure in event of failures.	Guarantee of message delivery, redundancy and downtime less than 5%.
Frequency	Frequency of integration needed between applications. Directly affects the operations.	Real-time, hourly, ...

Message Examples Scenario

- The scenario is a Joint Force Operation, where Navy, Army and Air Forces are cooperating to reach the same objective.
- The Armed Forces need to share their information to maintain an updated Situational Awareness.
- The first message example carries a request for verification of placement of units within a given area defined by the geographical coordinates;
- The second is the response for a Position Request Message, called Position Report Message.

Message Examples (AreaRequest)

- Structure of Units by Area Request Message;

```
<?xml version="1.0" encoding="UTF-8"?>
<schema targetNamespace="urn:int:nato:standard:mip:jc3iedm3.X:oo:1.4"
xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:jc3iedm="urn:int:nato:standard:mip:jc3iedm3.X:oo:1.4"
elementFormDefault="qualified" attributeFormDefault="unqualified">

<arg>
<header>
<MessageID>nnnnYYYYMMDDHHmmssnnnn</MessageID><!--  número, ano, mês, dia, hora, minuto, segundo e nanossegundo da mensagem -->
<ID type="integer">nnnnnnnn</ID><!--  Identifica o tipo de mensagem e informação através de uma Tabela-Código baseada no JC3-->
<DataUserResquestor type="string">nnnn</DataUserRequestor><!-- ID de quem solicitou a informação -->
</header>

<body>

<JC3IEDM>
<Location xsi:type="GeographicPoint">
<ReferenceCode type="string">xxxxxx</ReferenceCode>
<NameText type="string">xxxxxxxxxx</NameText>
<LatitudeCoordinatePoint1 type="double">nn.nnnnn</LatitudeCoordinatePoint1>
<LongitudeCoordinatePoint1 type="double">nn.nnnn</LongitudeCoordinatePoint1>
<LatitudeCoordinatePoint2 type="double">nn.nnnnn</LatitudeCoordinatePoint2>
<LongitudeCoordinatePoint2 type="double">nn.nnnn</LongitudeCoordinatePoint2>
</Location>
</JC3IEDM>

    <simpleTye name="requestType">
        <restriction base="integer">
            <minInclusive value="0" name="restart" /> <!--  Minutos de intervalo entre respostas (0=RESET) -->
            <maxInclusive value="1441" name="timeout" base="integer" use="optional" /><!-- Mais de 24h sem resposta é o timeout(1440min=24h) -->
    </simpleType>

</body>
</arg>
</schema>
```

eXtensible Markup Language file | length : 1512 lines : 35 | Ln : 1 Col : 1 Sel : 0 | 0 | UNIX | ANSI as UTF-8 | INS

Message Examples (PositionReport)

- Structure of Position Report Message;

```
<?xml version="1.0" encoding="UTF-8"?>
<schema targetNamespace="urn:int:nato:standard:mip:jc3iedm3.X:oo:1.4"
xmlns="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:int:nato:standard:mip:jc3iedm3.X:oo:1.4"
WMAPositionReport.xsd">

<arg>

<header>
<MessageID>nnnnYYYYMMDDHHmmssnnnn</MessageID><!--  número, ano, mês, dia, hora, minuto, segundo e nanossegundo da mensagem -->
<ID type="integer">nnnnnnnn</ID><!--  Identifica o tipo de mensagem e informação através de uma Tabela-Código baseada no JC3-->
<DataUserRequestor type="string">nnnn</DataUserRequestor><!-- ID de quem solicitou a informação -->
<DataUserProvider type="string">nnnn</DataUserProvider><!-- Identif. de quem forneceu a Info -->
</header>

<body>

<JC3IEDM>

<ObjectItemRef>
<OID>ORG2</OID> <!-- número do "Object ID" -->
<ObjectItemLocationInObjectItemList>
<ObjectItemLocationInObjectItem>
<Location xsi:type="GeographicPoint">
<OID>POINT1</OID>
<VerticalDistance>
<OID>POINT1</OID>
<ReferenceCode>MNSLVL</ReferenceCode>
<Dimension>-100</Dimension>
</VerticalDistance>
<LatitudeCoordinate>40.36917</LatitudeCoordinate>
<LongitudeCoordinate>74.0008</LongitudeCoordinate>
</Location>
<ObjectItemLocation>
<VerticalAccuracyDimension>10</VerticalAccuracyDimension>
```

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Related Work

- K. Lund et al. presented that there is a focus on the establishment of a service-oriented architecture (SOA) to increase interaction within the Allied Forces (Lund et al., 2009);
- However, this solution has been adopted for environments with great data communication capacities, which is the opposite of military tactical networks;
- Also recommends the architectural principles and technologies that are best suited to implement this infrastructure information;
- The main idea was to make SOA possible to take by all military levels, from strategic to tactical networks.

Conclusions

- Requirements and XML-formatted messages must be handle in the protocol to allow a satisfactory performance, despite of all overhead expected on the reading messages process.
- SOA enable a strong decoupling between clients and servers, and count with the existence of various tools for project development.
- The use of the Web Services technology allows a greater decoupling between the systems, which leads to independent programming language and platform for the existing C2 systems.
- NATO data model defines a pattern for information modelling, allowing the use of the same vocabulary to all C2 legacy systems.

Future Work

- This is an initial solution, using a set of messages and rules to manage traffic between C2S, using the protocol requirements.
- The future work will be based on design the complete system protocol architecture to allow the message handling in runtime.
- The implement of an encryption layer is also desirable. It should be strong enough to ensure the conduction of joint operations exercises without any interference, internal or external.
- This security layer must be designed and implemented without compromising the performance of the message exchange protocol.

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Thank You!

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