Towards a microservices architecture to support communication in C2 applications

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***Abstract*—Command and Control (C2) operations can involve diverse areas of activity, which in many cases require seamless cooperation among several branches of armed or special forces, as well as civilian organizations, to achieve their objectives. As each organization or branch has its own vocabulary and terminology, misinterpretations may arise during message exchange among participants of an operation, compromising interoperability and potentially leading to disastrous consequences. This work proposes a novel approach for intercepting and enhancing the semantics of textual messages exchanged between different applications in a C2 scenario, by leveraging Natural Language Processing techniques such as Entity Recognition. To implement this approach, we propose an SOA microservices architecture to address concerns related to modularity, maintainability, and performance. Experiments and initial results demonstrate the viability and effectiveness of this approach, which was primarily aimed at contributing to C2 operations, particularly within the armed forces, but can potentially be adapted to be applied in other domains where similar types of messages are exchanged.**

***Index Terms*—microservices architecture, command and control applications, message semantics enhancement**

I. Introduction

Command and Control (C2) operations, particularly in the military domain, require comprehensive information systems, which are comprised of a variety of subsystems. These systems are essential for supporting the command structure in the execution and monitoring of operations, as well as in the decision-making process [1].

C2 theory works as a management instrument within the command structure, establishing the authority and direction commanders wield over forces under command while conducting an operation, whether in military or civil scenarios [2]. Among its functionality, C2 systems must incorporate a chat function to support communication between commanders and their subordinates within the command hierarchy, known as Multi-Party Conversation (MPC) [3].

In military operations, one of the challenges is ensuring that dialogues among human operators are properly understood, enabling a timely response to task completion [4]. Besides, messages exchanged in C2 vary in importance, with some requiring more attention. These messages can be classified according to priority levels, such as standard, urgent, or extremely urgent [5]. Thus, when using an MPC facility, the C2 Communication Operator (C3O) must quickly identify priority messages. This implies that each message's contents must be scrutinized to identify key elements and assign appropriate priority levels. However, this prioritization is highly dependent on the C3O's perception and assessment, posing a potential challenge as the success of an operation may depend on the C3O's level of experience [5].

Therefore, mechanisms to enhance message understanding and enable semantic interoperability can be useful to mitigate the dependence on C3O's expertise. Moreover, C2 scenarios are complex and involve a network of devices and systems spread across terrains. Communications carried out on these terrains predominantly rely on wireless or radio networks, which can introduce longer message delivery delays compared to communications carried out via cable-based systems [6]. Typically, systems in these scenarios are monolithic, heterogeneous, and independently built, making the evolution toward semantic interoperability complex and expensive. Thus, a C2 scenario demands a flexible, modular, and easily maintainable software architecture solution.

Service-Oriented Architecture (SOA) [7] is an approach often recommended to address interoperability issues. However, C2 scenarios retain specific characteristics that must be addressed, including hierarchical communication restrictions and semantic interoperability reinforcement. To the best of

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