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

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Summary

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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;
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.
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 for Systems Integration?

- Verify what are the Functional Requirements;
- Define the Non Functional Requirements;
- 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:
- JC3I EDM (data model);
- Message Services (JMS);
- Web Services;
- CORBA;
- Microsoft .NET
### Table 1. Comparing technologies for integration

<table>
<thead>
<tr>
<th>Technology vs. Integration</th>
<th>CORBA</th>
<th>JAVA RMI</th>
<th>Web Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Project Difficulty</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Interoperability (independence of language and platform)</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Expected Performance</td>
<td>Excellent *</td>
<td>Very Good *</td>
<td>Good **</td>
</tr>
</tbody>
</table>

* Packets (message headers) are reading binary.
** Expected more overhead during packets reading.
- **2 views**: “TOP-DOWN” (Protocol) and “BOTTOM-UP” (JC3IEDM);

Figure 2. High Level Architecture
Types of Messages

- Position per Unit Request (PositionRequest);
- Position per Area Request (AreaRequest);

Used Technologies

- 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 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 **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
## Non Functional Requirements

<table>
<thead>
<tr>
<th>Type of Requirement</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timeliness</strong></td>
<td>Urgency of the communication or integration between applications.</td>
<td>5 seconds.</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Size of data that the integration between applications must handle (related to volume). Big file sizes reflects on raising the expected overheads.</td>
<td>File size of up to 10Mbytes.</td>
</tr>
<tr>
<td><strong>Resilience and Recovery</strong></td>
<td>Resilience of the integration infrastructure in event of failures.</td>
<td>Guarantee of message delivery, redundancy and downtime less than 5%.</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Frequency of integration needed between applications. Directly affects the operations.</td>
<td>Real-time, hourly, ...</td>
</tr>
</tbody>
</table>
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
<?xml version='1.0' encoding='UTF-8'?>
<schema targetNamespace='urn:intnato:standard:mip:jc3iedm.x:gg:1.4'
xmlns='http://www.w3.org/2001/XMLSchema'
xmlns:jc3iedm='urn:intnato:standard:mip:jc3iedm.x:gg:1.4'
xmlns:Msg='urn:intnato:standard:mip:jc3iedm.x:gg:1.4'
xmlns:MsgDef='urn:intnato:standard:mip:jc3iedm.x:gg:1.4'
xmlns:MsgDef: qualify attributeFormDefault="unqualified">
  <arg>
    <MessageID>nnnYYYYMMDDHHmmsnnn</MessageID><!-- número, ano, mês, dia, hora, minuto, segundo e nanosegundo da mensagem -->
    <ID type='integer'>nnnnn</ID><!-- Identifica o tipo de mensagem e informação através de uma Tabela-Códigos baseada no JC3 -->
    <DataUserRequestor type='string'>nnn</DataUserRequestor><!-- ID de quem solicitou a informação -->
  </header>

  <body>
    <JC3IEDM>
      <Location xsi:type='GeographicPoint'>
        <ReferenceCode type='string'>nnnnnnn</ReferenceCode>
        <NameText type='string'>nnnnnnnnnnn</NameText>
        <LatitudeCoordinatePoint1 type='double'>nn.nn</LatitudeCoordinatePoint1>
        <LongitudeCoordinatePoint1 type='double'>nn.nn</LongitudeCoordinatePoint1>
        <LatitudeCoordinatePoint2 type='double'>nn.nn</LatitudeCoordinatePoint2>
        <LongitudeCoordinatePoint2 type='double'>nn.nn</LongitudeCoordinatePoint2>
      </Location>

      <simpleType name='requestType'>
        <restriction base='integer'>
          <minInclusive value='0' name='restart' /> <!-- Minutos de intervalo entre respostas (0=RESET) -->
          <maxInclusive value='1440' name='timeout' base='integer' use='optional'/><!-- Mais de 24h sem resposta é o timeout (1440min=24h) -->
        </restriction>
      </simpleType>
    </JC3IEDM>
  </body>
</schema>
```

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Message Examples (PositionReport)

- Structure of Position Report Message;

```xml
<?xml version='1.0' encoding='UTF-8'?>
xmlns='http://www.w3.org/2001/XMLSchema-instance'
  <arg>
    <header>
      <MessageID>nnnnYYYYMMDDHHMMssmmm</MessageID> <!-- número, ano, mes, dia, hora, minuto, segundo e nanosegundo da mensagem -->
      <ID type='integer'>nnnn</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> <!-- Identifi, de quem forneceu a Info -->
    </header>
    <body>
      <JC3IEDM>
        <ObjectItemRef>
          <OID>OB62</OID> <!-- número do "Object ID" -->
          <ObjectItemLocationInObjectItemList>
            <ObjectItemLocationInObjectItem>
              <Location xsi:type='GeographicPoint'>
                <OID><POINT1</OID>
                <OID><POINT1</OID>
                <ReferenceCode>NWNLVL</ReferenceCode>
                <Dimension>100</Dimension>
              </VERTICALDistance>
              <OID><POINT1</OID>
              <ReferenceCode>NWNLVL</ReferenceCode>
              <Dimension>100</Dimension>
            </VERTICALDistance>
            <LatitudeCoordinate>40.36917</LatitudeCoordinate>
            <LongitudeCoordinate>74.0008</LongitudeCoordinate>
          </Location>
          <ObjectItemLocation>
            <VerticalAccuracyDimension>10</VerticalAccuracyDimension>
          </ObjectItemLocation>
        </ObjectItemRef>
      </JC3IEDM>
    </body>
  </arg>
</schema>
```
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 handled in the protocol to allow a satisfactory performance, despite all overhead expected on the reading messages process.

- SOA enables a strong decoupling between clients and servers, and counts 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.
References


References

• Lam, W., Shakararaman, V., 2004. *An Enterprise Integration Methodology*, IT Professional Magazine. IEEE.


• Multilateral Interoperability Programme (MIP), 2012. *The Joint C3 Information Exchange Data Model (JC3IEDM) Main v.3.1.4*. Germany, version 3.1.4.

Thank You!

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