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AFTER ACTION REVIEW SYSTEM DEVELOPMENT TRENDS

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ABSTRACT

In this paper we present an evaluation of current developments and directions in the After Action Review System (AARS). First, a common After Action Review (AAR) domain architecture is described that will form the basis for future AARS requirements and technologies. Next, a brief status of constructive, live and virtual AAR legacy systems is presented to illustrate current technology. Current limitations such as lack of standardized simulation interfaces and access to internal simulation data are discussed. Then we describe AARS driving factors, which include requirements and technology. Next, we associate AARS driving factors with technologies that will be required by future AARSs. In conclusion, we describe challenges to be met by future AARSs and the need to account for AARS requirements in developing simulation interface protocols.

1 BACKGROUND

Existing AARSs for simulation-based training exercises play an important role in delivering the training end product to the audience. Significant changes in user requirements and simulation technology are creating a need to develop the next generation AARS. Current training simulations are centralized and standalone. With the advent of distributed interactive simulation (DIS), simulation technology is moving toward distributed simulations and standardized links among constructive, virtual and live training devices. While past AARSs were designed to work with specific simulations, future requirements are for a standardized AARS that will support all categories of training simulations. Other significant trends include the need to collect and analyze larger volumes of detailed information from higher resolution simulations using fewer support personnel. With the trend towards linking command and control (C^2) systems directly with training simulations, the need exists to collect organic C^2 data to compare simulation ground truth with the training audience's perceived truth.

The AAR is the process of collecting, analyzing and reviewing the results of a training exercise. An AARS for simulation-based training exercises plays an important role in delivering the training end product to the training audience. In a training exercise, as in actual combat, the number and pace of events are such that no single person has a comprehensive view of what is happening and what it means. An AARS records all events in a data base, which an analyst can query to understand what happened, why it happened and how to improve for the next time.

An AARS consists of three major components, data collection, data analysis/reduction and the AAR presentation. Each of these is now described in more detail.

The AAR data collection component acquires all pertinent data for a training exercise from a number of sources. The majority of this data consists of simulation state and event information. Other types of data to be collected include observer/controller observations and data from the unit's organic command and control system. The data collection component builds the AAR data base from a diversity of data sources, and is the most critical element in the overall AARS design since it provides the source data that is used for both analysis and AAR product generation.

The AAR analyst must analyze and reduce large amounts of data to generate the products that support training objectives by providing feedback on critical battle management decisions. They use techniques such as correlation of forces metrics or viewing animations of specific areas and domains of interest to analyze the battlefield events. AAR data analysis falls into two major classes: products that are used frequently for a particular type of training and products required to address ad hoc areas of interest. The output of this process is an understanding of what happened during the exercise and a set of briefing products to use in the AAR to communicate the training feedback to the training audience.

The final step in the process is the presentation of the data products during the AAR to the training audience. This usually involves a facilitated discussion centered on the use of the AAR data to provide feedback on critical decision points in the battle. Technical components used in this area include multimedia presentation capabilities and video teleconference (VTC) support.

Current AAR capabilities for constructive simulations vary considerably and were generally custom built for each simulation. For example, the Corps Battle Simulation (CBS) uses a system called the CBS After Action Review System (CBS AARS) to support AAR for division through theater-level command post exercises (CPX). CBS AARS has been used extensively to support the Battle Command Training Program (BCTP), Corps and Joint Training Exercises. Another system, Warrior Preparation Center After Action Review System (WPC AARS) is used to support AARs for the Air Warfare Simulation System (AWSIM). These AARSs work only with a single simulation, a major drawback, because most current simulations do not provide standardized access to the diversity of data needed in large-scale exercises.

The Aggregate Level Simulation Protocol (ALSP) is a combination of infrastructure software and a protocol used to communicate between simulations. The 1994 ALSP Joint Training Confederation consists of six constructive training simulations linked through ALSP infrastructure software to provide an integrated training environment for major service, joint and combined exercises. A limited set of AAR capabilities for the ALSP Confederation is provided by existing constructive AAR systems. Some data is available from the ALSP message traffic sent between each member and the ALSP infrastructure software. However, this data is insufficient to meet AAR requirements since the content of the messages is driven by simulation interoperability requirements and not AAR requirements.

Current AAR capabilities for virtual simulation are driven primarily by ongoing work in the area of DIS, a relatively new technology. Current AAR capabilities focus on collection, management and replay of DIS Protocol Data Units (PDUs). A major benefit provided by DIS is accessibility to a large, standardized set of data reflecting the state of the simulated battlefield. An example of virtual simulation AARS is the Simulation Training Integrated Performance Evaluation System (STRIPES), built under the Advanced Distributed Simulation Technology (ADST) contract. Its capabilities include record and playback of PDU traffic, data visualization and statistical analysis.

Current live exercise AAR relies heavily on trained observer/controllers. Current instrumented ranges provide quantitative data on platform location, while instrumented ranges currently under development are being designed to support DIS protocols.

2 REQUIREMENT TRENDS

The importance of AAR to a training exercise, and thus troop readiness, is widely recognized by the Department of Defense. Lacking standards for current AAR capabilities, the Army has initiated the development of STAARS. In April 1994, a conference was held to discuss AAR issues and to develop future requirements for STAARS. As a result of this conference, a draft STAARS Mission Needs Statement (MNS) was written and distributed for comment. The draft MNS identified the following needs:

- A need exists to provide high quality AARs at the units' home stations.
- A need exists to conduct rehearsals before, during or after deployment to training events or actual operations.
- A need exists to record data, not necessarily applicable to training, for the purpose of supporting Research, Development and Acquisition (RDA) and Advanced Concepts Research (ACR).

A major goal of future training simulations is to support a principle called "Train as you fight." In other words, from the warfighter's point of view, a training exercise should have no perceivable difference from an actual battle or operation. To implement this, it will be necessary to connect a unit's organic command and control system directly to the simulation system. This has significant implications for AAR. To have a complete view of the synthetic battlefield, the AARS must be able to extract data from both the simulated battlefield and from the unit's command and control system.

Digitization of the battlefield is an emerging concept that has significant implications for AAR. In the battlefield of the future, the commander will have access to larger quantities of battlefield data at higher resolution. To train the commander to use this capability requires the system to simulate battlefield conditions with this same level of resolution. The AAR system of the future must also allow the AAR analyst to assess the performance of the commander and his staff in their effective use of the digitized battlefield.

The number of joint exercises using simulations has increased recently due in large part to ALSP's ability to provide the linkage of air, ground, naval, and logistics modules. In order to provide an AARS to a joint training audience, the next generation AARS must provide a seamless window into a federation of models (e.g., the Joint Simulation Model (JSIM)). In addition, the types of AAR products produced must be driven by the training needs of the joint training audience.

3 MODELING AND SIMULATION TRENDS

Future AARSs will be heavily influenced by ongoing modeling and simulation (M&S) technology trends. These trends include the move towards DIS protocols and the increased use of artificial intelligence (AI) technology in modeling human behavior on the simulated battlefield.

As defined in the DIS Master Plan, DIS is "a synthetic environment within which humans may interact through simulation(s) and/or simulators at multiple networked sites using compliant architecture, modeling, protocols, standards, and data bases."

The DIS Master Plan identifies capabilities that should be provided by a DIS-based system. It states that a DIS system "should provide a system of automated collection/ recording of simulation events, including human generated, as specified by the user."

The DIS Master Plan also identifies AAR capabilities required for advanced concepts and requirements, research, development and acquisition, training exercises, and military operations elements. These can be summarized as follows:

- AARS must collect and record actions, reactions and events generated by humans with little or no interference by observer/controllers.
- Training exercise elements must automatically synchronize voice, video and digital data, replay on demand, support a wide spectrum of training and testing exercises, support geographically distributed training audiences, rapidly process a wide variety of data and produce meaningful presentations of desired information.
- Military operations elements will require data collection capability on each piece of equipment that facilitates AAR. The ability to review the results of rehearsals for military operations will also be supported.

The movement of the M&S community towards the DIS standard presents benefits and challenges to the development of the next generation AARS. In the past, most simulation data was treated as private data, and access was by ad hoc or proprietary methods. DIS-based simulations, on the other hand, transmit a significant portion of the simulation state and events on a network. Thus, by listening to the network traffic, significant amounts of data can be collected; so much, in fact, that the challenge becomes the ability to process and understand the data.

One limitation of existing DIS PDU's is that the PDU content is not necessarily defined by AAR requirements. While DIS provides a significant increase in data accessibility, some needed data such as force structure is not supported. Furthermore, actual data requirements are driven by the training objectives of a specific exercise. In some cases it may be necessary to access internal entity data from a specific simulation in order to fulfill data collection requirements.

WARSIM 2000 has a significant impact on AAR requirements and is considered a "driving program" for AAR development. In the STAARS MNS, WARSIM 2000 is identified as the prime driver toward a standardized AAR system and the developer of many of the technologies required for future AARSs. The DIS Master Plan identifies standards for AAR as a key requirement. The plan stresses the need to develop standard data protocols that are based on data requirements from the Center for Army Lessons Learned (CALL). Significant WARSIM 2000 requirements are as follows:

- Support training at home station sites.
- Analyze simulation data using ad hoc queries.
- Compare simulation data with information in the unit's tactical data systems and decision support systems.
- Support collection of real-time audio and video from observers located at the training unit.
- Interface with CALL.
- Tailor data collection parameters.
- Automate the detection of common errors.
- Support AARs with reduced personnel.

Intelligent Computer Generated Forces (CGF) technology is playing an increasingly important role in training simulations. Past simulations such as CBS relied heavily on the use of role players to provide intelligent command and control of CGF. Current virtual simulation systems such as the Close Combat Tactical Trainer (CCTT) provide lower level CGF behavior representations and require large numbers of controllers. Future simulations will support direct connections between the training audience and the simulation. In order to support this capability, intelligent CGF is required to automate those functions currently provided by controllers. In addition, cognitive models will be required to portray mistakes, as required for WARSIM 2000. This will provide a rich set of new information that will assist analysts in understanding simulated behaviors.

An example of the application of AI technology to military simulations that has AAR implications is a system called Combat Outcome Based On Rules for Attrition (COBRA). COBRA is an expert system embedded in CBS. Its purpose is to improve combat attrition realism by using rules to affect combat outcome based on the combat situation. As a side effect of using COBRA, the rules used for a particular battle are saved in a file. This can provide a direct benefit for an AARS. The rule trace file can be reviewed to assess the outcome of a given battle. For example, COBRA will account for the situation where a unit trying to attack across a river is vulnerable to enemy fire. Reviewing the rule trace will quickly point this out. Explanation capabilities apply not only to training feedback but also to model validation.

4 AARS TECHNOLOGY

Given the pull of future requirements and the push of ongoing changes in simulation technology, the next generation of AARS will apply new technology in the areas of data collection, analysis and presentation.

4.1 Data Collection

Due to the large amount of data available, data collection systems must allow an analyst to specify what data to collect and at what frequency it is to be collected. Intelligent servers will distribute data efficiently to analysts and training audiences in geographically dispersed locations. Intelligent data collection capabilities will also detect high interest events, collect additional data and alert analysts to the event.

Future AARSs will allow extraction of data from command and control systems, including C^4I data bases, message traffic, voice and video. All data items will be time-tagged to allow the AAR analyst to construct a complete and correlated picture of both simulation and training audience events. See Table 1 for representative data that can be collected for C^4I systems.

Table 1: C^4I Data

Data Content	Examples
LAN & WAN Traffic: • USMTF • BFS/System Specific • Joint Army Navy Pub 128	• X309 Free Text • G131 Intsum • SITREP • Unit Status & Location • Assets/Supply • Gumball Chart Msg.
ABCS Data Bases: • Friendly Units • Enemy Units • Obstacle/Barriers • Battle Geometry • LOGSTAT • Force Level Data	• Unit Location • Unit Name • Status of Supplies
MSE Packet Network: • Node Status	• Node Affiliation
OPFAC Activities: • Audio of Comms & Internal • Video of Activity w/in Selected OPFAC • OPFAC Displays	• Audio Tapes, Radio, Telephone & Conversation • Video Tapes • C^2 Display Remotely Available for Analysis

Standardization of simulation interfaces, protocols and data bases will allow data to be collected from a wide variety of training simulation systems by a single AARS. This will allow an AARS to provide a correlated and consistent view of constructive, virtual and live simulation systems.

4.2 Data Analysis and Reduction

Next generation AARS data analysis and reduction capabilities will need to deal with increased quantities of detailed simulation information in the form of DIS PDUs.

Automated analytical tools will produce standardized AAR products, freeing analysts to focus on high interest events and special purpose AAR products. Using sophisticated natural language query tools, an analyst will quickly assess battlefield situations.

With the increase in fidelity and types of available simulation data, including perceived truth and ground truth, the analyst will develop a more complete understanding of what happened and why it happened. This will add a new dimension to simulation-based training.

With the advent of direct connections between simulations and organic C^4I systems, future AARS capabilities will allow the AAR analyst to tap directly into the training audiences' tactical decision support systems. By comparing the perceived truth from the C^4I equipment with ground truth from the simulation, the analyst will assess the commander's reaction to the perceived battlefield. By correlating command post data, voice and audio, the analyst will evaluate user performance based on a complete picture of the training audience environment.

4.3 AAR Presentations

AAR presentation capabilities of future AARS will support such concepts as "discovery learning" and "distance learning." Interfaces to CALL will provide the ability not only to learn lessons from individual exercises, but to compare across multiple exercises to discover trends.

In discovery learning, the training audience provides the majority of the insights and teaching points and arrives at the conclusions. Future AARSs will provide a dynamic presentation environment where the presentation can take unexpected turns and explore unanticipated areas. Intelligent query capabilities will allow the training audience to pose real-time questions and get the answer quickly. Presentation of the query results will be in formats based on the type of information presented.

AAR presentation capabilities of the future will provide a high fidelity window into training exercises. Users will be able to zoom in on any portion of a constructive, virtual or live battlefield and display detailed static and dynamic 3-D representations.

Video teleconference capabilities will support distance learning. Training audiences will be located in geographically dispersed locations such as fixed regional training sites, remote simulation sites and in command posts. Video teleconferencing will integrate personnel from all of these locations into a single integrated AAR.

AAR and simulation data produced from a training exercise will be made available to CALL. CALL will have the ability to review AARs and to replay actual portions of the exercise. By comparing the results of multiple exercises, it will be possible to discover trends.

4.4 Hardware and Network Technology

Given the information demands on AARSs of the future, application of new network technologies will be required. Heavy use of video teleconferencing for AARs will demand high bandwidth networks carrying voice and video. Network bandwidth will be stressed by increased simulation traffic from distributed simulations with detailed simulation states and events. AAR analysts in distributed locations will require rapid access to simulation and C^4I data. Given these heavy demands on information transmission, AARSs of the future will require advanced network technologies such as FDDI, T3 and asynchronous transfer mode (ATM).

5 SUMMARY

Even though standard simulation protocols provide a significant increase in data availability, simulation protocols are not driven by AAR requirements. To satisfy future AAR data requirements, it will be necessary to get AAR requirements from a large set of users. Once these requirements are identified, current simulation protocols should be expanded to include data required for AAR.

It will be incumbent upon AARS users to represent themselves in the modeling and simulation community. Users must ensure that AAR data requirements are accounted for in developing simulation standards such as DIS and ALSP. By developing standards that address AAR issues, AARS development costs will be reduced and AARS developers will be able to focus on developing analytical and presentation tools instead of building custom interfaces for each training simulation system.

Simulation and AAR technology are growing at a rapid pace. At the same time, the user and technical communities are realizing the importance of AAR to the training. Through the application of new technologies such as DIS, AI, high-bandwidth and long-haul networks and video teleconferencing, AARSs can be built to meet the demanding requirements of future simulation-based training systems. As AARSs increase in capability, the quality of the training feedback to the training audience will increase, leading to the ultimate goal of improved troop readiness.

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