

23rd ICCRTS

23rd International Command and Control
Research and Technology Symposium

MULTI-DOMAIN C2

November 6 – 9, 2018

Pensacola, USA

Title: A Newsfeed for C2 Situational Awareness

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A Newsfeed for C2 Situational Awareness

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Abstract

Coalition partners use C2 information systems (C2IS) to achieve shared situational awareness in support of business processes. Typically, a C2IS presents battlespace objects on a map. However, not all relevant information can be indicated to the user by means of tactical symbols. Moreover, due to the dynamics of the battlefield, the statuses of battlespace objects change over time and these changes may go unnoticed by the operator. The authors propose the concept of a C2 newsfeed that turns structured operational data into short text messages to report on relevant changes in the theatre of operations. The newsfeed takes into account contextual knowledge (time, place, role of the users, etc.), domain knowledge, and history (e.g., past status of an object) to produce concise textual descriptions. The newsfeed is designed as a micro service in a generic, web-based C2 demonstrator that supports the MIP4 Information Exchange Specification (MIP4-IES) and the MIP Information Model (MIM). In our paper, we will give a brief overview on the cloud-native architecture of the C2 demonstrator and the integration of the newsfeed.

1 Introduction

A C2 newsfeed is a service of a C2 information systems (C2IS) that explicitly informs the operator about changes within the theatre of operations. It does so by conveying short text messages.

By way of example, let us assume that a C2IS receives structured information on an enemy unit U that is firstly located at location A and later at location B . The symbol for U will be moved on the C2IS map accordingly. In addition, the movement from A to B can be reported to the operator by a short and easily comprehensible text message. Another example is a tank that lost its mobility while its fire power is being preserved. This information will most probably not be displayed on the map. However, it can be conveyed via a newsfeed.

Newsfeed messages can alert operators to critical events, e.g., that allied forces plan an air assault in an area where own intelligence units are currently operating. Newsfeeds complement standard map displays and provide accessibility to the current operational picture. They also provide histories of activities and events and, thereby, support the situational assessment over specific time periods as well as periodic reporting. Newsfeeds can be tailored for specific roles and contextual conditions so that only relevant information is conveyed and overtaxing the users is being avoided.

Fraunhofer FKIE has realised a C2 newsfeed demonstrator as a micro service for its InSAne (“Intelligent Situational Awareness”, [1]) framework. InSAne is implemented as a generic web-based C2 demonstrator that supports the MIP Information Model (MIM, [12]) and the MIP4 Information Exchange Specification (MIP4-IES, [13]). The MIP4-IES defines the exchange of structured reports about “Battle Space Objects” (BSOs) between coalition partners. BSOs can be either concrete objects, like tanks, or abstract objects, like events or control features. A BSO report formally represents the status of such an object on the battle field. Sequences of BSO reports describe progress within the theatre of operations. BSOs can be depicted on maps, using military symbology such as defined in APP-6 or MilStd 2525. A change of the situation leads to a change on the map and is, thus, stated implicitly. By a newsfeed, changes, which can be deduced from sequences of BSO reports, are stated explicitly.¹

The outline of the paper is as follows: in Section 2, we will introduce the motivation for a C2 newsfeed (Section 2.1), describe its general concept (Section 2.2) and give an overview on related notification services of widely-used C2IS (Section 2.3). In Section 3, we will present preliminary evaluation results. We explained our idea to various military subject matter experts, showed them two different mock-ups, and asked them to fill in a questionnaire. The responses were positive and give helpful advice for further development. In Section 4, we will describe the design of a demonstrator and the technological context of its implementation. To this end, we will firstly outline the latest MIP interoperability solutions, namely the MIP Information Model (MIM) and the MIP4-IES (Section 4.1). Secondly, we will introduce InSAne as the technological framework for the newsfeed demonstrator (Section 4.2). Thirdly, we will describe the newsfeed (Section 4.3). Finally, in Section 5, we will draw conclusions and give an outlook on future work.

2 C2 Newsfeed

Let us start with justifying the assumption of a newsfeed’s usefulness and describe the newsfeed concept.

2.1 Motivation

The essential user interface of a C2IS is the display of a map on which operationally relevant objects and events are represented by symbols. The map provides a situational overview on the theatre of operations. Since the theatre of operations is a dynamic environment that changes over time, the map has to be updated continuously. Accommodations can be achieved by the following means:

- new symbols can be added,

¹ The MIP4-IES uses the term “BSO” ambiguously to denote both real-world object and their representations/reports. Within this paper, we disambiguate by naming the real-world object a “BSO” and its representation a “BSO report”. Please note that BSOs, unlike “Battlespace Objects” according to the NATO C3 Taxonomy, also comprise events.

- existing symbols can be deleted,
- existing symbols can be moved, or
- existing symbols can be replaced.

A symbol will be replaced only if a feature of the symbolized object has changed. However, not every feature change leads to the replacement of a symbol. E.g., depending on the symbology standard, the symbol for a tank will change if the tank has been demolished. The symbol will rather not change if only the tank's mobility has been eliminated while its firepower is being preserved. Therefore, there can be changes of object features and, thus, of the current situation that won't be reflected by the map. It is useful to notify the operator of such changes if they are relevant for the assessment of the situation.

Even if a situational change is reflected by the map, it might be that it goes unnoticed by the operator. One reason can be that the operator turned away from the map for some time – very probable in a combat-situation – and afterwards does not reliably recognize every change of the operational picture. Another reason can be that the change lies outside the currently displayed map section and, thus, cannot be recognised. Therefore, it can be useful to notify the operator of situational changes even if these changes are also reflected by the map.

The purpose of a newsfeed is to give notifications on situational changes by short text messages. Via a newsfeed, both changes that are displayed on the map and changes that are not displayed on the map can be reported. To this end, text messages are automatically generated from updates of battlespace object representations, as they are provided through structured messages that have been received from partners. These structured messages can be BSO reports according to the MIP4-IES (see Section 4.1), "Tracks" according to the NATO Friendly Force Information standard (NFFI) or messages from the NATO Message Catalogue (APP-11 Message Text Format (MTF)), among other formats. Some of these messages, e.g. BSO reports, will usually be processed automatically and not be read by human operators. That is, if their alleged effect on the map goes unnoticed, then the entire message eventually goes unnoticed. A newsfeed can support its recognition by the operator.

A single newsfeed message names a single situational change. A complete set of newsfeed messages describes a series of changes within a specific time frame. Therefore, a newsfeed does not only inform about latest situational changes in an ad hoc manner but also gives an overview on developments within a period of time. It fulfils a reporting function.

2.2 Concept description

Let us assume that a C2IS is given. Within the system, representations of battlespace objects – e.g., BSO reports according to the MIP4-IES – are being created, manipulated and/or received from partners. The semantics of these representations is defined by an information model. They are stored in a time-line so that a sequence of representations of the same object reflects the object's development over time, that is, its history. Within the history, differences in attribute values of the representations can be detected, with every such difference (delta) pointing to a change of the represented object.

The procedure of computing deltas is generic with respect to a representation format. It need not be adapted to a specific operational context.

If the information model that provides the semantic references for the representations comes with a meta model (cf. Section 4.1), then deltas can be assessed with respect to it: does a delta denote an increase or a decrease of a certain measure? Can it be validated as a change for the better or for the worse?

Also the assessment of deltas is generic and need not be adapted to a specific operational context.

If a change has been detected, then a text message is generated by automatically filling in a pre-defined template with values from the object representation, the delta, and the assessment of the delta. Examples are

1. “Time T , location L : convoy X reaches pre-defined passage point P ”,
2. “Reporter R , time T : Enemy unit U moved from A to B ”, and
3. “Time T , location L : mobility status of tank X decreased from level M to N .”

Example 1 reports on the current state of the convoy; it can be derived from the latest update of the convoy representation alone. Examples 2 and 3 additionally refer to the previous states of their objects, namely by pointing to the previous location or mobility status, respectively. Example 3 also includes an assessment of the delta by noting that the mobility level “decreased”.

In order to improve the comprehensibility of newsfeed messages and, thus, reduce cognitive effort required from operators, the filling of the template can or even should be context-sensitive: the naming of the time, e.g., must always be sufficiently precise but should also be brief and easy to grasp. In many situations, it will be sufficient to name just hours and minutes, but neither seconds nor date. Other situations will require different formats. Times can be also be specified with respect to the actual time: “Convoy X reached passage point P N minutes ago.” The same is true for locations that can be specified with respect to other relevant objects: “Enemy unit U approaches facility F up to N miles.”

A challenge for making newsfeed messages concise and easily understandable is the identification of objects. Formal IDs are neither short nor easy to grasp, and pre-defined short names are not provided for every object. After a new battlespace object has been introduced into the news stream, it would be helpful to refer to it by a newly created short name (e.g., “Convoy Alpha”), a clear and intelligible definite description (e.g., “the UN convoy to X ”) or eventually a pronoun (“it”). Such referring expressions are context-sensitive – it has to be considered what the essential, discriminatory features of the object are, which of these features are known to the operator, and from which other objects it has to be distinguished. The computation of referring expressions might require a discourse representation structure [9], either for the entire news stream or for subsets that survived a relevance filter (see below).

The text message is enriched with metadata, including the originator of the object representation – in particular when it has been received from a partner – the time of reception, a link to the tactical symbol, the topic, etc.

At this stage of the processing pipeline, a text message has been generated which, in principle, can be conveyed via the newsfeed service immediately. However, in dynamic situations with very many changes, newsfeed users would be easily overtaxed if they would be notified of every single change. Therefore, filters have to be provided that reduce the number of news messages:

- Metadata-based filters allow for the ad-hoc filtering of the news stream. Users select criteria for the adaptation of the display of the newsfeed. Possible criteria are time periods, areas of interest, involved actors, types of deltas (e.g., movement or change of status), topics and discriminators according to the MIP4-IES, among other criteria.
- Relevance filters sort out all messages that are not in agreement with the criteria of a pre-defined role-profile. E.g., the newsfeed of a convoy supervisor should include only notifications that concern the supervised convoys and events in the area of interest that might affect these convoys.

Relevance criteria of any kind need not be used for filtering out non-compliant messages but can alternatively be used for prioritisation, i.e. the highlighting of messages that meet the criteria.

- If the formal representation of a plan is given, newsfeed messages can be selected with respect to that plan, in analogy to a relevance filter. News messages that refer to steps or other elements of the plan, like the reaching of a passage point, can be selected and displayed; others will be hidden. However, the plan need not only be used for filtering the news feed. It can also be used for detecting deviances and add respective notifications. It could alert the operator to missing news, e.g., that the expected reaching of a passage point has *not* been reported yet. As such, it would be a basic service for anomaly detection.
- Time intervals can be set to define the frequencies of notifications. This seems to be useful in particular for position reports, which are sent with a high frequency but should not appear on the newsfeed with the same frequency. Instead, they can be collected over a time period and summarized.

The aim of a filter is to reduce the number of messages in order to keep the newsfeed clear and manageable. The reduction of displayed messages can also be achieved by hiding obsolete messages. The most straightforward means is to let the user manage the newsfeed and allow him to remove read or irrelevant messages from the display. Another means is to automatically hide out-dated messages: if a unit gives a position report, most probably its previous position need not be shown to the user any more. The hiding of news messages can be combined with a summary function: let us assume that unit U moved from A to B and that the respective message appeared on the newsfeed but has not been marked as read. Let us further assume that the unit then moved from B to C . Instead of just adding a second news message, the first message can be replaced by the notification that U moved from A to C . That is, two changes are merged into one.

Since the newsfeed also fulfils a reporting function, it is an important requirement that news messages can be hidden but are still accessible for a retrospective assessment of the course of actions and events. In other words, news messages must not be deleted. If combined with a summary function, a service can be provided that enables the user to zoom in and out of the

news stream: on the lowest level (with the highest zoom factor), all news messages are shown, while on higher levels (with lower zoom factors), only summarized messages and/or messages with a higher priority are displayed. To fully exploit the reporting function, the newsfeed should be linked with a mission report service, e.g. a mission log book.

Tailored newsfeeds can support various roles, on the strategic, operational and tactical level. To this end, they can be accessed via diverse interfaces, both on stationary and mobile devices. The standard user interface of the newsfeed is a simple text interface that displays the news messages in chronological order and provides the means to filter and sort according to various criteria – its look-and-feel can be comparable to an email or chat client. Figures 4 and 5 in Section 4.3 show two mock-ups, one for a newsfeed that is integrated as a widget into a Desktop C2IS, the other for a mobile version. The C2IS newsfeed widget can be linked to the map display, so that the tactical symbol that is related to a particular news message can be highlighted, and selected movements can be represented as paths on the map. Finally, one can think of complementing the text interface with a Voice User Interface (VUI) that “reads” news to the user. It has to be evaluated, however, under which circumstances a VUI would be perceived as useful and usable.

2.3 Related services in existing C2IS

Various kinds of newsfeeds are used in headquarters: usually, at least one monitor shows a news channel with so-called “breaking news” in a constant newsfeed. Also the widely-used Microsoft Sharepoint, among other services, provides newsfeeds to which participants can contribute manually created messages.

Commercial C2IS offer related services which, however, do not provide the same spectrum of functions as outlined in the previous sections. We investigated a set of C2IS for headquarters. The list is not exhaustive but gives an exemplary overview. Among the assessed services are the following:

- Some C2IS enable the user to define trigger events and templates for notifications. A trigger event can just be the reception of a new business object, e.g. a plan or an order. However, triggers can also be activated by the creation, deletion or update of a battle-space object representation. If a trigger is activated, then the template is filled with values derived from the respective representation and, thereby, a notification message is generated. The notification reports on the actual status of the object without reflecting on its previous status. That is, neither deltas nor their assessments are considered.
- The C2IS allow for the creation of various map layers with filter and query functionalities. A pre-defined alert can be given when an update of the layer takes place – e.g., because an object within the layer has been changed. In order to define different kinds of alerts, different layers have to be defined.
- There are alert services that refer to the relations between objects and plans. E.g., an alert can be triggered if an object (a unit, a vehicle, ...) deviates from its planned route.

- Notifications can be presented as pop-up messages or appear in a dedicated panel. It is also possible to link a notification service with chat services and post messages to one or more chat rooms.
- Some C2IS allow for the dissemination of information from external newsfeeds, e.g., of incident information from event logs via an RSS feed.

There are two essential differences between the services we reviewed and our newsfeed concept as outlined in the previous sections:

1. Notification services of the reviewed C2IS notify on the current status of objects without taking the previous statuses of these objects, the deltas between the statuses or assessments of the deltas into account. Notifications are generated by filling pre-defined templates. Situation-specific adaptations, like the generation of contextually adequate time formats, referring expressions, and relative specifications of location, are not conducted. In other words, the reviewed services notify on changes but, contrary to our service concept, do not further process and evaluate these changes, neither content-wise nor in regard of presentation.
2. According to our newsfeed concept, a message is generated for every change that takes place. That is, by default, a newsfeed gives an exhaustive overview on all changes within the theatre of operations. Therefore, the newsfeed also fulfils a reporting function and can effectively support reporting services. By contrast, notifications within the C2IS we reviewed have to be defined in advance. In consequence, only notifications of selected changes/events will be generated, and a reporting function cannot be fulfilled.

According to our concept, filter conditions have to be defined in order to keep the news stream manageable. According to the reviewed services, a news stream has to be created in the first place, by defining trigger conditions. It depends on the number of filter or trigger conditions, respectively, which concept requires more effort from the user. We found it rather cumbersome to define a larger set of triggers for notification services. Probably, there will be a difference in usability. This, however, is subject for further investigation and evaluation.

3 Evaluation and feed-back from subject matter experts

We evaluated the newsfeed concept of Section 2 with military subject matter experts (SMEs). To this end, we firstly distributed a questionnaire and secondly held a round-table discussion.

We distributed the questionnaire via email together with a slide-show presentation of the newsfeed concept and the two mock-ups shown in Figures 4 and 5 below (Section 4.3). We received 14 answers in total, from 15 SMEs (in one case, two persons filled out a questionnaire together). Among the respondents were eleven commissioned and four non-commissioned officers. 13 of them were members of the German army, one of them was a navy officer and one an air force officer. Seven declared that they had practical knowledge of C2IS, four stated that they had predominantly theoretical knowledge. Not all respondents answered to every question.

3 Evaluation and feed-back from subject matter experts

Perceived Usefulness and Ease of Use (PUEU)			
Statement	Avg. Rating	Std. Deviation	Answers
The newsfeed would be useful for me	5.9	0.8	9
I could fulfil my tasks better with the newsfeed	5.4	1.0	9
The operation of the newsfeed would be simple	5.9	1.2	9
The usage of the newsfeed would be frustrating	2.5	0.8	8
The usage of the newsfeed would be cumbersome	3.1	1.1	8
I would use the newsfeed	5.9	1.9	9

Table 1: PUEU Questionnaire – Results

The questionnaire consisted of two types of questions, firstly for the quantitative assessment of the perceived usefulness and ease of use, and secondly for a qualitative feedback on operational usefulness and potential improvements.

According to the Technology Acceptance Model (TAM, [3]), perceived usefulness and ease of use are the most predictive factors of user acceptance and, in consequence, future usage. Based on Davis’ “Perceived Usefulness and Ease of Use” questionnaire (PUEU, [2]), we posed six statements to survey the SMEs’ assessments. The SMEs had to rate the statements on a scale from 1 (“do not agree”) to 7 (“fully agree”). The results are in Table 1. They are to be considered very positive, so that a high user acceptance for a newsfeed can be expected. The higher standard deviation for the sixth statement is due to an outlier who claimed that he would not use a newsfeed because of his specific task profile (he isn’t a user of a C2IS).

The questions asking for qualitative answers were:

- “In which contexts do you think would a newsfeed be useful?”
- “Do you have any suggestions for improving or extending the newsfeed?”

Regarding usefulness, several SMEs answered that they expect a newsfeed to help an operator get a better overview on the course of events and the progression of action. That is, the main advantage of a newsfeed compared to a map is that represents a sequence of changes rather than merely the current status. This is considered to be helpful in particular in situations with a heavy workload, due to many changes and many distractions. In such situations, a newsfeed can distil information and provide a concise overview. It can also effectively support reporting.

One SME noted that the newsfeed can have the side-effect of keeping the map simple. If a newsfeed is given, it can be sufficient to just show regular symbols on the map, without highlighting changes and overlaying details. The provision of a newsfeed can lead to the “purification” of the map and make it better comprehensible.

The SMEs did not agree on the contexts in which a newsfeed can be of advantage. While some saw its potential benefit rather on a higher level of the command line, others found it interesting in particular for the tactical level in order to give mobile units a comprehensive overview on the situation and the latest developments. One saw the opportunity to inform actors that do not have immediate access to a C2IS, e.g., civilian actors.

Regarding potential improvements, the SMEs reconfirmed that a newsfeed must not contribute to information overload and raise cognitive effort. Therefore, it should include means for configuring the newsfeed client according to individual and role-specific requirements, that is, to define filters and criteria for prioritisation. The interface must be clear and manageable. It should be linked with the map.

One SME noted that it might be necessary to assure the reception of messages. One means could be to explicitly request a confirmation. Without a confirmation, it should be impossible to remove or hide the respective message.

If some partners used the newsfeed as the primary or even only medium – one can think of a civil-military cooperation use case – then it might be of advantage if it were edited by a human. A respective function should be provided.

The round table discussion was held with four air force officers who are engaged in the specification of interoperability solutions. To a large extent, the participants confirmed the answers given in the questionnaires. They stressed the importance of prioritisation and the potential benefit of news message summaries. However, they were rather sceptical regarding the application of a newsfeed for tactical units. Instead, they stressed the importance of direct communication via radio, both for confirmation and feedback and for its psychological dimension of “talking to comrades.” They were also sceptical regarding the usefulness of integrating a newsfeed with a chat service – which is already provided by existing notification services (Section 2.3) – and the usability of a Voice User Interface (VUI). They found it probable that such functions would contribute to cognitive effort rather than providing relieve.

4 Design of a demonstrator

We implemented a newsfeed as part of a C2IS demonstrator. The design of the C2IS demonstrator follows a model-driven approach. It copes with multiple information models and interoperability standards, among them the MIM and the MIP4-IES. It enables the creation, exchange and reception of BSO reports, from which newsfeed messages can be generated. Within this section, we will outline the technological context of the newsfeed, namely the MIM and the MIP4-IES (Section 4.1) and InSAne (Section 4.2). Then, we will describe the newsfeed demonstrator (Section 4.3).

4.1 Enabling interoperability: MIM and MIP4-IES

The Multilateral Interoperability Programme (MIP, [13]) is a multinational military standardization endeavour with participation of 24 member nations, the European Defence Agency (EDA) and NATO. Its latest interoperability solution is the MIP 4 Information Exchange Specification (MIP4-IES). The MIP4-IES allows to share battlespace objects using a web service-based publish/subscribe exchange mechanism. The XML schemas that define the exchange of structured BSOs were derived from the MIP Information Model (MIM [5] [6] [12]), version 4.1.

4 Design of a demonstrator

The MIM is a model defined in the Unified Modeling Language (UML). BSOs are defined as a comprehensive taxonomy of classes. In total, the MIM defines more than 2,000 types of objects (actors, facilities, equipment, features, information resources) and hundreds of different actions. Each BSO comes with a set of structured attributes that further characterize the BSOs. For instance, there are more than 50 attributes that describe a military unit (name, echelon size, geographic location, readiness, hostility, address, . . .).² The extent of the MIM, and thus of the MIP4-IES, calls for a news feed implementation that, at least in a first step, is able to produce news in a generic manner to cover all potential updates for BSOs.

The MIM has a rich set of semantic annotations. UML stereotypes are assigned to each class, data type, enumeration, attribute, and association in the model. They provide additional information on the individual model elements that goes beyond standard UML semantics. For instance, each attribute is classified according to its intended purpose. Table 2 shows the corresponding excerpt of the UML profile. When assigning a stereotype, the respective element may get additional meta data. E.g., for each “measure” attribute, the data modeler has to specify the unit of measure. This unit is captured in the UML model in terms of a “tagged value.” The XML schemas for the MIP4-IES retain the semantic annotations. Therefore, they are directly accessible in C2ISs that implement the MIP interoperability standard (via reflection).

For the newsfeed, the meta data can be exploited to produce more meaningful text messages. E.g., instead of stating “The completion of task T has changed from X to Y ”, the newsfeed generator would be able to produce a text like “The completion of task T has increased by 5 percent.”

The MIM contains more than 400 code lists that are specified as enumerations in the UML model. Some enumerations have code values (literals) that do not define an order (such as colors). However, other enumerations do define an order, and the particular ordering relationship is specified in the MIM. An example is given in Figure 1: enumeration “TroopReadinessCode” defines the relation “is lower readiness than” and the individual code values are ordered accordingly both in the MIM and in the MIP4-IES schemata. Again, this meta information can be exploited by using terms such “improved”, “decreased”, etc. in news messages.

4.2 C2 demonstrator: InSAne

InSAne – short for “Intelligent Situational Awareness” – is a framework for a cloud-based C2 demonstrator that meets the demands of resilience, scalability, and adaptability by design. To meet these demands, InSAne employs cloud technologies according to the Cloud Service Model of the US National Institute of Standards and Technology (NIST, [10]). It incorporates a four-level architecture with

1. Metal-as-a-Service (MaaS) as the underlying physical realisation (hardware, this level is not included in the NIST model),
2. Infrastructure-as-a-Service (IaaS) for hardware management and the provision of virtual resources,

² Of course, not all attributes are operationally relevant in all contexts.

Attribute Stereotype	
binaryObject	A sequence of binary digits.
structure	A structure is composed of one or more attributes. It is defined by a complex data type.
code	A value of a finite list of allowed values.
indicator	A Boolean value.
ordinal	An assigned number that represents order or sequence.
duration	A length of time without a fixed start or end time.
<i>textual</i>	
identifier	A character string used to uniquely identify one instance of an object.
name	A word or phrase that constitutes the distinctive designation of a person, place, thing or concept.
text	A character string generally in the form of words of a language.
value	The concept of worth in general that is assigned or is determined by measurement, assessment or calculation.
<i>timepoint</i>	
dateTime	A date and time of day to various common resolutions.
date	A point in time described according to the Gregorian calendar in various common resolutions.
time	A time of day to various common resolutions.
<i>decimal</i>	
rate	A quantity, amount, frequency, or dimensionless factor, measured against an independent base unit, expressed as a quotient.
quantity	A counted number of non-monetary units, possibly including fractions.
amount	A number of monetary units specified in a currency.
number	A mathematical number that is assigned or is determined by calculation.
percent	A value representing a fraction of one hundred.
ratio	A relation between two independent quantities, using the same unit of measure or currency.
<i>measure</i>	
angle	A measurement expressed in units of degrees.
dimension	A one-dimensional linear distance measure.
temperature	A measure of degree of hotness or coldness in an object or in space expressed in degrees Celsius.
speed	The magnitude of the velocity of an object.
coordinate	The location of a point expressed in degrees.

Table 2: MIM Meta Model – Attribute Stereotypes

4 Design of a demonstrator

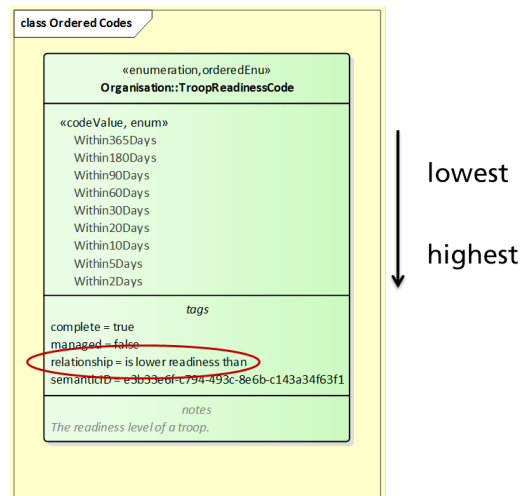


Figure 1: MIM Meta Model – Enumeration Stereotypes

3. Platform-as-a-Service (PaaS) for the provision of execution runtime, middleware, programming interfaces, databases, etc., and
4. Software-as-a-Service for APIs and functions to the end user, including COI services according to the NATO C3 Technical Service Taxonomy.

InSane adopts existing technologies, standards, and open source software for MaaS, IaaS, and PaaS. Adaptability is achieved by making the system extensible with new applications realised as micro-services on the SaaS level. Micro-services are small, independent from each other,³ and exchangeable. They allow for rapid development and immediate deployment.

The C2IS functionalities are divided into modules so that, on the one hand, components of one functional type, like e.g. user interfaces (UI), are divided from components of other types, like data storage components, and, on the other hand, bounded use contexts, based on specific domains and standards, can be distinguished. Thereby, the extension and further development by Domain Driven Design [7] is enabled.

An end-user functionality can be provided by several interacting services. For a map view on the current operational situation, e.g., a “Geo-Service” provides maps layers, a “Converter” service converts BSOs into symbol codes for BSO reports that are stored in a “MIP4 Storage”, a “Symbol Renderer” service then converts these codes into symbols according to APP-6, which are finally displayed on a map within a “Dashboard” client. (Cf. Figure 3 in Section 4.3.)

InSane copes with multiple interoperability standards, including Nato Vector Graphics (NVG), NFFI and MIP4-IES. Each standard, and accordingly each information model, comes with its own data store(s) so that the implementation of a new standard does not require the mapping to a common schema. Instead, converter services are implemented to translate one standard into another, and, as a further means to process multiple standards, synchroniser services are

³ Minor exceptions prove the rule.

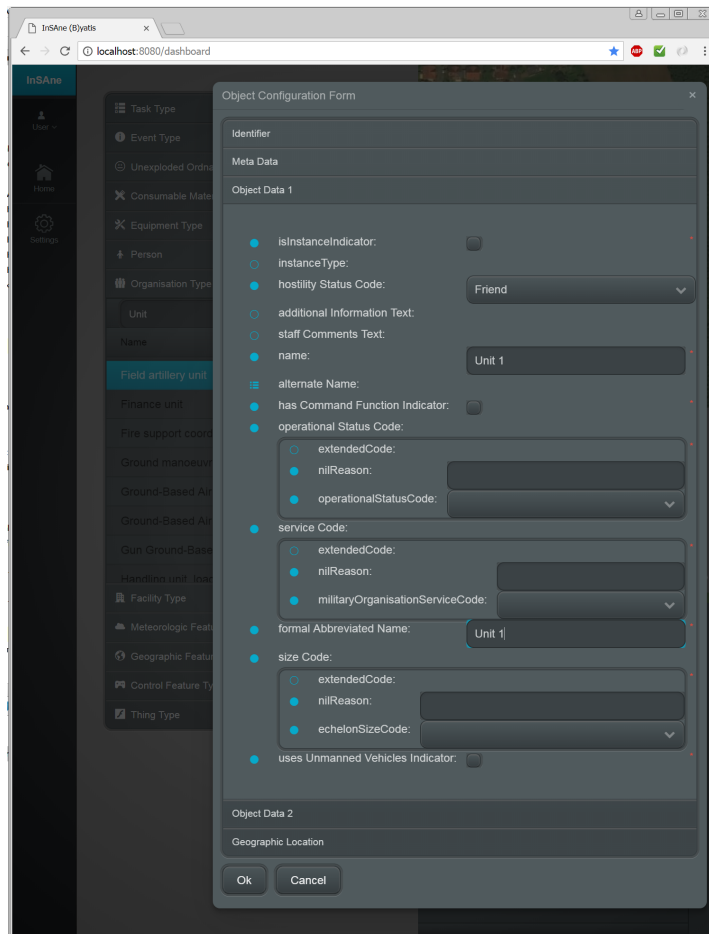


Figure 2: Dashboard with BSO report dialogue

provided to synchronise the information available in multiple models and, thus, multiple data stores.

Since InSAne incorporates a Model-Driven Architecture (MDA, [15]), aspects of the C2IS can be automatically generated from given models. To this end, models are transferred into Java representations from which data persistence and User Interface (UI) elements, like forms for editing object representations, are created. Figure 2 shows a sample dialogue for creating and editing BSO reports. The dialogue has been automatically created from the underlying BSO representation schemata.

The current user front-end of the demonstrator is a web-application that runs in browsers that support HTML5 and JavaScript. As a web-application, it runs without a specific deployment of software and software updates on the client side.

The InSAne architecture has been described in detail in [1].

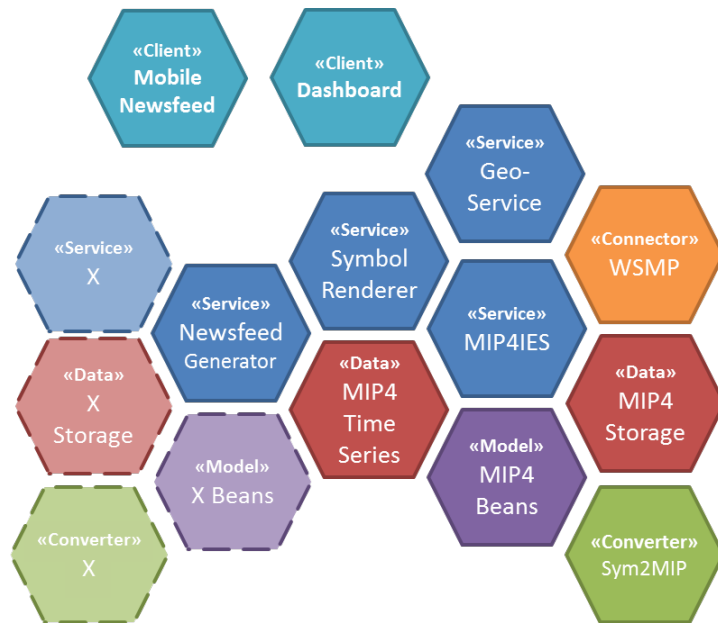


Figure 3: Selected InSane module instances

4.3 Newsfeed demonstrator

A newsfeed has been implemented as part of the InSane demonstrator. It is based on several interacting micro-services, as depicted in Figure 3:

- BSO reports can be created on the “Dashboard”, which is the C2IS user interface that provides forms to create and manipulate object representations. It also depicts the map with the current operational picture and provides a window for displaying the newsfeed.
- In addition, BSO reports can be received from partners via the “WSMP” connector.
- The “MIP4-IES” service serves as a glue for the MIP4-related services. It encapsulates the WSMP implementation and defines the MIP4 profile. (The WSMP connector can also be used to exchange non-MIP4 objects.)
- BSO reports are stored in two different data stores, firstly in the “MIP4 Storage” and, secondly, in the “MIP4 Time Series”.⁴ Only MIP4 Time Series supports history and can, thus, be referred to for the calculation and assessment of deltas, which trigger news messages.
- Newsfeed messages are generated by the “Newsfeed Generator” service. Whenever a BSO report is created, manipulated or received, the Newsfeed Generator is notified. It calculates the deltas of the MIP4 Time Series objects and validates them with respect to the MIM meta model. It then transfers BSO reports, deltas and their validations into text messages.

⁴ For one and the same model, several data stores can be created to support diverse functionalities, like the creation of heat-maps or various forms of data analytics.

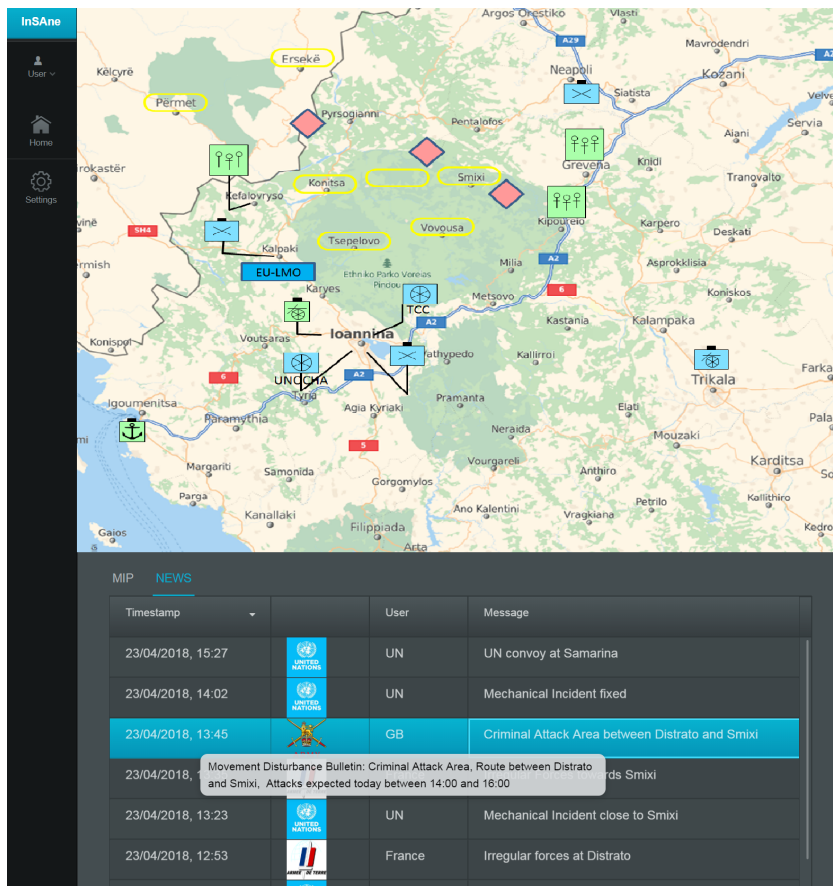


Figure 4: Mock-up of a newsfeed for an INSANE-based C2IS

- Finally, components for visualisation provide the user front end. News messages are given in a chronological order. They are linked to their respective symbols on the map display. By mouse hover, a natural language version of the entire BSO report is shown in a box. Figure 3 shows the mock-up of a desktop user interface. Figure 5 shows the mock-up of an alternative interface for a mobile client. This interface does not provide a map but just lists the news messages in chronological order. The interface is to be realised by a separate client service.

Essentially, the newsfeed consists of the Newsfeed Generator and components for visualisation, namely, parts of the Dashboard and/or further client services like the mobile application. Additional functionalities will be realised by extending the Newsfeed Generator and/or implementing further micro-services. Other services, like the “MIP4-IES” service etc., act as enabling services. We take them as granted; they will not be touched for the further development of the newsfeed.

5 Conclusions

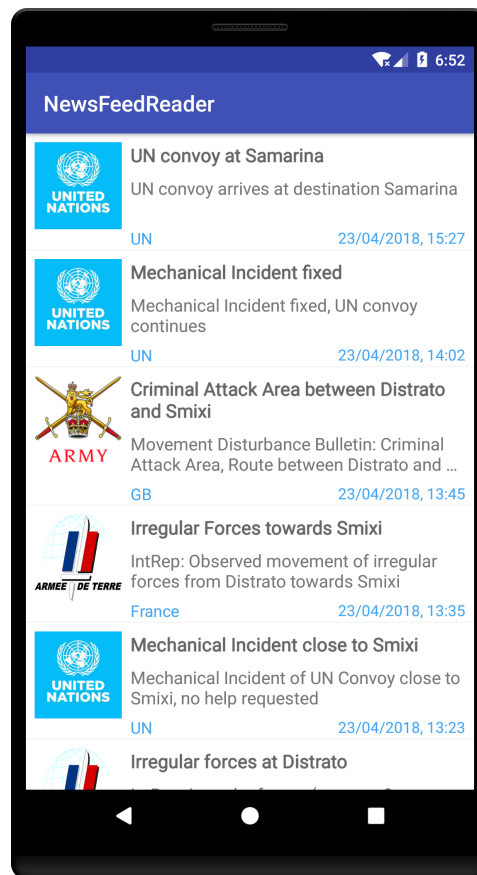


Figure 5: Mock-up of a newsfeed as a mobile application

5 Conclusions

In this paper, we presented the concept of a C2 newsfeed and the design of a demonstrator for a respective service. The newsfeed has been implemented as part of the InSAne C2 demonstrator. It automatically generates news messages from MIP4-IES-conformant BSO reports with respect to the MIM and the MIM meta model. The service requires very limited manual adaptation. Only filters will have to be configured for specific use cases.

We evaluated the newsfeed concept with military subject matter experts (SMEs). The evaluation results are positive, confirm the capacity of the concept, and support its further development.

Within C2IS, the standard representation of the current operational picture is given by a map. A newsfeed introduces text as an additional, very basic modality. It is meant to complement the map display: the modalities map and text are to be linked in order to make the overall representation of the actual situation both more comprehensive and better comprehensible.

Although a newsfeed is only meant to complement and not replace map displays in headquarters, for some actors it can be a useful service on its own. To these actors might belong mobile

or even dismantled military units as well as civilian partners who are often not equipped with a C2IS on their own. Previous investigations have shown that there is a demand to develop light-weight C2IS and other information services for civilian organisations, in order to improve situational awareness, enable interoperability between civilian and military partners and, ultimately, bring the comprehensive approach to its full potential ([16], [11]).

We follow a human-centred design approach to service development [8] with multiple iterations, each including requirements engineering, prototype implementation/refinement and evaluation. We started from a concept, created mock-ups as first basic prototypes, evaluated these with military SMEs, deduced additional requirements and implemented a running service. The next steps will be to evaluate the service and stepwise refine it, in particular for improving text generation, relevance filters and, in perspective, anomaly detection. It is also planned to develop reporting services, for which a newsfeed generator can function as an enabling service.

In order to support plausible evaluation and thereby assure the usefulness of the newsfeed, we aim at specifying capabilities (bounded contexts) that can effectively be supported by a newsfeed, together with respective use cases and demonstration scenarios. These scenarios will be used for the evaluation of advanced prototypes with SMEs, both military and civilian.

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