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Tools for Enhancing Distributed, Asynchronous Collaboration in Army Operations

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***Abstract*—Advances in digital communication technologies have had widespread benefits for distributed and asynchronous collaboration. It is only natural, then, to apply these technologies to digitize the battlefield. In fact, some tools have been implemented in the field and found successful in providing useful information to commanders and warfighters. This information is provided through a variety of media, including machine- and human-generated text, images, video, and files that combine different media (such as briefings that contain text and graphics). However, few efforts aim to provide human-generated, multimedia content in machine-generated text environments that are currently under development. This paper describes an effort to use semantic representations of battlefield data to provide commanders information that is relevant to their needs. Additionally, the tools developed make it possible to easily augment machine-generated planning alerts with human-generated content.**

***Keywords*—multimedia, collaboration, battle command, machine-generated content, human-generated content, semantically-based information retrieval**

I. INTRODUCTION

Technology advances increasingly facilitate distributed and asynchronous planning. The right technology, deployed appropriately, enables collaboration by team members that do not have to be in the same place at the same time. Deploying such technologies to aid Army operations planning has many benefits, particularly given the tempo of operations and associated short timelines for collaborative planning. The more collaboration commanders and staff are able to accomplish without being co-located, the faster they will be able to identify and meet key information requirements and develop effective plans for operations.

There are many facets of interest for technology and the battlefield in improving military commanders' capability to collaborate in a distributed and asynchronous environment. First, digital multimedia abounds on the battlefield and tools to facilitate communication of multimedia and other human-generated content can improve information sharing and decision-making. Indeed this is a stated goal of the Army, as noted in Army Field Manual 6-01.1 [7]. Second, improved representations of battlefield data facilitate anticipation of commanders' information needs during battle planning and execution. Finally, as information technologies enable machine-generated content to aid commanders in operations planning, tools that augment such machine-generated planning information with human-generated content can enhance the machine's ability to provide the commander with the information he needs for effective planning and decision-making.

A. *Benefits of multimedia communication*

Previous work carried out for this project has found that multimedia communication is both effective and desirable. Bower and Smith [5] found that recall and understanding were better when ROTC students were presented military orders in a multimedia environment than when presented the same information in a document consisting of text and static graphics. Specifically, 96% of participants receiving multimedia orders correctly identified the direction of enemy approach in a post-test, whereas only 70% correctly identified the direction of enemy approach after receiving orders in a static document. The document consisting of text and static graphics used as a control in this experiment mimicked the five-paragraph operations order described in Army Field Manual 5-0 [3], although many Army units now use graphical orders in which graphics such as annotated maps are supplemented with text boxes.

Further support for the value of multimedia communication was provided by Smith and Spencer [9], who performed an evaluation of a multimedia communication tool as part of a multinational military exercise. The tool, the Collaborative SLide Annotation Tool (CSLANT), enabled users to record a slide show along with voice and synchronized pointing and dynamic annotations. It also enabled message recipients to record a response, creating asynchronous dialogs. The goal of the study in [9] was to determine when military commanders would use such a tool and how they would use it, as well as to get the commanders' feedback on the tool, its features, and its usability. The ten officers participating in the exercise were instructed to use CSLANT whenever they thought such a message would be a helpful form of communication if they were taking part in an actual multinational operation.

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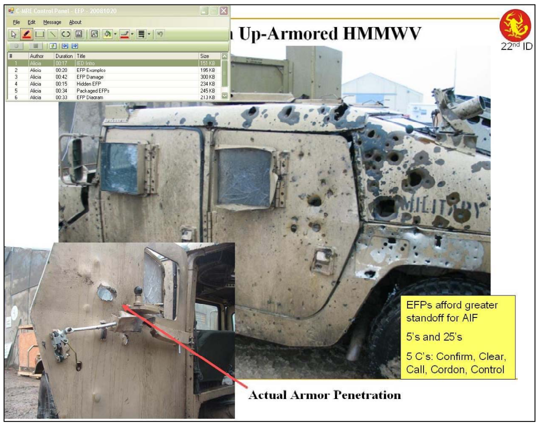
Altogether, the commanders created fifteen CSLANT communications during the experiment. Two were one-way communications and thirteen were asynchronous dialogs, in which one officer created a message and one or more officers responded to that message within the same communication. All of the messages discussed the commander’s intent and/or tasking for a subordinate or parallel unit, and all thirteen of the dialogs involved sharing knowledge relevant to the operation. Twelve of the thirteen dialogs were intended to add important details to a plan, and six dialogs were used to detect and correct misconceptions arising from live face-to-face briefings. For example, in one case a brigade commander briefed his battalion commanders on the operation and one of the battalion commanders created a CSLANT message to task his unit. Upon review of the battalion commander’s CSLANT message, the brigade commander responded with a CSLANT message correcting this misunderstanding.

While preparing and recording CSLANT communications, officers took advantage of all of the available features. In particular, all of the officers pointed to various objects on the slide display while they were speaking, and 70% of the officers drew on the slide while speaking. Note that the pointing behavior is a direct translation of behavior commonly seen during live briefings, and drawing on the slide seems a natural extension of pointing.

In their evaluations of CSLANT the commanders reported that such a tool could accelerate the Army planning process, partly by enabling them to communicate in a natural way without requiring all parties to be together for a live briefing. They also thought that the tool would better enable them to communicate the commander’s intent during planning, so that subordinate commanders would be more likely to understand and carry out that intent. Further, they felt that the persistence of messages recorded in such an environment improves performance because commanders do not have to rely on memory of conversations and live briefings. The officers also reported that CSLANT would be more useful if it were more fully integrated into the planning software.

The evaluation described in [9] established the usefulness and desirability of a tool enabling military commanders to engage in multimedia asynchronous dialogs during distributed operations planning sessions. It also provided insights into how commanders would use a tool for multimedia communications; that is, for providing clarification of their intent and for tasking subordinate units. The commanders also provided useful feedback on the capabilities and usability of CSLANT. As a result of this feedback, an upgraded multimedia communications tool was developed that features a more easily navigable interface and improved integration with other software tools. The upgraded tool, the Collaborative Multimedia Recording Environment (C-MRE), is being utilized in the current phase of the project discussed in this paper. C-MRE enables users to record an audio message along with an animated screen capture. Users can add messages to an existing file, creating the opportunity for asynchronous dialogs. Fig. 1 shows C-MRE in recording mode. The small window in the upper left corner of the screen is the C-MRE control panel, with several different “chunked” messages. The control panel window sits on top of the background image, in this case a briefing about explosively formed projectiles (EFPs) which provides a tutorial for soldiers in the field. A second recording mode (not shown) enables the user to record an audio and video message while manipulating objects directly in a target application. Fig. 2 shows C-MRE in playback mode. Again, there is a small control panel that sits on top of the image that is part of the briefing used to make the recording. Note the pointing and highlighting devices drawn by the user to focus attention on certain portions of the image.



#	Author	Duration	Title	Size
1	Alicia	00:17	IED Intro	151 KB
2	Alicia	00:20	EFP Examples	195 KB
3	Alicia	00:42	EFP Damage	300 KB
4	Alicia	00:15	Hidden EFP	234 KB
5	Alicia	00:34	Packaged EFPs	245 KB
6	Alicia	00:33	EFP Diagram	213 KB

EFPs afford greater standoff for AIF

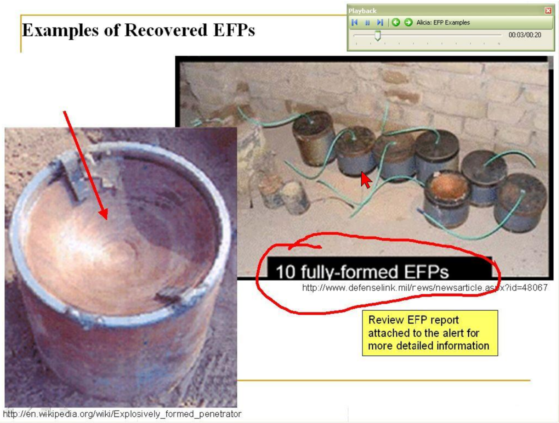
5’s and 25’s

5 C’s: Confirm, Clear, Call, Cordon, Control

Figure 1. Screen capture of C-MRE in recording mode. In this case, the user is recording a tutorial about explosively formed penetrators (EFPs).

C-MRE can be used to record a variety of messages pertinent to the current work, similar to those reported in [9]:

- Clearly communicating the commander’s intent across echelons
- Providing feedback on aspects of plans in development
- Recording a briefing about enemy activities and capabilities



Review EFP report attached to the alert for more detailed information

Figure 2. Screen capture of C-MRE in playback mode. In this case, the message recipient is viewing a tutorial about EFPs.

- Creating a “quick and dirty” training module to equip warfighters with information necessary to defeat emerging enemy tactics

Such messages recorded using C-MRE can augment communications capabilities provided by other media such as text, images, voice communications, and synchronous collaborative planning sessions.

B. Commanders’ Information Needs

During the planning process, the commander and his planning staff identify and seek to fill information requirements (IRs). Army Field Manuals 5-0 [3] and 6-0 [8] define information requirements as, “all of the information elements required by the commander and his staff for the successful execution of operations.” They are developed based on questions that need to be answered before planning can go forward as well as in anticipation of information from the battlefield during execution that would change the desirability of a given course of action.

IRs are identified through careful analysis of the orders received from higher headquarters, courses of action being developed and considered, intelligence reports, and other sources used in planning and decision-making. Many of these requirements are generated by the staff and submitted to appropriate agencies for input [3]. Unfortunately, the process of responding to IRs can be slow and laborious when staff members do not have access to the information they need to fill these identified gaps.

To reduce such delays, the Army has embarked on an effort to centralize and standardize battlefield information so that staff can answer a commander’s IRs in a matter of minutes rather than hours as has been the norm [7]. The battlefield data is still human-generated, but is standardized and indexed so it can be quickly searched when the commander expresses an IR. Thus, the effort required to fill IRs is diminished, but still more can be done to anticipate the commander’s information needs and fill them using a combination of machine- and human-generated content.

C. Digitizing the battlefield

There are also current Army projects aiming to introduce more digital technology to the battlefield. In the operational Army, the Tactical Ground Reporting System (TIGR) and FusionNet are web-based mapping tools that enable digital communication across echelons ([6], [10]). Users tag events in time and space, associate them with multimedia objects, and share them with warfighters at the same echelon and across echelons. Both tools were developed in direct response to operational needs in the current conflicts in Iraq and Afghanistan, where soldiers were building ad-hoc web-based communications systems to share key information about their areas of operation. TIGR and FusionNet have both received high marks from their users in the combat theater [6].

TIGR and FusionNet are most heavily used at lower echelons (company and below) where large-scale planning tools are not readily accessible. At higher echelons, the Command Post of the Future (CPOF) has become the collaborative planning tool of choice. CPOF combines a shared map display with voice communications to facilitate collaborative planning sessions. When the session is ended, users typically use a screen capture of the map display with text added (including tasking to subordinate units and a short description of the situation) as the basis for daily mission tasking. The collaborative session is recorded, but is not easily recalled or disseminated to assets not equipped with CPOF . Thus, the result of a dynamic multimedia collaborative session is a static graphical display from which voice collaborations are lost.

As another example, in the generating force (formerly the institutional Army), the Communications-Electronics Research Development and Engineering Center (CERDEC) has developed a digital representation of military operations orders and is in the process of implementing an architecture for distributed planning and operations execution [1]. The Tactical Information Technologies for Assured NetOperations (TITAN) Army Technology Objective (ATO) aims to develop technologies to help the Army meet its network-centric data strategy goals [2] as well as required capabilities that have been identified for battle command systems [4]. The TITAN architecture consists of several independent software services that use a common XML representation of an operations order and battlefield data to generate and share military orders, feedback on those orders, and other data related to operations planning and execution. The services are oriented toward meeting the commander’s information requirements and monitoring different aspects of mission execution to keep the commander up to date on the status of the operation. The services can alert the commander, for example, when a threat on the battlefield is reported, and then supplement the report with information about the threat’s capabilities (e.g., if the enemy is seen with a missile the services not only report the missile to the commander, but also automatically look up the range of the missile). TITAN also allows commanders and planning staff to take part in distributed, asynchronous, collaborative planning sessions. They communicate asynchronously with each other through the military orders they share, as well as through text-based instant message chats and voice communication.

The TITAN digital planning environment takes advantage of XML to represent operations orders so that the software agents can act on information contained in the order. The software agents then use this information to generate useful and timely alerts for commanders and staff during operations planning and execution. The XML representation of the OPORD enables the software agents to automatically prioritize information for the user, such that tasking to the local unit is presented first. The commander also can access information about neighboring units that is important to developing his plan.

Although TITAN’s XML representation of military orders provides the opportunity for semantically rich representation of battlefield data, it remains a machine-generated, text-based medium. The current state of technology does not allow effective representation of all of the key information required for operations planning in a fully machine-understandable way. When the information shared for the purpose of collaborative operations planning and execution is relegated to machine-understandable code with a few sentences of text, there is a great deal missing such as voice modulation for identifying key points [9]. Further, even if there is a good semantic representation of the content of an image, video, or other multimedia object, the image itself is not machine-understandable and is likely to provide information to a human viewer that would not be available to that human in an XML-only environment.

II. ADDING MULTIMEDIA TO DIGITAL COMMAND AND CONTROL ENVIRONMENT

The Multi-Media Support (MMS) Service is a software prototype developed from key insights about the usefulness and desirability of multimedia communications and the capabilities of semantic representations of battlefield data. Integrated with the TITAN operations planning environment, the MMS represents the transition of technology from one Army research program to another as well as a demonstration of ways in which human-generated content can be integrated into a digital planning environment. It also is an effort to bridge gaps between tools for sharing human-generated content such as TIGR, FusionNet, and CPOF; knowledge management best practices; and machine-generated communication structures such as those involved in TITAN. The MMS consists of software agents that can search for multimedia objects from various sources, characterize them using a semantic representation of battlefield data, and provide them to commanders, augmenting the machine-generated alerts and planning information already provided in the TITAN environment. The MMS prototype uses IRs published in TITAN as triggers to automatically search for additional information relevant to a commander's information needs, including human-generated and multimedia information sources.

As an illustration, when the commander publishes an IR for the existence of hot spots in his unit's area of operations, TITAN software agents search for and report on the presence of hot spots according to the number and locations of relevant battlefield events. The MMS automatically extends this request, searching for additional information that is relevant to the identified battlefield events, accessing a variety of existing battlefield sources in order to do so. For example, if the commander publishes an IR requesting information about Improvised Explosive Device (IED) hot spots in his operational area, the MMS uses a semantic representation of IED events (based on their representation in operational reporting systems) to summarize the nature of these attacks for the commander. It then provides the commander a machine-generated alert that includes both descriptive information based on the semantic representation of battlefield data and access to human-generated content. The human-generated content can be in any file format ranging from images and video to briefings, documents, and mixed media. A high level diagram showing relationships among concepts associated with an IED event, known as a significant activity (SIGACT) is shown in Fig. 3.

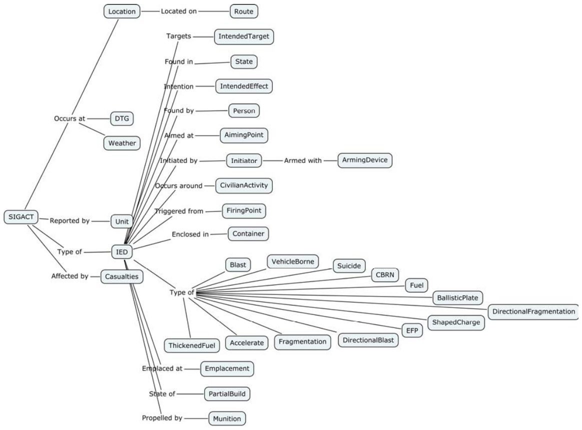
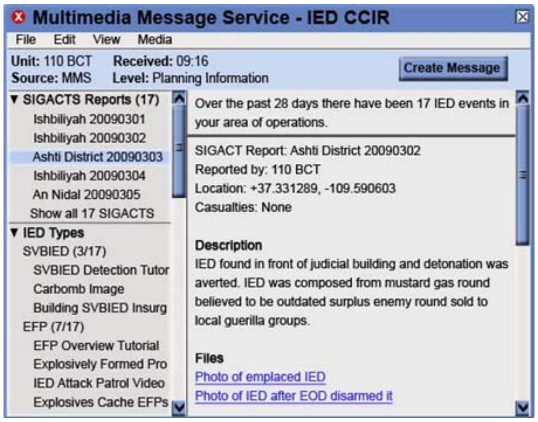


Figure 3. High level diagram showing relationships among concepts associated with an IED event.

Fig. 4 shows a screen shot of the MMS prototype with a summary description of notional IED events occurring during recent weeks of an operation involving the 110 BCT, a fictional Army brigade. In this case, the MMS found seventeen IED SIGACTS during the specified time period and provides links to reports specifically about those SIGACTS. The report for the third event is shown on the right hand side of the screen. In addition, the MMS applies the semantic representation of IED events to provide links to relevant information. For example, of the seventeen IED events reported in Fig. 4, three involved suicide vehicle IEDs (SVBIEDs), for which the MMS found three relevant retrievals: a tutorial about how to detect an SVBIED, a photo of a captured SVBIED, and an insurgent video showing an SVBIED being built. Similarly, seven involved Explosively Formed Penetrators (EFPs), for which the MMS found four relevant retrievals: a tutorial providing an overview of EFPs and tactics to defeat them, a briefing about EFPs, a video of an EFP attack on a patrol in this area, and a video showing the capture of an explosives cache used to build EFPs. Other information the MMS provides includes insurgent strategies for the emplacement of the devices, information about the design of the device such as how the detonation is to be initiated, suspected targets for these devices, casualties resulting from the events, and other summary information for the devices gathered from documents indexed using the



Unit: 110 BCT
Received: 09:16
Source: MMS
Level: Planning Information

▼ SIGACTS Reports (17)
Ishbiliyah 20090301
Ishbiliyah 20090302
Ashti District 20090303
Ishbiliyah 20090304
An Nidal 20090305
Show all 17 SIGACTS
▼ IED Types
SVBIED (3/17)
SVBIED Detection Tutor
Carbomb Image
Building SVBIED Insurg
EFP (7/17)
EFP Overview Tutorial
Explosively Formed Pro
IED Attack Patrol Video
Explosives Cache EFPs

Over the past 28 days there have been 17 IED events in your area of operations.

SIGACT Report: Ashti District 20090302
Reported by: 110 BCT
Location: +37.331289, -109.590603
Casualties: None

Description

IED found in front of judicial building and detonation was averted. IED was composed from mustard gas round believed to be outdated surplus enemy round sold to local guerilla groups.

Files

Photo of emplaced IED
Photo of IED after EOD disarmed it

Figure 4. Screen shot of a message generated by the MMS prototype describing IED events over recent weeks of a notional operation.

semantic representation. Upon receiving this alert, the commander might consider the information in refining his plan and/or create a message based on this information for others viewing this operations order.

Dialogs among commanders and staffs at different echelons also can be augmented using multimedia. The TITAN environment enables users to communicate via voice or instant message chats, but only the instant messages are logged for future reference. The MMS extends these communication capabilities via a Commander's Message Tool with which the commander can share a multimedia message with other users. The research team expects this to be a useful feature of the MMS based on the study reported in [9]. The commander might share images, video, or tutorials from an MMS alert, or he might use a tool such as C-MRE to record a message or collaborative planning session. Previous experience [9] suggests these multimedia messages will be used to describe commander's intent, clarify misconceptions in subordinates' interpretations of events, or provide explanations of battlefield events as the commander understands them. In the context of TITAN, they may also provide additional direction in response to an alert. These messages can then become part of the library of human-generated content that the MMS can search to meet future information needs.

The Commander's Message Tool enables users to incorporate the machine-generated content of any of the TITAN alerts (including those from the MMS) into richer human-generated content. For example, contextual cues such as the commander's voice modulation in a live briefing can be recorded during distributed planning sessions in a digital environment. The Commander's Message Tool also enables rich content to be communicated asynchronously and persist in the digital planning environment. This enables the digital TITAN planning environment to provide its users the benefits of multimedia communications described in [5] and [9], augmenting the capabilities for collaboration afforded by the XML representation of battlefield data.

By extending the information provided by the other TITAN services, the MMS more completely situates the human user – a commander or staff member – in the operational environment for which he is developing a plan. It provides a mechanism by which the content created and shared by soldiers in TIGR and FusionNet, and commanders and staff in CPOF, can be communicated to the commander in context, using a tool for machine-generated content to aid preparation for future operations.

III. FUTURE WORK

The MMS is currently a prototype that will serve as a test bed for future empirical studies involving combinations of machine- and human-generated content and the information contained within them. It also could be developed into a deployable tool for augmenting digital operations planning with human-generated content.

This research program that evolved from multimedia communications technologies to combining human- and machine-generated content in a digital planning environment will continue to develop tools and knowledge along multiple themes. The research will focus on methods for improving the machine-generated alerts delivered to commanders and staff, improving the human-generated content from which the machine generates alerts, and ensuring that the right content is delivered to the commander and staff during operations planning and execution. Underlying all of these research areas is a requirement to improve the representation of the data in the information system.

The XML representation used in the TITAN environment can be extended in multiple ways. One, it can be improved by incorporating richer semantic content, more precisely specifying the contexts in which commanders should receive alerts and providing more explicit relationships between data elements. Second, such a semantic representation can be extended to incorporate a wider range of battlefield data. Semantic representations express both data and relationships among the data, and can better represent key information characteristics such as context, facilitating machine-driven data integration and reasoning that can ease the data-processing workload for commanders and staff – leaving them more cognitive capacity for operations monitoring and decision-making tasks. A good semantic indexing approach would increase the software agents' capabilities to generate information-rich alerts based on automated pattern detection, correlation with other data sources, and higher-level reasoning. It can also assist human users in mission planning, reporting, and the reasoning tasks required for creating actionable intelligence from battlefield data. Such improvement in the XML representation should be able to leverage current efforts across the Department of Defense to develop XML interfaces for sharing battlefield data.

Semantically represented battlespace information can also aid warfighters in providing more detailed operations reports. A system that begins semantically indexing and searching for related information as an operations report is being entered can prompt the warfighter for details that he may not otherwise think significant enough to include in the report. For example, intelligent software agents with domain knowledge about arms caches, IED discoveries, and insurgent groups' tactics can be triggered by data being entered into an operations report. These software agents may be able to reason about observations from a series of reports that seem isolated from each other and prompt the warfighter to provide information that he may think unimportant or unrelated when not considered in the context that the intelligent agent has identified. These agents also can evaluate the report as it is being entered and provide feedback that aids the warfighter in indexing the report appropriately. Thus, semantic representations can provide *context-sensitive feedback*, prompting warfighters for information in a more meaningful way than standard report forms alone. Such real time feedback can also provide opportunities for the warfighter to experience incidental learning while reporting, teaching him about the domain of the software agent's knowledge that in turn expands the warfighter's knowledge of the situation. Such incidental learning and feedback from the information system can further motivate warfighters to provide more detailed reports because they are directly able to see the benefits of the information they and others provide.

Semantic representations of battlefield data can improve information search and retrieval as well. Currently, the MMS uses a semantic representation to infer *implied* information requirements from the commander's *specified* information requirements [7] by automatically broadening the search performed to fill the specified IR. Although the intent is to provide key human-generated content in a user-friendly way, it is possible that the automatic broadening technique will result in more information being delivered to commanders than they need. That is, the intent of the MMS is to fill implied and specified information requirements but not create *distractions* [7]. The research team will look at ways semantic representations can enable the commander to customize contexts for receiving alerts of different types to ensure that the information delivered by the MMS is useful to operations planning and battle command decision making. In addition, the team will consider hybrid methods for user-centered information retrieval from data sources that are partially semantically indexed to generate alerts, leveraging the semantic representation to improve performance over more traditional keyword searches.

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