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Title of Paper

Tailored Information Delivery and Service for Network-Centric C2 Support

Topics
Track 7: Network-Centric Experimentation and Applications
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(Extended) **Abstract**

The Problems and Challenges

Technology advances are providing our warfighters ever growing amount of information from multiple resources. As our military transforms from platform-centric warfare to Network-Centric Warfare (NCW), key to the success is the effectiveness of sharing the right information with right people at the right time and place. However, as told by practitioners, sometimes poorly chosen technological solutions for information services are more detrimental than the lack of information. Improperly organized flow of large amount of information could overload warfighters, divert their attention from quick response to critical situations, and deteriorate the quality and timeliness of decisions.

This paper presents a conceptual design of a solution to the problem of optimally presenting the extensive variety of battlespace information to warfighters engaged in different aspects of the theater operation. More specifically, we address the problem of providing Tailored Information Delivery and Service (TIDAS) to the operation units or members of a command and control (C2) center with respect to their mission perspectives and individual operational responsibilities. The term "tailored" here means a targeted and expeditionary dissemination of selective information, in a way we call "What You Get Is What You Need (WYGIWYN)." That is, tailored information is adapted to the needs and characteristics of the individuals and the tasks they are carrying out, and hence has more personal relevance. Such information is more mission focused, contains less redundant information, and causes less confusion for the battlespace situation awareness and assessment. Recipients of the tailored information need to spend less time to scrutinize the information, to filter the information from "chaffs," and to draw conclusions more effectively from the large amount of information pieces.

The Approach

In this paper we will describe an experimental TIDAS system in which ISR (Intelligence, Surveillance, Intelligence, Surveillance, and Reconnaissance) data from all sources will be properly examined, organized, integrated, and delivered in a timely and coordinated way to support expeditionary C2 decision making. The TIDAS system thus will have a clear recognition of particular information objects that are critically needed by individual warfighter or unit of action at certain points of operational space and time.

Processes involved in a TIDAS system typically include

1. Search, collect, extract, collate, and distill large amount of information from multi-resources in a NCW environment according to the C2 mission and operational situations (given by a metadata specification stored in a metadata repository).
2. Correlate, fuse, organize, and package the integrated and selected information according to each individual user's operational requirement and specification (stored in a user registry).
3. Deliver and display the customized information securely according to information priority with respect to user's mission and operation, user preference, as well as the cognitive characteristics of the information and the user (based on the data of user registry).
4. Provide interpretation and explanation of the delivered information, and perform reasoning on the information to produce a user-specific integrated battle space picture according to user's operational responsibilities and mission requirements.

It is noted that a tailored information sharing and delivering system should be very carefully designed. Otherwise, it will be at risk of missing critical information to key personal when trying to organizing information in tailored manner. A TIDAS system design and development thus must resort to a systems engineering approach that takes serious considerations of the major system components and their links at a collective functional level. The considerations include:

(1) The role of metadata, its repository, and knowledge representation (including user profiles and registries) for information search, collection, extraction (filtering), and distilling.
(2) The role of special software agents, acting as Information Brokers (IB), for integrating and packaging the Tailored Information Objects (TIO) with respect to the user requirement and metadata specifications.
(3) The role of distributed system controllers, serving as Systems Managers (SM), for maintaining the metadata repository, user registry, tailored information objects, and user interfaces; and coordinating the collaborative activities of the system component.
(4) The role of Service Oriented Architecture (SOA) for facilitating the secure and reliable information delivery and service, as well as the flexibility of the system configurations.

The Technologies

1. Theoretic Foundation on System-of-Systems

The theoretic foundation for the TIDAS approach lies on the principle of modeling the TIDAS environment as a hybrid dynamic system of systems, and the use of software agent technology for the control, coordination, and operation of the systems. TIDAS deals with the challenging environment that needs the system to have a capability of sustaining the diverse parameter variations and to be adaptive to the frequent situational changes. Our concept emphasizes the highly dynamic nature of the environment in terms of the types, meanings, and formats of the diverse information objects and the ways of dissecting, re-assembling, delivering, and sharing them timely to meet the needs of individual warfighter.

2. Knowledge Engineering and Management

There is a significant difference between information sharing and knowledge sharing. Information sharing alone is useful but requires knowledgeable operators at all points to correctly process and react to that information. A robust and flexible knowledge engineering and management (KEM) is essential for being able to capture the highest resolution and clearest picture of the battlespace situations through

knowledge sharing. The ability to transfer information to knowledge reduces the amount of processing and transformation required at each stage of the information pathway.

The TIDAS is to build with a use of Knowledge-enabled Multi-Agent System (KEMAS) approach to access, search and distribute intelligently packaged ISR products, including data streams of real-time moving images, to warfighters anytime and anywhere to support mission planning and operational execution. The synergetic integration of humans and autonomous systems (software agents), active and passive sensors, and data fusion engines in a cohesive loop of information gathering, analysis, management, dissemination, and decision making is to result an Adaptive Information Service Enterprise (AISE) that meets the needs of C2 operations in NCW.

3. Ontologically-based System Configuration

The stringent rules of engagement under which today's forces operate demand that all sources of data be properly examined, delivered, and shared in a timely and coordinated way. To do that, it requires a clear recognition of particular information objects that are critically needed by the individual warfighter at certain point of time during C2 operations. The functions of a well-designed TIDAS scheme is to aid warfighters by specifying the information requirement in terms of a progression of situations and actions to ensure that the primary tasks at hand will be carried out in a manner that is logical, efficient, and error resistant. A TIDAS must be designed with the whole mission in mind such that the computer system knows:

1) What tasks are to be performing by each of the warfighters?
2) When the task is to be conducted (time and sequence) by an individual warfighter?
3) How the task is to be performed (actions) by the specific warfighter?
4) What general and specific information are needed by the warfighters for the specific actions?
5) What type of feedbacks needs to be provided to other warfighters under different battlespace situations?

The ontology based KEM is to provide a common data dictionary and belief notation used, as much as possible, by all functional components of TIDAS. A common framework for encoding the meaning of information objects into a mission critical requirement matrix is to be provided. A crucial correlative bridge must be formed between the high-level information objects and the lower-level data encoding to support for low-level data classification that recognize the information objects and higher level semantic and synonym-set representations that comprise the battlespace situations. As well, the TIDAS belief projection framework is to provide a basis for calculating confidentiality and integrity for secure communications. For maximum flexibility, the TIDAS KE must have a system configurable semantic and inference mechanism where the problem space of the deployed environment guides the implementation of these functions.

4. Data Fusion Operations

The complexity of the computational structure of the Tailored Information Objects (TIO) extraction and packaging is determined by the breadth and depth of the mission requirements, user knowledge levels and responsibilities, and allocated computation resources. The computational components can be developed into analysis blocks that are scaled to the *intrinsic* signal and knowledge dimensions. For example, the recording, evaluating, and interpreting components form three aligned blocks of agents. The recording block provides reduction of data into groups of related information and places them at a lower level of the TIO. The evaluating block rates incoming information with respect to existing knowledge for pertinence, accuracy and reliability. The interpretation block uses outputs from the evaluating block and analyzes the significance of information in relation to what is already known, and deduces the probable meaning of the evaluated information. When the extraction agent accumulates information at a certain level, a pattern (combined states of the information) emerges at a discrete block that triggers an automated action of data fusion or pop off hypotheses for the fusion operations. An evaluation of the hypotheses in terms of the

state changes is then carried out in the packaging agent. Often a large number of hypotheses about the relations of information patterns have to be generated and quickly evaluated in a short time interval, especially in target dense situations and complex terrain layouts.

5. Intelligent Agents for Information Brokering and Packaging

Information brokering or mediation of high-quality information is a complex intellectual activity which cannot be fully replaced by automated methods. A central concept of Information Broker is the collection and utilization of meta-information to support retrieval, selection, and distribution of relevant information. An appropriate operation environment can considerably alleviate the experts' tasks and augment their productivity to provide their clientele with a timely, well-organized service of highly integrated and customized information. The software agent of the TIDAS system will play a unique role in conducting queries to information sources, improving the human-system interactions, and enhancing data discrimination and integration capabilities.

The major functionalities of the TIO extraction and packaging agents are to

1) Conduct targeted information acquisition, filter, dissection, distilling, and re-assembly of information objects according to the metadata categorization and ontology.
2) Perform association and correlation of information from multiple sources with different levels of certainties, and
3) Combine *a priori* knowledge with dynamic data to create an integrated picture of battlespace awareness accounting with estimates of uncertainties.

The process can further take into account uncertainties in the sensor measurements and intelligence sources by locating information clusters such that their supporting factor is maximized under the condition that the deny factor is minimized, done in a game theoretic framework. A collection of belief propagation and updating algorithms resides in the functional blocks of the agents to carry out these quantitative evaluations with respect to a set of relevant assessment propositions.

The Effect

Successful military operation begins with the abilities to share critical information and knowledge in a timely manner with a network of forces. The very nature of asymmetric warfare requires rapid response to threats from all dimensions in a coordinated and systematic way. The possession of an information integration capability is significant to these responses both notionally and operationally. The capability of TIDAS enables warfighter to gain better situational awareness and solutions to the threats of urgency, and in turn, to seize the initiative faster than the opponents. The major effect of the TIDAS thus will be the information, knowledge, and decision superiority for our warfighters in NCW environment.

The existing amount of all available information to our warfighters has often exceeded the cognitive ability of them in the face of many other tasks they're required to perform in the complex battlespace command and operations. Problems with today's information delivery and sharing operations include bandwidth limitations, system-of-systems configurations, rapid, adaptive and targeted delivery requirements, intuitiveness and condensation of information presentation, etc. There has been much effort in the development of effective solutions toward leveraging information gateways, allowing data links to seamlessly correlating information, transmitting selected information into and out of battlespace, and providing relevant information to warfighters timely. The tailored information service and delivery model provides a necessary piece of promise to the easing of cognitive bottlenecks and distresses. However, far more needs to be done to develop, test, and refine the TIDAS concept and co-evolve it with NCW doctrines, force organizations, command approaches, training, human-system-interactions, and other components to form a mission capable software package and service.