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Tailored Information Delivery and Service for Network-Centric C2 Support

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Abstract

C2 center staffs could be cognitively overloaded by overwhelming amount of information in modern warfare. A concept of "What You Get Is What You Need (WYGIWYN)" for alleviating the problem is discussed in this paper. The Tailored Information Delivery and Service (TIDS) is aimed at providing users with individually selected and organized information set that contains less redundancy, adapts to the tasks in hand, and causes less confusion. Built as a Knowledge-enabled Multi-Agent System (KEMAS), the TIDS extracts, collates, and distills information from multi-resources; correlates, fuses, and packages information according to each individual user's operational requirements and specifications stored in a user profile registry. The TIDS delivers and displays the customized information according to mission priorities, user preferences, and cognitive characteristics based on a metadata registry. The TIDS agents, acting as Information Brokers (IB), can also take into account uncertainties of the sensory measurements and intelligence sources, locate and extract information clusters such that their decision-supporting factors to individual user's C2 operational responsibility are maximized.

Key words: Information sharing, Information service, Network-centric warfare, C2 decision support, Tailored information objects, Software agents

I. Introduction

Warfare technology has been continuing a fast pace of advances. Modern electronic technology is providing warfighters with increasingly powerful sensory capabilities covering space, air, ground, and underwater. Superb computing facilities allow a vast amount of Intelligence, Surveillance, and Reconnaissance (ISR) data quickly collected and evaluated. Mighty software systems can generate hundreds to thousands of complicated action plans and alternatives, and provide "down to the point" assessment of possible outcomes. The automated systems reduce the burden on personnel by cutting down the number of physical units and mind efforts that have to be deployed to provide the situational awareness. Equally important, it makes time available for personnel to train for taking actions on more complicated situations, as it becomes the essential element in correctly reacting to asymmetric threats and combat. However, as told by practitioners, sometimes poorly chosen technological solutions for information services provided by automated systems are more detrimental than the lack of information. Improperly organized flow of large amount of information could overload the warfighters and decision makers, cause them busy on "filtering" the information from "chaffs" rather than focusing on the key aspects of the battlespace and on the critical decision making tasks, thus divert their attention from quick response to critical situations and deteriorate the quality and timeliness of decisions.

As U.S. military transforms from platform-centric warfare to Network-Centric Warfare (NCW), key to the success of this transformation is the effectiveness of sharing the right information with right people at the right time and place. As it was said "the ability to achieve a heightened state of shared situational awareness and knowledge among all elements of a joint force, in conjunction with allied and coalition partners, is increasingly viewed as a cornerstone of transformation" [AGF99]. 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 manner. The engagement calls for presenting large amount of ISR information to warfighters optimally, for example, delivering tailored information to different members of a commanding center with respect to different operational requirements and the specific missions they are undertaking. To do that, it requires a clear recognition of particular information pieces that are critically needed by an individual member at certain time point during the operation. An effective solution to this capability will reduce the workload, alleviate task saturation, improve situation awareness, and increase decision effectiveness.

This paper presents a conceptual design of a solution to the problem of optimally presenting the extensive variety of ISR information to warfighters engaged in different aspects of a theater operation. More specifically, we address the problem of providing Tailored Information Delivery and Service (TIDS) to the operation units or members of a C2 center with respect to their individual operational responsibilities with the mission requirements. The term "tailored" here means a targeted and expeditionary dissemination of selective information, in a way "What You Get Is What You Need (WYGIWYN)." That is, the tailored information is adapted to the needs of the individuals and the characteristics of the tasks they are carrying. Such information is more operational focused and mission relevant, contains less redundancy, and causes less confusion to the situational awareness and assessment. Recipients of the tailored information need to spend less time to scrutinize the information, filter the data, and draw conclusions from the information objects more effectively.

User-tailored information service environments have the potential to better support war-fighters by collaboratively collecting, creating, processing, storing, and disseminating battlespace information. However, the realization of the service requires system structures and techniques that allow for explicit collection of certain meta-data about sources like content, accessibility, quality, and usefulness, as well as categorization schemes used in the re-organization and packaging of information objects. Additionally, think about information security. People with different security clearance have limited right to access different categories and pieces of data. Especially in the global war on terrorists with a world-wide alliance of U.S. military operations, the information would be accessed by or delivered to own force, alliances, and friends or possible friends in various categories and locations that should be distinctively specified according the roles and security levels. The TIDS approach could provide the necessary facilities and functionalities to associate information with contingent roles of users and tasks to be performed, and to ensure that services are in compliance to the security settings.

The paper is organized as follows. In section II, we present the basic concept of TIDS operations. Section III discusses the software system model for the TIDS development. A conceptual TIDS system architecture and its functional blocks are described in section IV. Section V summarizes the TIDS effort with concluding remarks.

II. TIDS Concepts

From the perspective of effectiveness, the existing model of information service for C2 operation leaves a gap between the cognitive ability of many users and the burden of processing they have to endure in the face of many other tasks they are required to perform. Though problems with today's information delivery and sharing operation also include bandwidth limitations, rapid delivery requirements, data condensation, intuitiveness of information presentation, etc., adaptive and targeted information delivery is one problem that deserves particular attention. There has been much research effort in the development of effective solutions toward leveraging information gateways to allow data links to seamlessly share information, transmitting selected information into and out of battlespace, and providing relevant data links to warfighters timely. New information service and delivery models, represented by the commercial Internet and Web technologies, provide great promise to ease the bottleneck and distress. However, more needs to be done to alleviate the overloading burden and improve the efficiency in C2 information service.

TIDS is meant to optimally present data to individual users with different perspectives, such as those working in distributed collaborative C2 operation environment where each member has individualized responsibilities. The challenge is to design coordinated ways to collect, extract, fuse, and package multi-source information that not only retains the degree of commonality required for efficient C2 member collaboration but also is tailored to the needs of each individual C2 member. Processes involved in a TIDS operation typically include

1. Search, collect, extract, and distill large amount of information from multi-resources in a NCW environment according to the C2 mission and operational situations (given by a common data 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 the C2 mission and operation, individual user's preferences, as well as the cognitive characteristics of the information and the individual users.
4. Provide interpretation and explanation of the delivered information, and perform reasoning on the information to produce a user-specific, integrative battlespace picture and corresponding actionable knowledge according to the user's operational responsibility and mission requirements.

It is a general understanding that for an effective C2 operation, sensors, geospatial databases, force locators, and automated reasoning systems in commanding centers should be operating on a common network. The required capability of correlating, integrating, and disseminating the disparate information from heterogeneous sources that come with varying degrees of certainty and reliability in real-time is an impediment issue in crucial military operations [SZ96, KA97, RJ00]. Our view of human-system interaction in TIDS is toward the maximization of the overall C2 system's capability (both human and computer) in an information exchange and sharing environment. That is, the relationship between humans and computer systems should be mutually complementary. For example, sense making, which includes situational awareness, mental models, intuition, knowledge, understanding, and decisions, occurs largely on information specific in the cognitive domain. The task also focuses on individual psychology, professional experience, and collaborating in communities of interest (COI). In this paradigm the automated system is not a replacement of human (except in the hazardous and human-not-reachable environment, where automated systems are supposed to reduce the human presences for completing the necessary tasks). The principle on what the automated system should do is to extend and enhance the human's capabilities, in other words, to free human's hands from tedious tasks and assist them to do what they can do the best[1]. It must act as a force multiplier to a well-trained, knowledgeable operator, and balance between not overloading the decision makers with extraneous information and inadvertently excluding critical information from them. This is the principle of TIDS.

Domain-customization is an important area of concern in TIDS. A domain is simply an area of interest. The problem is, users' information requirements are not static, nor can they always be anticipated ahead of time. A quick and easy way to customize information extraction to new and changing information requirements would take advantage of users' domain knowledge with on-line assistance. The task can be executed proactively upon the availability of relevant information from multi-sources and performed by intelligent software agents in a Service Oriented Architecture (SOA). The incorporation of TIDS in a SOA will make it more viable to create domain-specific brokering environments for different brokering scenarios and configurations necessary for a TIDS system implementation. The architecture provides a foundation and construct to enable tailored information delivery in the publishing-and-subscribe model.

[1] As humans and machines (automated systems in general and computers particularly) possess distinctive and mutually complementary sets of traits in nature, it is essential to let each do what they can do the best, and let the outcome of combined efforts be the multipliers of their capabilities.

III. TIDS Models

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 delivery to key personnel when trying to organizing information in tailored manner. A TIDS 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 manner. The considerations include:

(1) The role of a knowledge engineering process, applied in the design, construction, and implementation of the concept, for dealing with metadata, its repository, and representation (including user profiles and registries) for information search, collection, extraction (filtering), and distilling.
(2) 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.
(3) The role of 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.
(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.

III.1 The role of knowledge engineering

It was said that "shared information does not automatically, if ever, lead to shared understanding," [Kau05]. There is a significant difference between information sharing and knowledge sharing. Information sharing requires knowledge sharing at all points to correctly process and react to the information. A robust and flexible knowledge engineering (KE) process is essential to being able to capture the highest resolution and clearest picture of the environmental situations in the battlespace.

The functions of a well-designed TIDS scheme are to aid warfighters by dictating and specifying what information is in need, extracting and packaging the necessary information and then delivering them promptly. To ensure that the primary tasks at hand will be carried out errorless and efficiently, a TIDS system must be designed with the whole mission in mind and specific situational knowledge in hand, such that the computer system knows:

1) What tasks are to be performing by each of the users?
2) When the task is to be conducted (in time and sequence) by an individual user?
3) How the task is to be performed (or actions to be taken) by the specific user?
4) What general and specific information are needed by the users for the specific actions?
5) What type of feedbacks needs to be provided to other users?

This knowledge set is critical to the TIDS for determining what information the user should have at different stages, under different situations, and in different types of missions. Though much of the information needs of a user can be dynamically handled in real-time through the information management agents, a user profile registry needs to be established. In this user-centric model, the TIDS's KE must provide a common data dictionary and metadata notations used, as much as possible, by all functional components. A common framework for encoding the meaning of information objects into a mission critical requirement matrix should also be established. A crucial correlative bridge must be formed between the high-level information objects and the lower-level data encoding agents to support low-level data classification activities. The activities are to recognize the information objects with respect to higher level semantic and synonym-set representations that form the battlespace situations. The TIDS belief projection framework should provide a basis for calculating confidentiality and integrity for secure communications as well. For maximum flexibility, the TIDS KE process must have a system configurable semantic and inference mechanism where the problem space of the deployed environment guides the activation of these functions.

III.2 The role of distributed system controller

The theoretic foundation for the TIDS concept lies on the principle of modeling the TIDS as a dynamic system [AH00], and the use of software agent technology for the control, coordination, and operation [DS97, AKZ98, GPS00]. TIDS deals with a challenging process that needs to sustain diverse environmental variations and frequent situational changes. The system must be coupled with the highly dynamic nature of environment in terms of types, meanings, and formats of the diverse information objects in presence and the ways of dissecting, re-assembling, delivering, and sharing these objects timely in order to meet the needs of individual users.

A TIDS process is accomplished through the consistent activities and collaborations of three functional sub-systems within the TIDS system, (1) a Client/user Management (CM) sub-system, (2) an Information Management (IM) sub-system, and (3) a Persistence Management (PM) sub-system. The CM maintains a user registry and profile repository (URPR) that holds each individual user's mission-relevant information requirements, cognitive characteristics, specific needs and requests for information from diverse sensors and heterogeneous sources. The IM is to collect, dissect and re-assemble information to produce tailored information objects (IO) that meet the individual user's needs. It maintains an Information Object Repository (IOR) that holds information available to users and has a timely repository updating mechanism. It also maintains a Metadata and Ontology Repository (MDOR). All information dissemination and management is based upon a metadata categorization maintained in the MDOR. To execute TIDS, the MDOR must contain information object schemas and other appropriate data that set various attributes of the user demands. Information requests and user characteristics are mapped into the metadata categorization from the URPR to MDOR. The PM is in charge of overseeing the maintenances of the URPR, IOR, and MDOR, ensuring their consistence and timely updated with respect to situation changes and time lapses.

There will be at least three operational modes of a TIDS process carried out by the information delivery compartment of the system.

a. <u>IO Push mode</u>: When a new or updated piece of information object is collected/received, it is placed into the IOR. The IO service agent scans the IOR, compares and tries to match the new piece with the characteristics of certain users. With proper packaging (or simple in its original form) according to the specifications of the individual user (data stored in URPR), the information piece is disseminated to the specific user by the TIDS agent.
b. <u>IO Pull mode</u>: A user can always initiate a request for a specific piece of information to be retrieved and delivered. Upon receiving the request, the task coordinate agent creates a task plan, the IO extraction and fusion agents scan the IOR (or instructs retrieval coordinate agent), retrieve the relevant information (if available), package and deliver the tailored IO to the requesting user.
c. <u>IO Pick mode</u>: When a new information object type is created in MDOR (as a result of new sensor type or ISR source installation), the TIDS engine (user interface agent) sends a message to all registered users with a description of the new IO, alerting all users about its availability, and notifying specific users based on the matches of the new IO with stored user profile. However, the IO is actually retrieved by the user agent at a proper time according to the user's task schedule and current activity.

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 TIDS system components can be developed into functional blocks that are scalable to intrinsic information dimensions and knowledge levels. For example, the recording, evaluating, and interpreting components form three aligned blocks of functionality. The recording block provides reduction of data into groups of related information and places them at a lower level of the IOR. The evaluating block rates incoming information with respect to existing knowledge (metadata) for pertinence, accuracy and reliability, and replaces the IO to a middle level of IOR. 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. The results are placed at a high level of the IOR. When the evaluation agent accumulates information at the middle level, a pattern (combined states of the information) emerges in the IOR that triggers an automated action of data fusion that pops off a set of hypotheses by the fusion agent. An evaluation of the hypotheses in terms of the state changes is then carried out in the interpretation block.

III.3 The role of software agents

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 (IB) is the collection and utilization of metadata to support retrieval, selection, and distribution of relevant information. An appropriate operation environment can considerably alleviate the expert's burden and augment their productivity. To provide the users with a timely, well-organized service of highly integrated and customized information, the IB agent of the TIDS system needs play a unique role in conducting queries to information sources, improving the human-system interactions, and enhancing data discrimination and integration capabilities.

In a TIDS process, the IB considers many variables and their relations, such as

(1) Prioritizing the tasks and schedules – It is necessary to know not only what operations are required, but also what the priorities they have.
(2) Collecting, fusing, and organizing the data with diversities such as the terrain, threats, capacity, location, time, etc. and dealing with the data that contain high levels of uncertainty.
(3) Evaluating and assessing the feasibility and effectiveness of various hypotheses qualitatively and quantitatively.
(4) Resolving conflicts regarding data from dissimilar sensors, distinguishing data from real time sensor data and archive databases.
(5) Correlating data in terms of time, location, taxonomy, etc.
(6) Maintaining trustiness of the data regarding to the data resources, time latency, sparseness of data collection, etc.

In addition to the IB agent, the IO extraction and packaging agent is another key component of the TIDS system. The major functionalities of the IO 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/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 TIDS process can further take into account uncertainties in the sensor measurements and intelligence sources by locating information clusters such that their supporting factor to certain mission objective is maximized under the condition that the uncertainty factor is minimized. A collection of belief propagation and updating algorithms can be applied in the functional blocks of the IM agents to carry out these quantitative evaluations with respect to a set of relevant assessment propositions.

III.4 The role of SOA

The Web-based Service Oriented Architecture (**SOA**) of the Net-centric information systems facilitates customer tailored secure and reliable information service, allows the TIDS system to disseminate and deliver highly integrated (high entropy) information to targeted users through multi-points distributed services timely and dedicatory. The publishing-and-subscribe service model coming along with the SOA for information sharing has become a mainstream in Net-centric environment. The model allows fast delivery and easy sharing. However, if implemented inappropriately, the publishing-and-subscribe model would amplify the problem of information overloading. Thus, the problem of tailored information service should be considered in parallel with the publishing-and-subscribe model.

IV. TIDS System

V.1. TIDS architecture

The KEMAS for TIDS are organized in three layers:

(1) The user interaction agents (UIA) layer,

(2) The information delivery agents (IDA) layer, and

(3) The information extraction agents (IEA) layer, as shown in Figure 1.

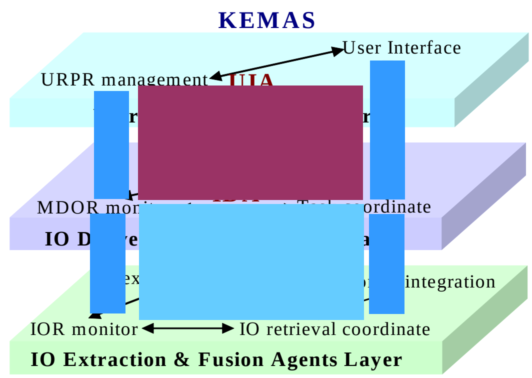

Figure 1. KEMAS layers.

Major functional components of the system are

(1) Metadata repository – a common language for information provider and consumer (sender and receiver),

(2) User registry/profile/ontology (subscriber) – specification of user role, characteristics, and demands of information (Knowledge management),

(3) Agents (publisher)/ information broker - that extract, fuse, package, and deliver information tailored to the user's needs.

Other auxiliary components include a user-system interface, a system controller/coordinator, a display/visualization, and agents to search and collect information.

There are two types of agent interactions in the KEMAS.

(1) Vertical agent interaction that operates in request-and-service mode for agents between layers, and

(2) Horizontal agent interactions that operates in negotiation-and-collaboration mode for agents at the same layer.

V.2. TIDS functional blocks

The basic functional capabilities of TIDS agents are described in the following.

1. *The UIA Layer*

The UIA layer has three agents: a user interface agent, a URPR management agent, and an IO display agent (Figure 2). The user interface agent provides adaptable, real time communication and data exchange between the TIDS and users. The data entries are in accordance to the information requirements of the users. The URPR management agent creates, stores, and updates user information. It has the capability to manage the lifecycle of information requirements between the TIDS system and the

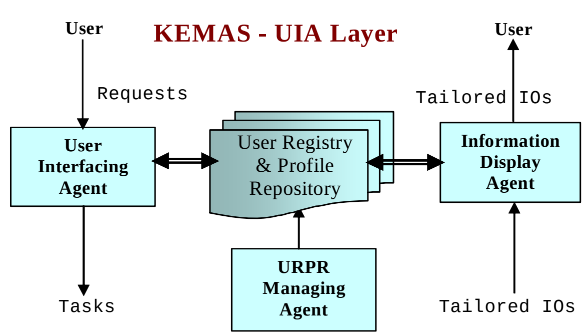

Figure 2. Functional flow of UIA layer

users. The functions include coupling with the mission and battlespace situation changes, and ensuring interoperability of the system. The information display agent maintains a built-in Display Preference Table (DPT) that specifies the places and formats (visual, voice, light, etc) of the information presentation in terms of warfighter attention span, task burden, and psychophysics. The DPT entries are set according to the information metadata categories as specified in the MDOR.

2. *The IDA Layer*

The IDA layer contains three agents: (1) the task coordinate agent, (2) the MDOR monitoring agent, and (3) the information objects deliver-facilitating agent (Figure 5). These agents interact with each other and with the MDOR to create tailored ISR packages and deliver them to the users. Information requests and user characteristics are mapped into the MDOR from the URPR at the IDA layer. The task coordinate agent coordinates the processes of mapping the specific user requests to the metadata categories and generating task plans for IO retrieval and extraction. It oversees the IO subscribe and publish processes, ensuring its consistency and timeliness with respect to situation changes and time lapses. The MDOR monitoring agent maintains the metadata and ontology repository which contains information object schemas, metadata tags, and categorical specifications that set the attributes for the information to be collected, extracted, fused, packaged, and delivered. The delivery-facilitating agent assembles tailored IO packages by taking IO from the extraction and fusion agent at the IEA layer, and interacts with the user interface to perform the IO delivery. The action is based on a pedigree to select appropriate information source and metadata tags stored in MDOR to disseminate appropriate information product.

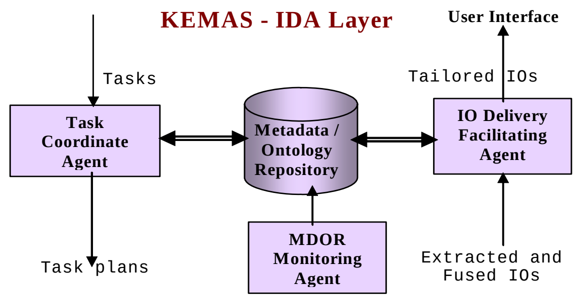

Figure 3. Functional flow of IDA layer

3. *The IEA Layer*

The IEA layer has four agents: (1) the IO search and retrieval agent, (2) the IO retrieval coordinate agent, (3) the IOR monitoring agent, and (4) the IO extraction and packaging agent (Figure 4). These agents collaborate to capture and generate tailored information objects that meet the requirements of users. The IO search and retrieval agent responses to the task plan set by the task coordinate agent of the IDA layer, examines the current states of the IOR, and generates IO queries to the retrieval coordinate agent. The IOR monitoring agent collects information objects from the retrieval task coordinate agent, organizes and stores the IO in the IOR, and makes timely updating IOR. The IO retrieval coordinate agent interacts with the ISR sources, and coordinates the information retrieval by activating various query and search processes, retrieving the latest information. It also responses to the query requests of the IO extraction agent, interacts with the various information sources, sends the newly acquired information to the IOR, and notifies the IO extraction and fusion agent. The agents in IEA can actively seek to retrieve information from certain sources by searching globally for relevant ISR sources and contents when it is necessitated by the requests of specific user. Both the IOR monitoring agent and the retrieval coordinate agent have the capability of handling a large throughput of IO. The IO extraction and packaging agent interact with the IOR to associate, correlate, partition, and re-assemble the IO in terms of metadata categorization, and create certain information clusters that fit the specific needs of individual users (publishing).

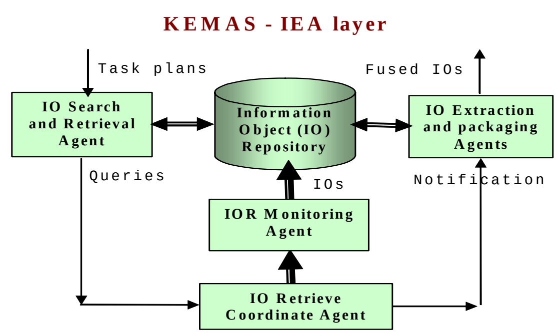

Figure 4. Functional flow of IEFA layer

V.3. Data extraction and IO packaging techniques

The primary parts of the data extraction and packaging agents consist of the following three types of computation components:

(1) Continuous computation component that handles variables in analogical representation of environmental knowledge,
(2) Discrete computation component that handles variables in prepositional representation of environmental knowledge and inference outcomes, and
(3) Hybrid computation component that handles measurements and evaluations functions applied to the continuous and discrete variables.

In a simple configuration, a continuous component can be constructed to serve as a representation of image frames retrieved from an environmental terrain database. A discrete component can extract the state representations of object identities from the images by an integration of the environmental knowledge with the real time sensor inputs. The hybrid component contains a set of evaluation criteria and cost functions that can be applied to the continuous and discrete representations to provide a situational assessment about the scene in the images. Statistical and symbolic logic based inference mechanisms, such as the Dempster-Shafer's belief combination [Ba91], Hidden Markov Models (HMM) [Ma97], and first-order predicate logics [DT99], can be applied in these computation components. A typical inference process could include operations for sequential invocation of the space decomposition, truth propagation, parameter modification, and proposition reposition. A relevance feedback technique, which is an automatic parameter modification based on judgments regarding the relevance of individual information, can be applied among the components in the process [LCV02]. The process can also includes the application of reasoning that seeks explanation of observed data.

Functional components of the IO extraction and packaging agents also include those that interact with information objects in the IOR and use cues to find missing data for various intelligence resources that are difficult to determine the context automatically. The hierarchical alignment of the functional components renders the TIDS system considerable scalability. In a typical TIDS process, the bottom layer of the system hierarchy is devoted to interaction with information sources. The agents at this layer make use of various computational mechanisms to support the real time data filtering, extraction, and distilling processes. In the middle layer the functional components are set for real time data integration and reasoning with an application of various inference mechanisms. At the top of the hierarchy, the functional components accommodate the evaluation and presentation of information extracted from the lower layers. Adaptation takes place at all these layers by adjusting the agent functions' parameters. Control functions embedded in these layers regulate how state changes affect and propagate the IO from one state to other. The KEMAS implementation of TIDS provides a domain specific solution to information sharing. The system will be easy to deploy and manage, is extensible and automatically modifiable in accordance with security requirements and physical limitations of end system connections.

V. Conclusion

One feature of the modern battlespace is the growing amount of information from multiple resources available to the warfighters. Successful C2 operation begins with the ability of sharing critical information and knowledge in a timely manner with the networked 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. The capability of TIDS enables warfighter to gain better situational awareness and reach solutions to the emerging threats, and in turn, to seize the initiative faster than the opponents. The major benefit of the TIDS will be the information, knowledge, and decision superiority in NCW.

Command and control (C2) operational environments are knowledge intensive. Available information sources are not always exploited efficiently to enable commanders to get relevant information and make informed decisions. 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 are crucial. However, the viability and successful operation of tailored information service requires a systematical construction of metadata repository, carefully defined domain ontology, proper setting up of user registries, and thorough understanding of user needs. The reverse side of a proper implementation of tailored information delivery and service (TIDS) would be catastrophic.

The foremost objective of a multi-service expeditionary information dissemination enterprise, as studied in this paper, is to extract, deliver, and share the "right" information to "right" user at "right" time in "right" format. The information service should be organized to optimize the utilization of the information for warfighters, to improve the human-system integration, and to enhance combat capabilities in complex battlespace situations. Our research took the first step of developing a tailored information delivery and sharing system concept to connect the enormous amount of ISR information from heterogeneous networked resources to disparate users (commanders, planners, unit leaders, warfighters, etc.) and facilitate secure information sharing among them. The system will provide a capability that automatically disseminates the latest information products across battlespace based on user-defined information needs, to cross-cue and collect multiple spaces, airborne and land based sensors, and terrestrial intelligence sources, and to present the information in pictorial forms clearly and succinctly to the warfighters. An ultimate goal of the research is to create a system of information management solution that demonstrates advanced human systems integration and establish how communities of warfighters and commanders can achieve profound improvements in their ability to exchange meaningful information and create a common operational picture to successfully plan and execute complex, collaborative missions. To focus the research tasks, security, an important factor of information management, is not dealt with in this project. However, various security measures can be readily incorporated into the TIDS system design.

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