Computational Narrative in Support of M & S Behavior Representation

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ABSTRACT:  The basic purpose of modeling and simulation (M&S) tools are to tell a story, helping the analyst extract meaning or enhance understanding about a situation or system. The amount of detail available in the story could vary from “Veni, Vidi, Vici” to the entire text of “War and Peace”. By definition, M & S systems leave out details of the simulated environment. However the contextual information embedded in these details are necessary to build a complete picture. Narrative supports this detailed view. Narrative is a natural and intuitive way of describing the semantics and status of a situation. There have been extensive studies by cognitive scientists highlighting the value of narrative for understanding, memory, inference, and problem solving. Several M & S efforts on Human Behavior Representation (HBR) have at their core a focus on story telling and story understanding. The impact of narrative on training simulations is prominent in many tools developed at the Institute for Creative Technologies (ICT), for example, the leadership training of Full Spectrum Warrior and the emotion-modeled virtual human application. Within the SIW community, there are also systems being developed that center around some aspect of narrative. There a several ongoing working groups, such as The Military Scenario Definition Language (MSDL) development group, the C-BML (Coalition Battle Management Language) effort, and C2IEDM (Command and Control Information Exchange Data Model) that are attempting to create computational forms of knowledge for exchange between automated systems and human stakeholders. This paper will discuss the use of narrative to add context and derive meaning from M & S systems. It will also present the status and progress of the narrative research effort here at ARL, which developed a narrative ontology and an XML schema language. The purpose of this paper is to generate discussion of narrative as a means for supporting the exchange of information from M&S to C4ISR systems.

1. Introduction

The well-known radio journalist and on-air personality, Paul Harvey, had a recurring segment of his show called “The Rest of the Story”. (Aurandt, 1984) He would supply a teaser statement about some event or person prior to a station break, pledging to fill in the background information later. The added details and contextual information would always lead to a compelling, entertaining, and frequently surprising twist to the tale.

Narrative focuses on three concepts: the story, the storyteller, and the audience. A story is an account of incidents or events. The audience is the body of listeners or spectators that experience a story. The storyteller acts as the interface between audience and story. The storyteller drives audience perception. Perception is the understanding or insight into the story. Perception is also related to the point-of-view from which the story is told. The legendary filmmaker Kurosawa, in his seminal film Rashomon, used multiple perceptions to enhance the drama of the film. (Kurosawa, 1987) The movie is essentially a detective story about a murder, where the story is revealed using four different perspectives on the same incident. It is up to the audience to reconcile the differing accounts and determine what actually occurred. The impact of this style of storytelling was so compelling, the term the Rashomon Effect is used in some legal circles to describe the situation where eyewitness accounts differ significantly. There are other factors that influence narrative, such as the size of the audience, the number of storytellers, the media for storytelling (print, visual, auditory), the purpose of the story (educational, entertainment, informative), etc. Effectively using these factors and applying narrative techniques is how screenwriters, literary authors, and filmmakers are able to drive the perceptions of an audience.

1 “I came, I saw, I conquered”, Julius Caesar, 47 BCE
In a similar fashion, narrative techniques complete and enhance the stories that are inherent in all simulations. By definition, simulations leave out certain details of a situation, balancing the accuracy of the story against the complexity of completeness. However, many of these details can be inserted into the simulated events after-the-fact, given sufficient knowledge of the domain. This computational narrative will support automated reasoning about the stories being told by M & S applications, as well as presenting the scaffolding to include behavioral aspects to the simulation.Overlaying simulation objects with intent, motivations, and objectives gives the analyst a description of why the simulation proceeding in a certain manner, as well as what happened.

The purpose of this paper is to highlight the narrative approaches that are inherent in several ongoing M & S applications. Recognizing the storytelling nature of these systems and the potential for automated contextual enhancement will leverage the significant research in narrative from other disciplines. Incorporating M & S systems with C4ISR applications, particularly the Future Combat System (FCS), will necessitate a multi-disciplinary approach to making seamless communications with automated systems.

2. Narrative as Cognition

Mateas and Sengers coined the term narrative intelligence (NI) to describe the cognitive ability of capturing knowledge through narrative. (Mateas, 2003) Narrative intelligence means that we think in stories. NI draws from multidisciplinary definitions of narrative, such as art, psychology, cultural studies, literary studies, and drama. NI researchers are concerned with designing narrative interfaces, agents that interact through narrative, storytelling and story-understanding systems. Kerstin Dautenhahn, of the University of Hertfordshire, proposed the Narrative Intelligence Hypothesis, which views narrative as a necessity in the development of complex social structures. (Dautenhahn, 2001) Dautenhahn claims that communicating through narrative evolved as social dynamics became more complicated.

Some influential cognitive scientists propose that narrative is central to models of explanation and inference. Jerome Brumer described the characteristics of narrative that separate it from random phrases in a language (Bruner, 1991):

- Narratives are about unusual events that are worth telling
- Narratives describe characters, with intentions, interacting in a setting that supports their beliefs
- Narratives require a plot, with a higher meaning

Roger Schank, a prominent researcher in the field of artificial intelligence, felt that stories are essential to learning and understanding. Schank modeled cognition in terms of scripts, mental templates that the mind executes based on the situation and environment. (Schank, 1977) He also attempted to define generalized classes of actions, creating categories like mtrans to denote the mental transfer of information and ptrans to describe actions that involved a physical change of location.

There have been several previous efforts at developing abstractions of narrative. Propp's Morphology of a Folktale was an effort by a 20th century literary scholar to create a hierarchy and structure of the standard folktale, as a basis for analysis. (Propp, 1968) Propp identified recurring patterns within the genre and built relationships between the patterns and the form of the folktales. Dallenbach, another literary critic, attempted to describe a specific narrative pattern, that of a play-within-a-play. (Dallenbach, 1989) This is a particularly useful storytelling device, when, for example, the narrator of a story is telling the tale as a series of flashbacks. This technique is also used effectively in film making, as presented in the movie Memento. (Nolan, 2001) The story unfolds in a non-linear fashion, alternately showing the audience the end and the beginning of the narrative, while moving the storyline towards the middle. The results and the catalyst for events in the movie are revealed through discovery.

Joseph Campbell and Carol Pearson examined the concept of myths and storytelling as societal or cultural metaphors. Campbell's work is widely known as a treatise on the use of myth to explain the values and principles from a civilization. Examining how a group creates its mythos gives greater insight into what motivates their world. In The Power of Myth, Campbell talks about the goals and characteristics ascribed to heroes and how they are a microcosm of people in general. (Campbell, 1988) Pearson focuses on the protagonist of stories, defining a series of archetypes for categorizing goals and motivations. (Pearson, 1989) A protagonist is the character that drives the plot and initiates the action. The antagonist is a character that attempts to block the goals of the protagonist. Pearson
defines an archetype as “deep and abiding patterns in the human psyche that remain powerful and present over time”. Pearson relates archetypes to phases of psychological development or personality type.

3. The Narrative in Training Simulations

The Institute for Creative Technologies (ICT) grew out of a study commissioned through the National Research Council (NRC) and sponsored by the Department of Defense (DOD). The goal of the study was to determine how to merge the efforts and capabilities of the entertainment industry with the M & S needs of the military. The mission of ICT is to develop synthetic environments and immersive technologies for training, analysis, and operational systems. ICT has become one of the army’s leading proponents of training M & S. There is a strong narrative aspect to many, if not most, of the projects under development at ICT. Three such systems are the Mission Rehearsal Exercise (MRE), the Army Excellence in Leadership (AXL) project, and the game simulation Full Spectrum Warrior (FSW).

The MRE is a virtual reality environment that seeks to immerse trainees in the sights, sounds, and stresses of real-world scenarios. (Swartout, 2001) Using speech recognition software, the user interacts with the characters, attempting to complete mission objectives through persuasion and negotiation. These virtual humans can act as friendly forces, civilians, or antagonists while simultaneously coaching the participant’s decision-making. In order to make the simulation tractable and minimize the complexity of AI reasoning necessary, there are three types of virtual humans: scripted, AI-based, and AI-based with an emotion model. Scripted characters have a limited range of behaviors and functionality in the story, similar to the “extras” in a filmed narrative. AI-based characters are the ones that directly interact with the trainee and, therefore, must be able to reason about and interpret changing situations. Narrative is about context, assigning goals and obstacles to explain the actions of characters in a story. The third type of character uses an emotional behavior model to modify their perceptions, objectives, and receptiveness.

Creating dramatic, compelling storylines is central to the effectiveness of MRE. The trainees’ level of engagement is enhanced by including stress and uncertainty into scenarios. The participant must be not only knowledgeable with standard military protocol, but must have some familiarity with the local culture of the inhabitants in the simulated environment. MRE even incorporates a crowd behavior model that can be adjusted to exacerbate an already tense situation.

The AXL project uses filmed narratives of leadership scenarios to support an interactive case method of training. (Hill, 2004) The storytelling of fictional case studies, highlighting specific leadership obstacles and requirements, guides leader development by creating “what would you do?” situations for analysis.

One of the most successful army training simulations based on gaming technology is Full Spectrum Warrior (FSW) by ICT. FSW was an attempt to merge the familiarity and accessibility of a commercial gaming platform (Microsoft’s Xbox) with a squad-level cognitive training simulation. (Korris, 2004) The tool relies heavily on narrative and immersion to establish mission objectives and training guidelines. The backstory of the game involves MOUT (Missions Over Urban Terrain) in a generic southwest Asian nation.

An interesting aspect of FSW’s transition to a commercial video game and its subsequent popularity is the unconventional method of play. Unlike most combat-centered role-playing games (RPGs), it is not a first-person shooter. In other words, the participant does not carry or directly fire a weapon. As the squad leader, the player accomplishes his objective by giving orders associated with specific game controls. The squad leader controls two fire teams, alpha and bravo, that are programmed to emulate the standard tactics, techniques, and procedures (TTP) of a small infantry unit. (Figure 1) The squad, with appropriate movement in realistic formation, automatically accomplishes doctrinal behaviors (such as bounding overwatch, directing fire in sector, and suppressing fire). The individual entities on the fire teams are not only given particular roles (team leader, automatic rifleman, rifleman, grenadier), but are given specific identities and personalities.

For the commercial version of FSW the artificial intelligence in the game engine was scaled back to increase the vulnerability of the opposing forces (OPFOR). The adaptability of the unmodified OPFOR made the game harder to defeat and, therefore, not as appealing to the commercial gamers who are used to games where pattern recognition and repetition are the key to success.
4. Narrative for the Semantic Battlespace

The army has identified a need for the digital battlespace by both computational systems and subject matter experts to aid the C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance). The Future Combat System (FCS) envisions a seamless merge of information systems and hardware, communicating on the battlespace in real-time with persistent data. The Global Information Grid (GIG) will support much of the infrastructure of FCS; the Department of Defense (DOD) mandated interconnected set of information capabilities for war fighters, policy makers, and support personnel. One of the primary policy requirements on GIG assets is interoperability using common or enterprise-level communications and computing architectures. The multiple data sources, communication channels, heterogeneous platforms, and information systems in FCS will not only generate cognitive overload to the war-fighter, but will make information fusion difficult. The problem is context: how to add semantics to the data to assist decision makers and battle planning.

The Command and Control Information Exchange Data Model (C2IEDM) evolved from a need for unambiguous definitions of entities on the battlespace. (Turnitsa, 2005) As a common reference model, C2IEDM supports the interchange of data between command and control information system (C2IS) databases. The need for C2IEDM grew out of problems of interoperability between systems during joint exercises. The Multilateral Interoperability Program (MIP) Organization member states, which include over two dozen NATO (North American Treaty Organization) or affiliated countries, sought a common specification for C2 data compliant with level 5 interconnection standards.

The narrative aspect of C2IEDM emerges from its ontological construction. Currently, over 190 entities contain the concepts in the C2IEDM ontology. There are two structural types within the relational model of C2IEDM: objects and actions. Objects are the persons, places, or things that represent the classes or categories of items on the battlespace. Actions are the tasks and events that can occur between entities and external to their interactions. Although a C2IEDM system does not contain complete narratives of the battlespace, the behavior and activities of each entity are described extensively through its corresponding action tree. The action trees describe the objectives of an activity, the effects, whether the tasks are planned, current status, and whether they are functionally/temporally related. It is not difficult to imagine constructing coherent narratives of the battlespace using C2IEDM object and action building blocks.

Another army effort at capturing domain knowledge is Battle Management Language (BML). I participated in the first BML Symposium, sponsored by the SIMCIOIPT (Simulation to C4I Interoperability Overarching Integrated Product Team), which was held at Fort Leavenworth. The symposium was an exploratory workshop to determine what a BML would look like and in what format. At that time, XML was a relatively new knowledge representation technique and unproven. Much of the discussion focused on possibly assist with adding context to the battlespace through ontological approaches, capturing knowledge from army domains and encoding it in machine-readable form. Narrative will enhance these tools because it represents a dynamic view of ontology. The simplest definition of narrative is “character in action”. The semantic battlespace will require “ontologies in action”, not just definitions of concepts, rules, and relationships, but canonical stories of the interactions between the concepts.
using the JCDB (Joint Common Database) as the basis for a BML. Carey (Carey, 2001) defines BML as: “…an unambiguous language used to command and control forces and equipment conducting military operations and provide for situational awareness and a shared, common operational picture”. The purpose of BML is to standardize the terminology and symbology of the battlespace based on doctrinal information, allowing automated C4I systems and stakeholders to interact.

C-BML (Coalition Battle Management Language), a current incarnation of BML, leverages work from the OIPT, C2IEDM, and other C4ISR efforts. (Blais, 2005) C-BML is to improve situational awareness by introducing consistency in the discourse of the battlespace, allowing automated simulated and robotic forces to interpret and respond to commands. The same five W’s that are the basis for storytelling (Who, What, When, Where, and Why) can be represented with C-BML. The CBML group is collaborating with the development of MSDL to insure that the standards will be consistent.

MSDL (Military Scenario Definition Language) is an effort to create a standard interchange format for military M & S systems. Most simulations have some form of scenario script or language, but these representations are either proprietary or platform dependent. The definition of MSDL will support C2 simulations with an international standard for data representation and file transmission, usable by live, virtual, and constructive simulations. (Surdu, 2005)

5. An XML Schema for Narrative

Scenario-based design techniques are used in software engineering, cognitive science, and HCI (Human-Computer Interaction) to aid in decision making, comprehension, design, and training. Software developers use scenarios for rapid prototyping, computer simulations, and to assist system development. (Carroll, 1995) Scenarios are narratives that illustrate future possibilities or existing systems, and help policy makers and system designers choose among alternative courses of action.

The research that led to the design and implementation of the Scenario Markup Language (SCML) used an ontological view of narrative to create an XML grammar. The impact of such a narrative-based language was confirmed by an empirical study of decision-making. (Hobbs, 2005)

Figure 2 SCML-S Schema Design

The initial version of SCML is a DTD (Document Type Definition) specification. The DTD format was initially the primary format of XML grammars. However, DTD-based languages are limited due to being weakly typed, having grammar specifications not written in XML (required external processing), and structurally constrained by the requirement of a root element.

The updated version of the language, called SCML-S (SCML-Schema), supports strong data typing in the language. It is also possible to have stand-alone scenario elements embedded in non-SCML documents since there is not the constraint of a root element. Object-oriented techniques were used during schema design, allowing for inheritance of features for derived types as well the creation of complex, user-defined types from the basic types. It is easier to integrate schema documents with relational or object-oriented databases, as well as XML-oriented data storage structures. XQuery and XForms technologies for distributed information storage and retrieval assume an XML Schema.

Figure 2 is an excerpt of a structural view of the SCML-S schema. Actions are the fundamental building blocks of the narrative structure. An action is a change of state in a story. Meaningful sequences of actions make up events, and predetermined lists of events combined into episodes. Episodes are goal-based objects, with the individual events occurring to support sub-goals. Each scenario is a succession of episodes, representing the plot of the narrative. This embedded goal network is derivable from any coherent narrative, representing an overall meaning of the story.
SCML-S tags correspond to the concepts and rules from the scenario ontology. Rules for combining and nesting tag elements result from the associations, multiplicities, and cardinalities represented in the conceptual model. The design of the schema version of SCML focused on the anticipated instance documents and the potential authors of instance documents in the language. The ultimate goal was adherence to an open, extensible architecture while incorporating more narrative features in the language. Some of the modifications and new features embedded in SCML-S include:

- Open content construction that allows instance documents to contain additional elements that are not contained in the schema. The use of `<any>` and `<anyAttribute>` schema primitives support extensibility.
- Reworking element attribute definitions to handle real-time scenario activities such as automatic timeline generation and storyboarding. The addition of the duration attribute to action and event elements to support the generation of timelines.
- The `mattelImage` attribute of the `scene` element supports graphical overlays. The use of an intrinsic binary data type allows direct embedding of graphics for the creation of storyboards.
- SCML-S simple schema data types were created using enumeration, pattern matching, or multiplicity facets. These derived schema types are necessary to establish the range of acceptable scenario elements.

Figure 3 is an example of an encoding of a military story. The narrative was taken directly from the after-action report (AAR) describing the battle of Medina Ridge from the first Gulf War. (HQ 2nd Battalion, 1991) The Battle of Medina Ridge was a pivotal tank battle fought on the 27th of February, 1991, between the U.S. 1st Armored Division (Iron Tiger Brigade) and the 2nd Brigade of the Iraqi Republican Guard Medina Luminous Division near Basra. As the largest tank battle during the Gulf War (and the largest in history up to that point), several narratives and detailed accounts of the battle exist, such as in the book “Lucky War” by Robert Swain. (Swain, 1997) Play-by-Play descriptions of the battle such as the number of coalition M1A1 tanks (166), the number and type of tanks for the opposing force (OPFOR) (Soviet-made T-72s and T-55s), and particular battle location (west of Phase Line Kiwi) are readily obtainable and available for constructing a distributed narrative.

Figure 3 SCML-encoded Combat Narrative

The example in Figure 3 is a partial encoding of one episode of the battle. The amount of markup for a particular instance of a narrative document would vary, based on the context available and the amount of processing required for the source information. The contents of the original AAR are free-form natural text, adhering to army standards for memorandum. This SCML-coding was done manually; however, there are several natural language processing tools that could automate the encoding. The setting of the battle in the example is temporal, using the designation “G+3”. This corresponds to ground day plus three, a relative measure for the battle the start of operations. Each `event` can be given `duration`, using a built-in XML schema data type of the form HH:MM:SS, to enable automatic generation of timelines for activities. The inclusion of an `annotation` storylink reference shows how additional/background data for any particular story element is inserted throughout the document. In this case, the link is to an internal reference using XPath notation to locate further details on the Adnan Republican Guard, such as force structure and command hierarchy.

The distributive narrative on the battle could be further expanded by linking the document with other literary information already available. In his book “Certain Victory”, Brigadier General Robert Scales wrote the first official account of Desert Storm. The book contains compelling personal combat narratives, from multiple perspectives, interspersed with official documentation and artifacts. Figure 4, taken from the Scales book, is an overlay map that pertains to the same battle described in the SCML exemplar. (Scales, 1998) It would give further context to the combat narrative to embedded XPointer references that could include graphics such as this, as well as the ability to create layers of the story.
Along with the continued refinement of SCML-S, there are other narrative research and development tasks at ARL. The design of an SOA (Service Oriented Architecture) compliant narrative service for the battlespace is being examined. The integration of the cognitive modeling architecture ACT-R (Adaptive Control of Thought – Reasoning) (Gonzalez, 2003) with SCML-S to use pattern matching and military doctrine to create canonical stories for the battlespace. Multimodal storytelling will result from XSL-T (XML Stylesheet Language – Transformation) parsers for mode generation. Finally, the narrative ontology is being ported to OWL-S (Web Ontology Language – Schema). OWL-S, the successor to DAML+OIL (DARPA Agent Markup Language + Ontology Inference Language), is a standard for representing ontologies on the semantic web. (Horrocks, 2002)

This narrative schema provides a textual, non-proprietary, platform-independent representation of scenario information that can be used by a wide range of military decision-making activities. By using military doctrine to assign context to narrative constructed from multiple data sources, lessons learned can be exchanged between M&S and C4ISR systems. Behavioral and emotional models can be intertwined with the narratives, as well.

Figure 5 is an illustration of an SOA-enabled narrative service. The narrative generator on the right-hand side of the diagram is based on the implementation of the SCML simulation experiment platform. Each
component of the generator is responsible for adding information to the plot structure. These components could be software systems, direct user input, or a combination of automated and human intervention. The process presupposes the availability of data providers across an information network, supplying data from mission plans, AARs, sensor readings, automated reports, and other digital artifacts. A data user, interested in the fusion of the multiple data sources into a coherent picture, sends a narrative request to the service. Within the generator, the purpose of the Filter component is to remove non-relevant background information. The Parser examines the filtered data, building action tokens. An action token is a series of fields, such as action name, type, actor, setting, and time-stamp. It is not necessary to have every field to construct a story; the minimum is a list of actions/actor pairs. The Semantic Analysis would have to contain specific domain knowledge to search for canonical event patterns. A database of significant events, the collections of actions for each event, the condition triggers/transitions, and inter-action dependencies are required for this analysis. The output of this component is a sequence of events constructed from the action tokens. The majority of the story creation work happens in the Inference Engine. Episodes can be determined by doing pattern matching on the sequence of events and associating the results with a goal network that describes the probable arrangement of intent. A similar style of goal pattern matching is used to detect the specific scenario that occurred. Once the scenario structure is complete, the inference engine can add other narrative information, such as cast of characters and scene changes. Finally, the inference engine uses the appropriate style sheet to generate the encoded narrative. From this encoded narrative (similar to our Medina example), multiple narrative forms can emerge, presenting the plot structure of the story in several different ways.

6. Implications of Narrative on Modeling & Simulation

The use of narrative in all the forms mentioned in this paper will lead to the creation of narrative repositories; digital libraries of stories within different domains. The question is how will these narrative-based representations of information assist modeling and simulation? The TCDL (Technical Committee for Digital Libraries) outlines several technical challenges for the development of digital libraries as collective memory: storage, user interfaces, classification and indexing, information retrieval, content delivery, presentation, administration and preservation. (Neuhold, 2002) These challenges map well to the potential uses of narrative within M&S.

- Storage: A stories-as-documents approach is an alternate technique for storing information in document-oriented XML databases.
- User Interface: Data transformation and story manipulation using XSL can create flexible user interfaces that support multiple formats, direct manipulation, content-oriented queries, and browsing based on annotations.
- Classification and Indexing: Classifying information is an attempt to collect data in a manner that is intuitive to the user or a specific group. The reason that even ontological approaches to classification are difficult is that the meanings are still domain specific. However, the ability to navigate through story-based archives using criteria such as genre, theme, style, and plot could help automate the process.
- Presentation: There are multiple XML technologies and initiatives, such as VoiceXML, SVG (Scalable Vector Graphics), and SMIL (Synchronized Multimedia Integration Language), for customized presentations from narrative digital libraries.

7. Conclusion

Philosophers have used both ontology and narrative as methods for describing and interpreting existence. In the multidisciplinary field of cognitive science, narrative figures prominently in models of cognition and views of intelligence. Computer scientists have embraced ontologies for domain modeling and scenario-based design for user-centered software development. There are several ongoing M&S applications that are implicitly or explicitly using narrative. Narrative is a powerful method for adding context to simulation artifacts, filling in the rest of the story. Seamless, net-centric systems, like FCS, will require the development of a semantic battlespace; machine-readable formats that can be interpreted by automated systems as well as domain experts. By recognizing the narrative inherent in M&S applications and leveraging the multidisciplinary work on narrative from cognitive science, entertainment, and film theory, the semantic battlespace will become possible.
8. References


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