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Bringing new arrangements to C2 – Experiments with social information

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Abstract

New technology, arrangements, processes, and ways to organize should be explored in combination to find new effective approaches to Command and Control (C2). Collecting, sharing, and processing information to achieve effective C2 should be done in ways that both exploit and honor the social aspects of information. That is, by efficient means inform the user, aggregate and refine information, in constructive ways bring forward disagreements, uncover potential risky misunderstandings and remove errors, and establish trust in the information. In short, the technology and our arrangements of C2 should work together to provide for the underlying processes necessary to build shared awareness, trust, and agreements to foster constructive collective behavior.

To increase the understanding of the new opportunities that technology brings with respect to new C2 arrangements, and ways to share and work with information, we have done experiments with an experimental, for research, “data centric social tactical reporting system” – The Collective Environment Interpretation (CEI) system. The CEI system is leveraged on commercially available services and technologies and has been made available for android-based smartphones and web browsers.

Using the CEI system we address issues involving both social and information networks. The CEI system incorporates some of the designs and mechanisms we are used to find on the web and in social media, but aspects that have not been explored much in the military domain: openness, high availability, ease of use, simple data models, and vague organizational footprints. Further, the CEI system collects user-contributed information. Mechanisms to support the collective effort to improve the quality of information, and to establish trust in information and even inducing the users in the process of building a shared awareness, are of great interest.

Based on our questionnaires, interviews, and observations, along with the user-contributed data from our experiments, we discuss our findings.

Introduction

Technology providing for efficient Command and Control (C2) is a timeless topic. A robustly networked force is one of the basic tenets of Network Centric Warfare (NCW) or Nato Network Enabled Capability (NNEC) (Alberts & Hayes, 2003; Nato C3 Agency, 2005). In relevant models, it improves information sharing, which enhances the quality of information and shared awareness; this further enables collaboration and thus increases missions' effectiveness.

Further, to find new effective approaches to C2, technology, arrangements, processes, and ways to organize should be explored in combination. Collecting, sharing, and processing information to achieve effective C2 should be done in ways that both exploit and honor the social aspects of information. *Shared awareness* is a prerequisite for constructive and effective collective behavior in any situation of some complexity. As the NCW models state, sharing information improves shared awareness. Still, building shared awareness is best done as an active task. By that we mean that shared awareness is nothing someone can give you. It takes some effort and should be an interactive process between its participants, much in the same way as learning a new skill is best done while participating in relevant activities: Someone can lecture you, you can read everything of relevance, but eventually you will need to get involved, ask questions, and test your understanding. Similarly, an officer being briefed will often ask questions to further build and test his own understanding.

Our C2 arrangements and systems may be designed to support similar processes. Participants should not only share information, they should also be involved, and our systems and processes should invite for this to happen. Their understanding should be tested against each other at every practical occasion—and new technology is constantly changing what is considered practical. Such information could be aggregated and refined, errors, disagreements, and potentially risky misunderstandings could be uncovered, and finally, trust could be built, both in the information being exchanged and between participants.

The term Web 2.0 was once a popular term used to express what was then seen as new aspects of the web. One of the elements mentioned in the article "What is Web 2.0" (O'Reilly, 2005) is the aspect of "harnessing Collective Intelligence" or the shift in focus from one-way publishing to participation. The early days of the web did not allow for many interactive services, but progress in technology and digital literacy made that possible. With social technology like Facebook, Instagram, Twitter, and like losing their novelty and being taken for granted, we may no longer reflect much on these changes from one-way dialogues to discussions and social interaction. Still, the opportunities that lie in technology supporting two-way communication, discussions, and dialogues are not well understood in military settings.

The military uses communication services like chat, e-mail, and Video Conferencing (VTC) extensively. These are flexible systems in the sense that they do not "care" what the collaboration is about, and have little understanding of the context. These systems may be used for anything, though the collaboration may or may not be efficient. These services reflect no particular structure and do not contribute directly to any particular business process. The subject of the collaboration is hence not a part of these systems. We recognize that many consumer-oriented services are extremely successful in terms of involvement, interaction, and user participation, and we want to borrow from

design patterns and architectures of social technologies to investigate their suitability in semi-structured military processes.

Our Collective Environment Interpretation (CEI) system incorporates some of the designs and mechanisms we are used to find on the web and in social media, but those that are not often explored in the military domain: openness, high availability, ease of use, simple data models, and vague organizational footprints within the system. Further, the CEI system collects user-contributed information. Mechanisms to support the collective effort of improving the quality of information, and to establish trust in the information and even inducing users in the process of building shared awareness, are of great interest.

For our study, and with our CEI system, we have chosen tactical reporting as our use-case. The availability of smartphones and the idea that every soldier is a sensor makes this use-case interesting for other reasons as well. Tactical reporting is an area that is traditionally characterized by hierarchical information flows and hierarchical filtering of information. Broad involvement and cross unit communication has traditionally been difficult.

With the CEI system, we have conducted a series of discovery experiments in training and exercises. The aim has been to gain better knowledge of how information may be shared and organized to actively build shared awareness in a process that invites users to dialogue about the information and collectively interpret it.

The rest of this paper is structured as follows. We first present some related work and give additional background. We then describe the CEI system and its design fundamentals. Thereafter, we describe our experiments, the method used, and the practical completion of the experiments. Then, our results are presented and discussed. We end this paper with some concluding remarks and possible further work.

Background and related work

In a blog post from 2004, Tim O'Reilly (O'Reilly, 2004) used the term *The Architecture of participation* to describe systems that are designed for user participation. He explained that *the participation and collaboration is something that is built into the system* and discussed the architecture of systems and services being such *that users pursuing their own "selfish" interests build collective value as an automatic byproduct*. We understand that few C2-related systems are designed with such mechanisms and secondary goals in mind; therefore, we would like to investigate what the collective value is that we could possibly build in our C2 systems.

Wiki is a technology and collaboration model best known from Wikipedia. Wikis are unique in the sense that a wiki lets users edit both the content and the structure in a collaborative way. One of the design principles mentioned in *The Wiki way - quick collaboration on the Web* (Leuf & Cunningham, 2001) is "Open", meaning "Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit." This principle in action will enable readers to become editors, as they may make minor or major revisions. A consequence of the "open" design principle is that the content of a wiki becomes evolutionary. Writing a good-quality, comprehensive article implies a significant amount of work. Therefore, since it is easier to correct a minor mistake, add a paragraph, rewrite a passage, move some content or link to existing content—in essence: build upon what is already in a

wiki—the content is generated in an incremental and evolutionary way. The resulting article is a sum of multiple contributions. There is no guarantee, but for most articles, over time, the quality is improved.

With many wiki implementations, like with Wikipedia, articles are marked with improvement suggestions, and every article has a companion "Talk" page with a discussion/dialog of improvement issues regarding its main article. The preserved historical versions of articles and the discussions in the "Talk" page should contribute to increased trust in such user-contributed information. The evolutionary process of users contributing data and gradually improving quality may also be a means to build shared understanding: A user participating in such discussions, even if only browsing, should get a better understanding of the topic and the other participant's stand. In that case, the dialogue itself contributes substantially to the process of the participants building a shared understanding, and shared awareness. We may say that it represents a *collective interpretation* of the given topic.

The parallel evolutionary process is not used widely in military organizations. There are obvious complicating characteristics of this process, but the presence of new technology should make it more relevant. Wiki documents, and user-contributed content in general, do not have the authoritative status (Anderson, 2008) that is often expected from military documents used for decision making. What quality such information has and how it may be trusted is a central question. With our work, we are testing the same mechanisms in relation to C2 to implement processes that foster dialogues of "How should we understand this observation or incident?" In an earlier report (Fidjeland et al., 2010), we have also proposed wiki-based planning as a C2 tool supporting parallel planning.

The web is full of examples of successful services based on user-contributed data: Wikipedia we have mentioned. OpenStreetMap (OSM) is a project where users contribute to building a map of the World (OpenStreetMap, 2014). The WikiCrimes system is an example of collective intelligence in law enforcement (Furtado et al., 2010; WikiCrimes, 2015). Moreover, social media is often used for ad-hoc information sharing during crises. The 17th ICCRTs best paper *The Role of Social Media in Crisis* presents a few use-cases and discusses its role (Manso & Manso, 2013).

The Tactical Ground Reporting (TIGR) system is an in-service system-supporting company-level and below in collecting, storing, and disseminating tactical information. TIGR breaks from the traditional hierarchical, bottom-up filtered information flow of reporting, and instead builds on the success of direct peer-to-peer collaboration (Evans et al., 2013; General Dynamics C4 Systems, 2012; Talbot, 2008). The US TIGR System has shown some of the military potential that lies in a bottom-up approach with user-contributed information and a relatively broad dissemination of information with little filtering applied.

The Nett Warrior is a soldier system of the more traditional type, but it now also uses a smartphone as an end-user device (Dixon & Henning, 2013). This US system is an integrated dismounted leader situational awareness system for use during combat operations (Program Executive Office Soldier U.S.Army, 2014).

Most tactical or soldier reporting systems focus on the *collection* and *dissemination* of information, and within a limited size group. Other C2 systems may be digital implementations of existing analog processes and do not necessarily contribute new ways to for users to participate and interact. Such sharing of information or sharing of C2 products is for the majority of cases still implemented as one-

way processes. However, building a real understanding and awareness requires dialog, involvement, and iterative processes. With our experiments we wanted to get better knowledge of information sharing and how situational awareness may be established with more open and interactive processes.

The Collective Environment Interpretation (CEI) System

We now present some background on the concept of which the CEI system is built; thereafter, we present more details on the architecture and functionality of the system.

The concept of the CEI system

The purpose of the CEI system is to foster some sort of community where shared awareness is built among its users. We did choose tactical reporting as our use-case for this work, but the basic ideas should be transferable to other C2-related use-cases. The CEI system has become what we now categorize as a *data-centric social tactical reporting system*.

We wanted the CEI system to collect user-contributed information and have mechanisms to support the collective effort of improving the quality of information and to establish trust in it. We also wanted to design the system to facilitate a process similar to that of the evolutionary process of wikis, as described earlier.

The CEI system promotes openness and is built for high availability. We wanted it to be effortless to both consult the system and to contribute information to the system. It should be practical to contribute even the smallest piece of information. To support high availability, the system is designed to be intuitive and easy to use. The system's simplistic and general data models should help keep the system intuitive and flexible. Finally, the absence of organizational structure in the system is another measure to ensure high availability and to keep the system more flexible in terms of who may use it and how.

For clarity, we did not aim for a soldier system for combat operations, but for a situational awareness tool for sharing information and facilitating some open processes necessary for establishing shared awareness within a larger unit or across organizational borders.

Architecture of and functionality in the CEI system

The CEI System is implemented as a technology demonstrator. It is first mentioned in our report on *Web-oriented Architecture – Network-based Defence development made easier* (Fidjeland & Reitan, 2009). The very simple explanation of the system is that it will keep positions and observations reported by its users, together with comments, in a centralized database for users to access.

The system is for research and demonstration and has been made into a prototype suitable for experiments. The system has multiple parts (see Figure 1). In the experiments we are reporting, we used a client/app for android smartphones and tablets and the server backend of the system. The android client of the system is basically a map application that gets updated with tracks, observations, and comments from other users of the system (see Figure 2) (Karlsen & Reitan, 2014). The modules of the backend are the CEI server, a map server, and a user directory server.

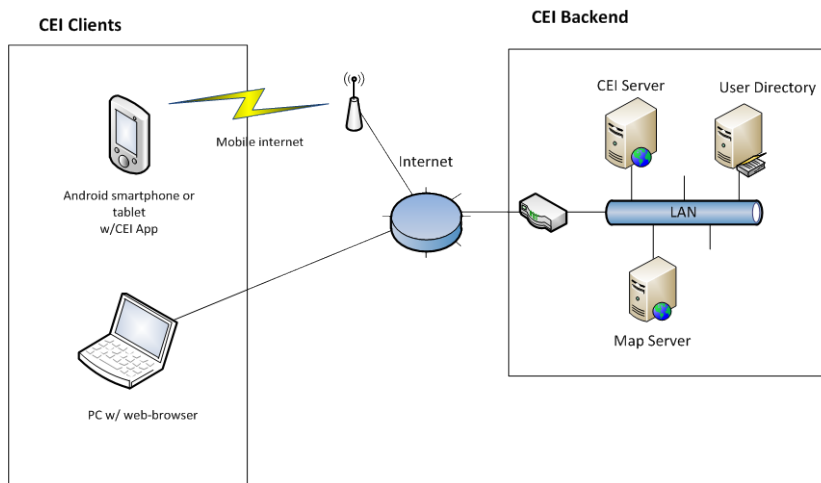


Figure 1: Architecture of the CEI system

Using the android application, the user can choose to share his/her position or to be tracked. The user may also register and share an observation or ask a question related to a location on the map. Finally, the user may comment on other users' observations or comments. Observations may be tagged for easier filtering when retrieving information. When a location, track, observation, or comment is posted, that information is made available to any other user of the system. There are no mechanisms limiting access to that information.

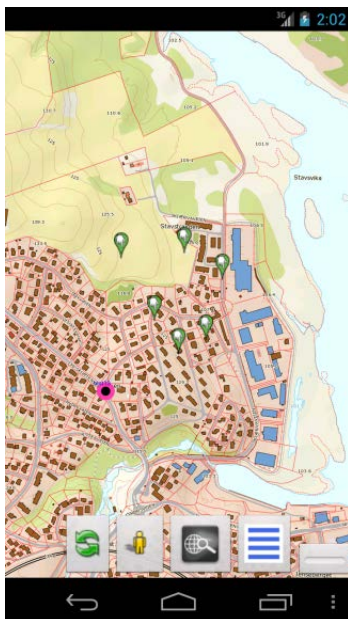


Figure 2: Screenshot from the CEI app

The system, quite deliberately, uses a very simplistic data model (see Figure 3 for the details of an observation). Our hypothesis is that an uncomplicated data model makes it easier for new users to grasp the basics of the app and the system. It should be easy for new users, without training, to contribute their observations and comments to this system.

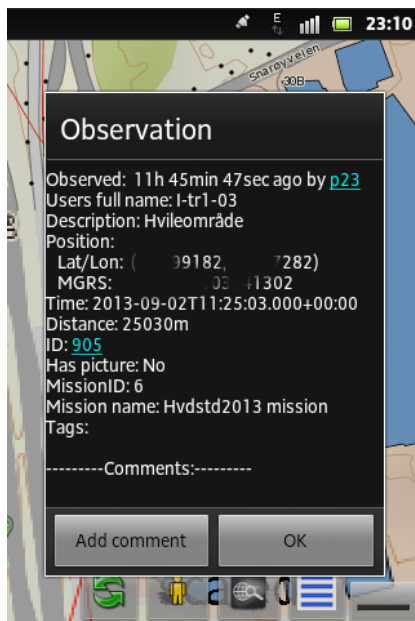


Figure 3: Details of an observation in the CEI app

The comments are the most obvious attempt to enable two-way communication (dialog) between the system's users. The system should make it easy to harness and disseminate data, but it should also invite users to some sort of dialog. We wanted the system to foster a process of "collective interpretation" that help remove errors, refine the information, and establish trust in the information. Simultaneously, we were hoping that shared awareness could be improved. The android CEI app also has shortcuts to interact with other smartphone services. For example, from an observation it is possible to initiate a call and send an SMS or an e-mail to the person submitting the observation.

The Experiments

Methodology

We have previously, with good results, conducted open exploratory or discovery experiments addressing the use of smartphones and pads in military settings (Reitan, Fidjeland, Hafnor, & Darisiro, 2012). We wanted to use much of the same approach for these experiments. We have found discovery experiments to be well suited to our relatively broad research questions. These experiments yield a lot of information in the form of coverage. However, exploratory experiments do not aim to verify any detailed hypothesis.

According to NATO (NATO Allied Command Transformation, 2013) discovery experiments are used to introduce novel systems, concepts, organizational structures, and/or technologies, to a setting where their use can be observed. We wanted our participants to be able to test the CEI system and become sufficiently familiarized with it for them to provide feedback on the process.

We collected data through questionnaires, semi-structured interviews, observations, and analysis of the data submitted to the CEI system during the exercises.

Experiments

With the CEI system, we conducted three discovery experiments with a prioritized home guard company-sized unit. The first was done only at a platoon training event, the second at a company exercise, and the last one at a larger five-day exercise. The final exercise involved many more units, but the CEI system was only available to the home guard company that we followed. In this paper, we are mainly reporting results from the last exercise.

The exercise scenario was a complex terrorist attack in the capital of Norway. The unit we followed used the first two days in camp, training and getting combat-ready. At the beginning of the third day, the unit got its order to move and then to guard a building complex, where they stayed until the end of the exercise. At the site, the unit had to handle different incidents. None of these incidents were aimed to test the CEI system, and we had no particular events prepared in the exercise scenario targeting the use of the CEI system. The CEI system was intended to be something in addition to what they already used. Unlike with a technical test, we also wanted to uncover challenges in other dimensions like challenges in the organization, process, or human dimensions.

For the exercise we had prepared thirty android smartphones and pads that were made available to different functions in the company. The HQ had a laptop PC running Android with the CEI system installed. The server was placed at our research institute. No dedicated network was deployed, and only Internet and commercial mobile networks were used. The system was only to be used with unclassified information.

Questionnaires were used both before and after the participants used the system. Interviews were only done in preparation to and at the start of the last exercise; we were not able to do interviews after the last exercise.

The questionnaires were partly built using standardized questions from the Technology Acceptance Model (TAM) tradition (Venkatesh, Morris, Davis, & Davis, 2003) adjusted to address the concept and the CEI system. The scaled questions were on a seven-point Likert scale (1 to 7). The TAM framework allows for in-depth analysis, but we did not get enough respondents from these experiments to consider correlations between variables. In our analysis, we only consider averages and the simple distributions of single variables.

Results and discussion

In this section, we present the results from our experiments. The results we report are from a set of questionnaires and the data the participants submitted to the system. In addition, we offer more details and our interpretation of these results based on interviews and observations.

Usefulness

The participants were asked about the CEI system's usefulness, and they scored the usefulness quite high (see Figure 3). We also found the participants, with just a few exceptions, to be quite enthusiastic.

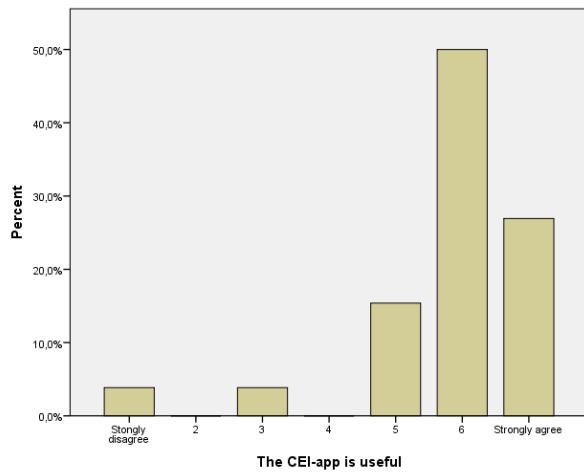


Figure 4, "The CEI app is useful"

Moreover, when asked if the CEI app was a good idea, most agreed strongly (see Figure 4). We got similar results when we asked if they were satisfied with the app and the smartphone or tablet they were using. Furthermore, when asked if the CEI app will give results that are useful for solving a mission, the majority was still positive, but not as absolute as with usefulness in general (Figure 5).

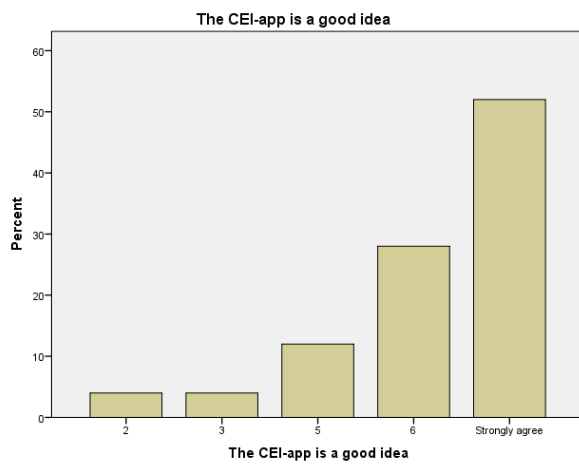


Figure 5, "The CEI app is a good idea"

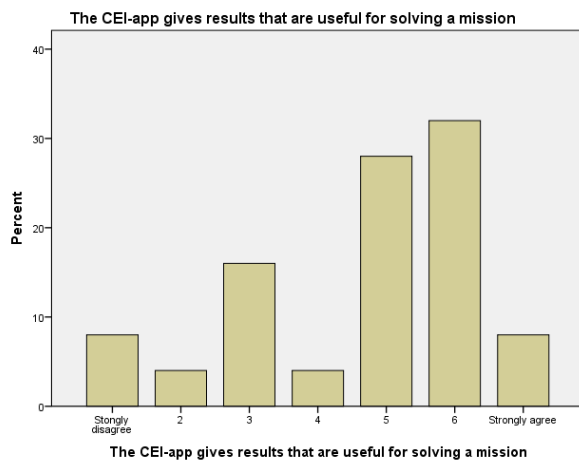


Figure 6, "The CEI app gives results that are useful for solving a mission"

Intuitive and easy to use

We also wanted to determine whether the users found the CEI app intuitive and easy to use, and most participants did. Figures 6 and 7 show these results. Our interviews and observations also indicated the same. The only objections we got, with respect to ease of use, were from iOS users who experienced some challenges with the Android smartphones and would have liked to see an iOS version. The concepts of the system with *observations*, *comments*, and *tracks* were said to be easy to grasp.

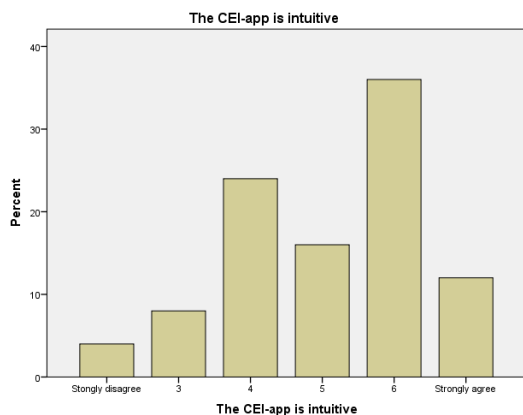


Figure 7, "The CEI app is intuitive"

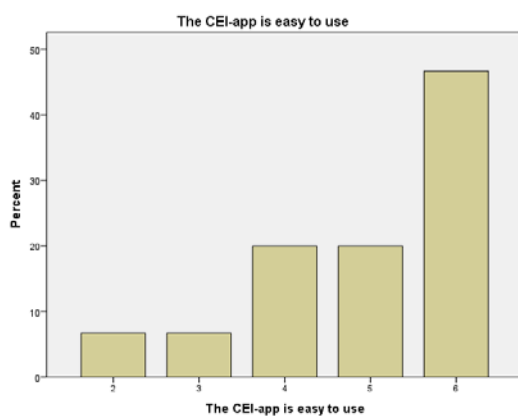


Figure 8, "The CEI app is easy to use"

Actual use

The system appeared to be used less than the enthusiasm and reported usefulness indicated. We have no data on overall usage, but at the end of the experiment, we found less data in the CEI system's database than we expected.

In addition to minor incidents and irregularities, we found that points of reference were put into the system. For example, access control posts, resting areas, emergency rooms, and signal buildings in the area were registered. Some of these observations were registered by those who arrived early to the area, so their observations may have been relevant for the rest of the company when they later

moved into the area. Unfortunately, we have little data on how the information was consumed or used.

Some positions and tracks were also found in the system. For example, the MP had used the system to keep track of each other on the move, and the dog handlers used the system while tracking.

The *comments* were hardly used, and they were only used by the same unit that first reported the observation. The comments were then used to add more detailed information regarding the original observation. The dialogue we hoped for, like the discussions and interpretations of observations, was not present in the CEI system. In case the CEI app started any dialogues, other channels (voice, SMS) must have been used to continue and complete the dialogue.

Even though we did not find many observations in the system, we still found cases regarding the same object reported from teams that normally do not communicate much due to their distance in the hierarchy. For example, the same suspicious car was first observed and reported by a reconnaissance team and then reported again by an MP team. It is not given that the MP team would have gotten this report from the reconnaissance team without the CEI system. This is the type of information that may be easily filtered away in the hierarchy. This information was not explicitly linked or commented on in the system, but may have started a dialog outside of the CEI system.

Why the system was not used

In addition to making the CEI system available and providing a short instruction pamphlet, we did not do much to promote and advance the use of the system. However, active bootstrapping is common with networked systems containing user-contributed information. In general, a system with a great deal of information is more attractive to use and consult than one with little information. To some extent, we anticipated there being few observations posted to the system. In the questionnaire, the participants were therefore asked why they did not share data. Like with the questions in the graphs above, a statement was given, and each participant could answer on a seven-point scale if they agreed. One is *Strongly disagree* and seven is *Strongly agree*. Table 1 shows only the average.

Statement	Average
The battery was empty	4.1
The information would not have reached the right person	4.0
It would have taken focus from away the mission	3.5
It may have put the mission at risk	3.1
The information I wanted to share was classified	3.1
It was difficult to decide what to share	3.1
I did not remember the app	2.7
I had no relevant data to share	2.6
It does not fit our way of working	2.5
The app did not work	2.2
I did not want to bother others with irrelevant information	1.5

Table 1: Why was information not reported using the CEI System (scale 1 to 7).

As shown in Table 1, quite a few had problems with obvious issues like the battery. This may further be a contributing, but probably not the only, reason for why there are concerns that the information would not reach the right person. In this case, there is likely a lack of trust in the system's fit with

respect to the information reaching and getting the right attention from the persons or functions that need to act on this information.

Our observation was that many of the participants ended up not using the system once the exercise incidents started happened and their workload increased. These observations are in accordance with the high concerns of "It would have taken focus away from the mission" and "It may have put the mission at risk."

Further, a system like the CEI System is based on openness and broad involvement and the dissemination of information. To test this, it also made sense to have a system for unclassified information. This approach certainly raised some issues. The interviews resulted in very different responses from different functions. For example, in general we found the MP, medic, and dog platoons to be more positive than those more likely to be involved in direct combat. Also, in the interviews, an intelligence officer, originating from security concerns, referenced the CEI system as "useless for our information." In advance we had imagined intelligence as being a significant consumer of information from the CEI system.

We imagine it not being totally clear to all the participants what sort of information the CEI system should be used with, but we are a little surprised that "It does not fit our way of working" was not expressed more frequently as a concern. And especially since some of the above mentioned concerns indicate some unease with the openness, extensive sharing, and vague organizational footprints of the CEI system.

Concluding remarks regarding further work

New technology, arrangements, processes, and ways to organize should be explored in combination to find new effective approaches to C2. We have conducted discovery experiments with smartphones and pads, and our data-centric social tactical reporting system, the Collective Environment Interpretation (CEI) system. The CEI system is designed to foster a non-hierarchical community where the aim is to help its users build shared awareness.

Using the CEI system, we have attempted to address issues involving both social and the information networks. The CEI system incorporates some of the designs and mechanisms we are used to finding on the web and in social media, but those not commonly explored in the military domain: openness, high availability, ease of use, simple data models, and vague organizational footprints. The CEI system collects user-contributed information and has mechanisms that aim to support the collective effort to improve the quality of information, establish trust in it, and actively build shared awareness.

We have conducted a series of discovery experiments. These discovery experiments give great coverage in terms of the broad area of problems addressed, but we do not get many clear answers. For that reason, there are many issues left for further work.

The participants reported the CEI system to be useful, and most participants were eagerly enthusiastic. However, to us there is a contradiction in the usefulness being reported and the sparsely populated database we found at the end of the experiment. More detailed information on how the participants found the CEI system useful is therefore needed. We see evidence of some use, but not extensive. Unfortunately, our data on usage comprise only on information production and

not information consume. Further work will also need to address the issue of information consumption and how it may have contributed to shared awareness for the system's users.

The system exposes its users to information. There are indications that the system has contributed to the overall flow of information and shared awareness. We found no explicit dialogue in the system, but got indications that the system may have contributed in dialogues outside of the CEI system. Further work should also investigate how the system may have triggered or contributed to dialogues or processes outside of the system. In addition, if and how shared awareness was improved, due to the presence of the system, is still unclear.

There are numerous ways to bootstrap the use of such systems. Extra information may be added, the purpose of the systems may be clearly stated in exercise goals, and use of the system may be directed. A system with more apparent activity and more content is more likely to be found attractive. With too little content the system becomes unattractive. It is common to consider a *critical mass* of users or content as a tipping point of such systems. Different bootstrapping techniques may be applied to help reach a critical mass. Knowing some of the challenges and concerns, such techniques may be applied more precisely in later experiments.

For the CEI system, we have chosen tactical reporting as our use-case. We strongly believe that the basic ideas we have applied are transferable to other C2-related use-cases where building shared awareness is of importance.

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