Review of Ontology Based Storytelling Devices

Dov Winer[1,]

[1] MAKASH – Advancing ICT Applications in Education, Culture and Science, Israel

dov.winer @ gmail.com

Abstract. A great deal of research concerning mechanisms to interpret, manipulate and generate stories in different media has been carried out. The basic concepts related to ontologies and their components are introduced. We review then the role of ontologies in storytelling including the distinction between fabula, suzjet and narrative. Several recent innovative initiatives that provide interesting devices for storytelling through the implementations of ontologies are reviewed.

Keywords: narrative, storytelling, stories, story generation, meaning, semantics, semiotics, ontology, AI, semantic web.

1 Introduction

"We live immersed in narrative, recounting and reassessing the meaning of our past actions, anticipating the outcome of our future projects, situating ourselves at the intersection of several stories not yet completed." [1].The concept of storytelling is older than human history itself. Wisdom, knowledge and information were passed down orally. With the emergence of widespread personal computing and the Internet, the relationship between storytelling and technology has transformed dramatically in a short period of time. Frank Nack [2] provides a succinct review of the phases of this development. He indicate that the notion of the 'digital' include the capability to combine atomic information fragments. The cognitive possibilities of the digital combined with the idea of 'semantic and semiotic productivity', allowing an endless montage of signs, inspired a great deal of research in Artificial Intelligence (AI) that embody mechanisms to interpret, manipulate or generate stories in different media. The basic vision was that the machine should not only support the author but also become an active partner in the pleasures of immersion and interaction. This paper will review some ontology base storytelling devices that resulted from this research program.

2 Ontologies

Ontologies can provide for the formal expression of the different components of narratives. This is a basic requirement in attempts to generate computer generated story telling. In this section we review some basic concepts.

What is an ontology?

Corcho et al. [3] are concerned with ontologies as part of their work in the OntoWeb project. Ontologies aim at capturing domain knowledge in a generic way and provide a commonly agreed understanding of a domain, which may be reused and shared across applications and groups. Ontologies provide a common vocabulary of an area and define, with different levels of formality, the meaning of the terms and the relations between them.

The definition most referred in the literature is that of Gruber [4] "an ontology is an explicit specification of a conceptualization". Borst (1997) [5] slightly modified it saying that: "Ontologies are defined as a formal conceptualization of a shared conceptualization". Studer et al [6] explained this as follows: "conceptualization refers to an abstract model of some phenomena in the world by having identified the relevant concepts of that phenomenon. Explicit means that the type of concepts used and the constraints on their use are explicitly defined. Formal refers to the fact that ontologies should be machine-readable. Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual but accepted by a group".

What are the main components of an ontology?

Knowledge in ontologies is mainly formalized using five kinds of components: classes, relations, functions, axioms and instances:

Classes in an ontology are usually organized in taxonomies. Classes or Concepts are used in a broad sense. A concept can be anything about which something is said, and therefore could also be the description of a task, function, action, strategy, reasoning process etc.

Relations represent a type of interaction between concepts of the domain. They are formally defined as any subset of a product of n sets, that is: R: C1 X C2 x … X Cn. Examples of binary relations include: subclass-of and connected-to.

Functions are a special case of relations in which the n-the element of the relationship is unique for the n-1 preceding elements. Formally functions are defined as F: C1 x C2 x … x Cn-1 → Cn. Examples of functions are Mother-of and Price-of-a-used-car that calculates the price depending on the car-model, manufacturing date and number of kilometers.

Axioms are used to model sentences that are always true. They may be used for defining the meaning of ontology components, defining constraints on the values of attributes, the arguments of relations, verifying the correctness of the information specified in the ontology or deducing new information.

Instances are used to represent specific elements.

Web Ontology Language (OWL)

OWL is a Web Ontology language. Where earlier languages have been used to develop tools and ontologies for specific user communities (particularly in the sciences and in company-specific e-commerce applications), they were not defined to be compatible with the architecture of the World Wide Web in general, and the Semantic Web in particular.

OWL uses both URIs[1] for naming and the description framework for the Web provided by RDF[2] to add capabilities to ontologies. See World Wide Web Consortium Semantic Web Activity[3] and OWL Web Ontology Language Overview[4].

3 The role of ontologies in digital storytelling

Schank (1990) [7] argues that stories are crucial to how we mentally represent the world around us. Memory can be thought of as containing two subsystems: a memory for concepts (which can be termed semantic memory) and a memory for stories (which can be termed episodic memory). Semantic memory can be thought as a conceptual map

Researchers in narratology distinguish between the fabula or collection of facts and knowledge about a narrative world, and the suzjet, or the presented order of the events, Slabbers (2006) [8]. Callaway and Lester (2002) [9] refer to the suzjet as the narrative stream. The fabula and the narrative stream are separable in the sense that one fabula can result in different stories by varying the order in which the events are told.

Human authors and computational models of narrative prose generation need a large amount of background information. This background knowledge is called by Callaway (2000) [10] the story ontology. The ontology contains simple facts such as "Trees have green leaves" and concepts of generic characters, generic events and generic objects. The fabula then consists of specific instances of these generic characters, events and objects. Finally the plot is a subset of the fabula; a particular ordered set of events in the fabula.

A good example for the distinction between fabula and suzjet is given by Wood (2005) [11] working on medical narratology. He reminds that in the Russian Formalists language, the medical students are bound to what they perceive to be the *fabula* of their patient's life, but they are not bound to the *suzjet* of the patient's narrative. Or in another terminology, they must be faithful to the story but not

---

[1] Cool URIs for the Semantic Web http://www.w3.org/TR/cooluris/
[2] RDF Primer W3C Recommendation February 2004 http://www.w3.org/TR/rdf-primer/
[3] World Wide Web Consortium Semantic Web Activity http://www.w3.org/2004/OWL/
[4] OWL Web Ontology Language Overview http://www.w3.org/TR/owl-features

necessarily the plot – Forster (2002) [12]. The story or *fabula* is the actual sequence of events as they occurred in time. The plot or *suzjet* is the logico-temporal arrangement of events by the narrator based on causality (Brooks, 1984) [13]. This constraint of the student (to the *fabula* and not the *suzjet*) is clearest in pediatrics or psychology where physicians necessarily discount parts of the patient's story and often even disagree with the narrative construction the patient offers. Of course, the only access to the *fabula* offered the student *is* the *suzjet* and its context. So the student creates a new *suzjet* from the patient's *suzjet*.

Swartjes and Theune (2006) [14] seek to make similar distinctions but more aimed at formalization. They cite Mieke Bal [15] that distinguishes between fabula, story and narrative text. The fabula consists of a series of logically and chronologically related events that are caused or experienced by characters in a story world. A story is a fabula that is looked from a certain angle. A narrative text is an expression of the story in language signs (e.g. words, pictures). Swartjes distinction is similar but more formal:

The fabula layer is an account of what happens in the story world and why. It is a causal network of all events that took place in the story world.

The plot layer is based on a relevant selection of the fabula layers that forms a consistent and coherent whole, adhering to an Aristotelian understanding of these concepts. One can say that many plots coexist within one fabula.

The presentation layer represents the information needed for the actual presentation of the plot in a certain medium.

Cavazza and Pizzi (2006) [16] reviewed theories issued from contemporary narratology that either identify fundamental concepts or derive formalisms for their implementation. They take an Interactive Storytelling perspective and discuss in particular the extent to which these theories can inspire IS technologies and highlight issues for the effective use of narratology. The theories discussed are those of based on Aristotle, Propp, Greimas, Barthes and Bremond.

4 Ontology based approaches to storytelling

A Virtual Environment for Story Generation

Uijlings (2006) [17] presents a model of a virtual world with two components: a specification of actions and an object ontology which enables the execution of these actions. This model (1) is completely formalised in logic, facilitating reasoning in general (2) gives elegant solutions to problems commonly encountered in dealing with time and action (3) provides a lot of narrative power with almost complete coverage of narrative interesting actions (4) is simple in terms of modeling complexity and computational reasoning demands (5) can be extended with various reusable story settings, reducing the work of constructing virtual worlds (6) allows the inclusion of narrative information usable in natural language generation.

For the simulation he decided to use a formal knowledge representation language in conjunction with mechanisms of change. He considered the respective advantages of CycL, KIF and OWL which is designed for sharing and reusing ontologies on the Semantic Web and chooses the later. In this work we have a clear working application of ontologies to the task of modeling the knowledge and generating stories.

Story Fountain

Mulholland, Collins and Zdrahal (2004) [18] describe Story Fountain, a suite of functions supporting investigation of topics requiring accumulation, association or induction of information across a story archive. It uses ontologies to describe the stories and the domain to which they relate. In the ontology a distinction is made between the story (what is told) and the narrative (how it is told). A narrative presents a story, and also has a presentation style and URI. A single story may have multiple narratives, for example for different audiences. Drawing on Chatham and others (see Schank, 1990) [19] a story has central actors (persons or groups), physical objects and a theme. A story also contains a number of events. An event has actors, a location, a specification of the time in which it happened, and additional properties depending on the type of the event.

This approach has been very productive and several applications in the area of education are now available [5][20][21]. A mature implementation of this approach is presented by the authors with the Bletchley Park Text application for post museum use of online resources. See: Mulholland, Collins and Zdrahal (2005) [22]. Bletchley Park Text allows visitors to express their interests by sending keywords via SMS during their visit. Later the visitor can access a set of stories (historical descriptions and first person accounts) related to their interests and a list of suggested follow-on topics.

DRAMMAR – Formal Encoding of Drama Ontology

Damiano, Lombardo and Pizzo (2005)[23], Damiano and Lombardo (2009) [24] present the DRAMMAR, a theory that abstracts from the procedural aspects of drama generation, and is intended as the starting point for specifying, implementing and evaluating practical storytelling systems in a principled way. A number of systems have been developed for the generation of dramatic content and narrative content, however, a formal characterization of the output generated by these systems is still lacking. DRAMMAR is a description of drama ontology as a first step towards s comprehensive formal system, including decision procedures for analyzing or generating drama.

DRAMMAR is structured into two levels. The action level models the intentional behavior of the characters in a plot by enforcing a BDI (Belief-Desire-Intention) perspective on characters as intelligent, goal-directed agents: following Bratman's theory of practical reasoning (Bratman, 1987)[25], BDI agents form goals to pursue

[5] Paul Mulholland http://people.kmi.open.ac.uk/paulm/

their desires, and, given their beliefs about the world, devise plans to achieve them. This level is augmented with a representation of emotions as provided by the OCC model (Ortony and Collins, 1988)[26]. The directional level accounts for the realization of a direction through the use of attributes that model the effect of plot incidents onto the characters' (i.e. agents') mental and emotional state.

Art-E-fact Ontology

Lamsfus et al. (2004) [27]describes a domain ontology developed to represent the associated knowledge and enable the description, exchange and sharing of multimedia added-value content for the creation of artistic expressions. It seeks to extend domain-specific aspects of CIDOC-CRM. CIDOC-CRM is a formal ontology intended to facilitate the integration, mediation and interchange of heterogeneous cultural heritage information; its scope is the curated knowledge of museums [28].

Artists can create a Mixed Reality exhibit by using the generic system to shape a specific instance of expression. They make choices of specific interaction devices and physical props to be used for anthropomorphic interactions, as well as corresponding interaction metaphors; they define dialogues with a degree of autonomy and behavior of virtual characters, and they create multimedia elements to be accessed during run-time. Lately an application has been developed which provides an extensible, ontology-based model of context that filters incoming tourism information based on the context of visitors [29].

GRIOT

Harrel (2006, 2007)[30] [31]has developed GRIOT whose purpose is to generate interactive multimedia events, and its main component is a novel algorithm called Alloy, which generates new conceptual structures by integrating other conceptual structures, based on recent research in cognitive linguistics, computer science, and semiotics; in particular.

An ontological application for archaeological narratives

Kilfeather and McAuley (2003) [32] describe their attempt to develop tools which would facilitate a meaningful story or narrative structure to be developed from existing or newly created contents. They used a customized annotation system to support the construction of personal or shared spaces. The aim was to allow authors to establish semantic relations between narrative resources and select and meld them together. The ontology was developed on the foundations of previous taxonomies and thesauri related to Irish archaeology.

MuseumFinland

Hyvonen et al (2004, 2006) [33][34] present one of the more comprehensive attempts to apply an ontology based, semantic web approach for the integration of Museum information. It enabled the integration the databases of three different museums with different relational database schemas, database systems and collection management systems. The end user is provided with a semantic search engine with two major services: (1) a semantic view-based search engine based on underlying concepts and ontologies instead of simple keywords. (2) a semantic recommendation system through which explicit and implicit semantic associations can be found and used for browsing the collections.

The search engine, OntoGator, is based on multi-facet search paradigm. Concepts or keywords are called categories and organized into a set of hierarchical orthogonal taxonomies e.g. taxonomy for artifact types – furniture, clothes, weapons etc. The taxonomies are called subject facets or views. A search is structured by selecting categories from different facets: Clothing from an Artifact facet; Cotton from the Material facet; and category 1800-1900 from a Time facet. The resulting query is a conjunctive constraint over the facets with disjunctive constraints over the sub-categories in each facet. The system turn up to be useful in many ways: Exact definitions; Terminological interoperability; Ontology sharing; Automatic content enrichment; Intelligent services.

Hyvonen et al (2004) [33] cites other systems that have explored the idea of annotating cultural artifacts in terms of multiple ontologies: Hollink et al. (2003) [35]; van den Berg (1995) [36] ICONCLASS ; the Art and Architecture Thesaurus (AAT) by Peterson (1994) [37]; and CIDOC/CRM by Doer (2003) [38]. The innovation of MuseumFinland lies in the capability of using RDF(S) ontologies and inference rules as basis of search.

A development of the MuseumFinland initiative is FinnONTO[6] whose purpose is to lay a foundation for a national metadata, ontology, ontology service, and linked data framework in Finland, and demonstrate its usefulness in practical applications. The Finnish national epic, Kalevala, has been modeled in RDF/OWL and published as part of the semantic portal CultureSampo [39]. A spinoff of FinnONTO, SUBI[7] [40] - Semantic ubiquitous services is focusing on mobile applications of this infrastructure.

Ontology driven access to museum information

Signore (2005) [41] argues that relying on a core ontology, web browsing can take advantage of the basic semantic web technologies (RDF, OWL) appropriately linking information according to the user preferred interaction metaphors, associating information on the basis of spatial, temporal, classification affinity. This can greatly improve the access to the information and knowledge stored in museums. For this purpose there is need of semantic annotation and a mental model and interests of the user.

A core ontology is one of the building blocks to information integration. Its goal is to provide both a global and extensible model into which the data originating from distinct sources can be mapped and integrated, and base concepts that future metadata

[6] Finnonto http://www.seco.tkk.fi/projects/finnonto
[7] SUBI Semantic ubiquitous services http://www.seco.tkk.fi/projects/subi/

initiatives could build on when developing domain specific vocabularies. CIDOC Conceptual Reference Model [42] represents ontology for cultural heritage information as it describes, in a formal language, the explicit and implicit concepts and relations underlying the documentation structure used for cultural heritage.

The user metal model can be expressed in terms of preferred interaction metaphors. A user interested in temporal Context will be interested in Classes like: E2 Temporal Entity - E52 Time-span, and their subclasses at various levels, like E3 Condition State, E4 Period, and E5 Event. The context can be expressed in a more precise way stating the properties the user is interested to navigate (e.g. P117 occurs during, P118 overlaps in time with, etc.) to build up the temporal interaction metaphor.

MakeBelieve

Liu and Singh (2002) [43] describe an interactive story generation agent that uses commonsense knowledge to generate short fictional texts from an initial seed story step supplied by the user. A subset of commonsense describing causality is selected from the ontology of the Open Mind Commonsense Knowledge Base [44]. Binary causal relations are extracted and stored as crude trans-frames. Fuzzy, creativity-driven inference over these frames produces creative "causal chains" that are used in story generation.

The Game Ontology Project (GOP)

The Game Ontology Project (GOP)[8] has been active since 2002 and currently is headed by Michael Mateas and Jose Zagal.

The GOP is a framework for describing, analyzing and studying games. It is a hierarchy of concepts abstracted from an analysis of many specific games. The approach is to develop a game ontology that identifies the important structural elements of games and the relationships between them, organizing them hierarchically. GOP provides a framework for exploring, dissecting and understanding the relationships between different game elements. Research questions include: How can we understand interactivity in games? How game play is regulated over the progress of a game? What roles does space play within games? Zagal (2010) [45] summarizes some of the results of these inquiries.

Narrative Control and Autonomy for Virtual Characters

Lockel, Pecourt and Pfleger (2005) [46] sought to combine multimodal dialogue systems and storytelling research to achieve immersive and believable interaction for human users in a virtual world with a narrative background. They used different components sharing the same ontological knowledge representation to supervise the narrative, deliberative and reactive aspects of character behavior. The main objective

[8] Game Ontology Project http://www.gameontology.org

is to keep the story going without destroying the perception that the user is dealing with characters acting by their own will.

The knowledge resources are modeled using an ontology containing all relevant concepts and their relationships: (1) Story World: a representation of the stages, characters and props populating the story, including the possible interactions between them, their roles etc. (2) Fictional mediation: data relevant for the control of the overall story structure and allows the author to model her desired story by instantiating concepts of the ontology. (3) Inter-Agent communication: concepts used for inter-agent communication and the representation of user contributions. This approach was later reviewed by Cavazza and Donikian (2007) [47].

A Fabula Model for Emergent Narrative

Swartjes and Theune (2006) [48] present a formal model of the fabula for representing the emergent event sequence in order to be able to exert influence on it and generate stories that "retell" the emergent narrative. They adapt the General Transition Network model developed by Trabasso and originally employed for the analysis of stories. The fabula ontology elements they define and implement in OWL are the following: Goal (G) – a desire to attain, maintain, leave or avoid certain states, activities or objects. Action (A) – a goal-driven, intentional world change brought about by a character. Outcome (O) - in this context it is a mental concept – when a characters believes that its Goal is fulfilled, the Goal has a positive outcome. Event (E) – any change in the world that is not the direct and planned result of any character action. Perception (P) – the explicit notion of Perception is important because the Character Agents do not necessarily perceived all that happens in the story world. Internal Elements (IE) – Anything that happens within a character, such as cognitions, emotions, feelings and beliefs. These are only the top elements of a more extensive subsumption hierarchy. They distinguish four types of causality that are used to connect the fabula elements: physical causality, psychological causality, motivation and enablement.

Using the formal fabula model in combination with a sophisticated Narration component the authors were able to generate stories that are more coherent than those generated in previous versions of the Virtual Storyteller. For

This work provided a substantial contribution for the development of the Emergent narrative approach for interactive storytelling in which stories result from local interactions of autonomous characters. For a description of a technique for emergent narrative that enables the characters to fill in the story world during the simulation when this is useful for the developing story see [49] and [50].

Acknowledgments. This work has been partially supported by the European Commission grant IST-034984 for the project MOSAICA Semantically Enhanced , Multifaceted Collaborative Access to Cultural Heritage http://www.mosaica-project.eu.

References

1. Brooks, P.: Reading for the plot: design and intention in narrative. Knopf, New York (1984) Cited by Ivo Swartjes, Whose story is it anyway, PhD Thesis, University of Twente 2010.
2. Nack, F.. The pathe tells a story. In: Roibas, A.C., Marcus, A., Sala, R. (eds.) Mobile TV: Customizing Content and Experience, Springer-Verlag, London (2009)
3. Corcho, O., Fernandez-Lopez, M., Perez A.G. Ontoweb Technical Roadmap v1.0. Deliverable D1.1 of the Project IST-2001-29243 Ontoweb (2001) Retrieved September 2010 from: http://www.deri.at/fileadmin/documents/deliverables/Ontoweb/D1.1.1.pdf
4. Gruber, T.R. (1993). A translation approach to portable ontology specifications. Knowledge Acquisition, V5. Cited in [3]
5. Borst, W.N. (1997). Construction of engineering ontologies. Centre for Telematica and Information Technology. University of Twente. Enschede, NL. Cited in [3]
6. Studer, R, V. Richard Benjamins,V,R., Dieter Fensel, D.. Knowledge Engineering: Principles and Methods. Data Knowl. Eng. 25, 1-2, 161-197 (1998)
7. Schank, R.C.. Tell me a story: a new look at the real and artificial memory. New York: McMillan (1990)
8. Slabbers, N.. Narration for Virtual Storytelling. Masters' Thesis, University of Twente (2006)
9. Callaway, C.B., Lester, J.C.. Narrative prose generator. Artificial Intelligence, 139, 2, 213-252 (2002).
10. Callaway, C.B.. Narrative prose generator. PhD Thesis, North Carolina State University (2000)
11. Wood, J.H.. Interventional Narratology: Form and Function of the Narrative Medical Write-up. M.A. Thesis Graduate School of Vanderbilt University (2005). Retrieved January 2007 from: http://etd.library.vanderbilt.edu/ETD-db/available/etd-01282005-100236/unrestricted/NarrativeMedicineThesis.doc
12. Forster, E.M. Story and Plot. In: Narrative Dynamics. Editor: Brian Richardson. Ohio State University Press, Columbus (2002)
13. Brooks, P.: Reading for the plot: design and intention in narrative. Knopf, New York (1984)
14. Swarthes, I., Theune, M.. A fabula model for emergent narrative. Proceedings of the conference Technologies for Interactive Digital Storytelling and Entertainment (TIDSE) 2006, Lectures Notes in Computer Science. Springer, Berlin Heidelberg (2006). Retrieved January 2007 from: http://www3.cs.utwente.nl/~swartjes/Files/Tidse06_swartjes.pdf
15. Bal, M. (1997). Narratology: Introduction to the theory of narrative. 2nd Edition. University of Toronto Press (1997)
16. Cavazza, M., Pizzi, D.. Narratology for Interactive Storytelling: A Critical Introduction. In Gobel,S. R. Malkewitz, R., Iurgel, I. (Eds.): TIDSE 2006, LNCS 4326, 72-83, Springer Verlag Berlin Heidelberg (2006)
17. Uijlings,J.R.R.. Designing a Virtual Environment for Story Generation. Masters' Thesis, University of Amsterdam (2006)
18. Mulholland, P., Collins, T., Zdrahal, Z.. Story Fountain: Intelligent support for story research and exploration. Proceedings of the 9th international conference on Intelligent user interfaces , Madeira, Portugal ACM Portal(2004). Retrieved September 2010 from: http://kmi.open.ac.uk/projects/cipher/iui-2004-mulholland.pdf
19. Schank, R.C.. Tell me a story: a new look at the real and artificial memory. New York: McMillan (1990)
20. Conole, G., Scanlon, E., Kerawalla, L., Mulholland, P., Anastopoulou, S. & Blake, C.. From design to narrative: the development of inquiry-based learning models. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications

2065-2074. Chesapeake, VA: AACE (2008) http://www.pi-project.ac.uk/publications/Inquiry_learning_models_edmedia_final.doc
21. Mulholland, P., Zdrahal, Z., Abrahamcik, J. and Wolff, A. .Intelligent support for inquiry learning from images: a learning scenario and tool. Artificial Intelligence in Education (AIED 2009), Brighton, UK. (2009) http://people.kmi.open.ac.uk/paulm/papers/aied-2009.pdf
22. Mulholland, P., Collins, T. and Zdrahal, Z). Bletchley Park Text: Using mobile and semantic web technologies to support the post-visit use of online museum resources. Journal of Interactive Media in Education (Portable Learning: Experiences with Mobile Devices. Special Issue, eds. A. Jones, A. Kukulska-Hulme and D. Mwanza) . (2005, http://jime.open.ac.uk/2005/24.
23. Damiano, R., Lombardo, V., Pizzo, A.. Formal Encoding of Drama Ontology. In: Subsol, G. (Ed.): VS 2005, LNCS 3805, 95-104, Springer Verlag, Berlin Heidelberg (2005)
24. Damiano, R., Lombardo, V. A unified approach for reconciling characters and story in the realm of agency, International Conference on Agents and Artificial Intelligence (ICAART), Porto, 19-21 January 2009, 430-437 (2009)
25. Bratman, M.E.. Intention, plans and practical reason. Harvard University Press, Cambridge MA (1987)
26. Ortony, G.C., Collins, A. The cognitive structure of emotions. Cambridge University Press . (1988)
27. Lamfus, C., Karagiannis, G., Sotorpoulou, S., Eskudero, H., Marcos, G., Linaza, M.T., Daniilia, S.). The art-E-fact ontology: a possible contribution to CIDOC-CRM. CIDOC/Sig Conference (2004). Retrieved January 2007 from http://www.vicomtech.es/publicaciones/CIDOC04_AEF_Ontology.pdf
28. CIDOC-CRM, http://www.cidoc-crm.org/
29. Lamsfus, C.,Alzua-Sorzabal, A., Martin, D., Salvador, Z. Semantic-Based Contextual Computing Support for Human Mobility. Information and Communication Technologies in Tourism, 16, 603-615 (2010) http://www.springerlink.com/content/p5472v4107075303/
30. Harrel, F.. Walking Blues Changes Undersea: Imaginative Narrative in Interactive Poetry Generation with the GRIOT System , in Proceedings of the AAAI 2006 Workshop on Computational Aesthetics: Artificial Intelligence Approaches to Happiness and Beauty, AAAI Press. (2006) http://icelab.lcc.gatech.edu/pps/Harrell-AAAI2006.pdf
31. Harrel, D.A.. Theory and Technology for Computational Narrative: An Approach to Generative and Interactive Narrative with Bases in Algebraic Semiotics and Cognitive Linguistics. PhD Dissertation, University of California, San Diego (2007) http://silver.skiles.gatech.edu/~dharrell3/pps/Harrell-Dissertation-Intro.pdf
32. Kilfeather, E., McAuley, J. An ontological application for archaeological narratives. Proceedings of the 14th International Workshop on Database and Expert Systems Applications (DEXA'03), IEEE (2003)
33. Hyvonen, E., Junnila, M., Kettula, S., Mäkelä, E., Saarela, S.,Salminen, M., Syreeni, A., Valo, A., Viljanen, K. et alFinnish Museums on the Semantic Web: The user's perspective on Museum Finland. Paper presented at the Museum and Web 2004 Conference . (2004) Retrieved January 2007 from: http://www.archimuse.com/mw2004/papers/hyvonen/hyvonen.html
34. Hyvönen, E. Towards a National Finnish Semantic Web Infrastructure for eCulture. Semantic Computing Research Group (SeCo) http:// www.seco.hut.fi. Presentation at the Symposium on Digital Semantic Content across Cultures, Paris, the Louvre , 4-5 May, 2006 Association Franco-finlandaise pour la Recherche Scientifique et Technique. (2006) http://www.seco.tkk.fi/events/2006/2006-05-04-websemantique/presentations/thursday-1140-Hyvonen.pdf

35. Hollink, L., A. Th. Schereiber, J. Wielemaker & B.J. Wielinga. Semantic annotations of image collections. In Proceedings of KCAP'03, Florida (2003)
36. van den Berg, J.. Subject retrieval in pictorial information systems. In Proceedings of the 18th International Congress of Historical Sciences, Montreal, Canada, 21–29 (1995)
37. Peterson, T. . Introduction to the Art and Architecture Thesaurus (1994) http://www.getty.edu/research/conducting_research/vocabularies/aat/.
38. Doerr, M.. The CIDOC CRM—An ontological approach to semantic interoperability of metadata. AI Magazine 24, 3, 75–92 (2003)
39. Hyvönen,E., Palonen, T., Takala, J. . Narrative Semantic Web - Case National Finnish Epic Kalevala. Poster Papers, the 7th Extended Semantic Web Conference, Heraklion, Greece (2010) http://www.seco.tkk.fi/publications/2010/hyvonen-et-al-narrative-sw-2010.pdf
40. Kauppinen, T., Paakkarinen, P., Mäkelä, E., Kuittinen, H., Väätäinen, J., Hyvönen, E.. Geospatio-temporal Semantic Web for Cultural Heritage. Digital Culture and E-Tourism: Technologies, Applications and Management Approaches, (2010) http://www.seco.tkk.fi/publications/2010/kauppinen-et-al-geospatio-temporal-2010.pdf
41. Signore, O. Ontology Driven Access to Museum Information. Paper presented at the CIDOC 2005 Annual Conference of the International Committee for Documentation of the International Council of Museums ICOM-CIDOC
May 24 – 27, 2005 Zagreb, Croatia. (2005) http://www.w3c.it/papers/cidoc2005.pdf
42. Crofts,N., Doerr, M., Gill, T., Stead, S., Stiff, M. (Editors). Definition of the CIDOC Conceptual Reference Model (2010)
http://www.cidoc-crm.org/docs/cidoc_crm_version_5.0.2.doc Official Release of the CIDOC CRM http://www.cidoc-crm.org/official_release_cidoc.html
43. Liu, H., Singh,P.. MAKEBELIEVE: Using Commonsense Knowledge to Generate Stories. In Proceedings of the 18th National Conference on Artificial Intelligence, AAAI 2002, AAAI Press , 957-958 (2002)
44. Common Sense Computing Initiative at the MIT Media Lab http://csc.media.mit.edu/papers
45. Zagal, J.P.. Ludoliteracy: Defining, Understanding, and Supporting Games Education", ETC Press, Pittsburgh (2010) http://www.ludoliteracy.com/ http://www.lulu.com/content/7968921
46. Lockelt, M., Pecourt, E., Pfleger, N. Balancing Narrative Control and Autonomy for Virtual Characters in a Game Scenarion. Proceedings of Intelligent technologies for interactive entertainment : first international conference, Intetain 2005, Madonna di Campiglio, Italy, November 30 - December 2, 2005 : Maybury, M., Stock, O., Wahlster, W. (Eds.) . (2005).: http://www.virtual-human.de/Vortraege/intetain.pdf
47. Cavazza, M., Donikian, S. (Eds.).Virtual Storytelling: Using Virtual Reality Technologies for Storytelling. ICVS 4th International Conference Proceedings, Springer (2007) http://tinyurl.com/virtualstory
48. Swartjes, I., Theune, M.. A Fabula Model for Emergent Narrative. Proceedings of the Third International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE 2006), 4-6 December 2006, Darmstadt, Germany. Lecture Notes in Computer Science 4326, 49-60 Springer-Verlag Berlin Heidelberg, (2006)
49. Swartjes, I., Kruizinga, E., Theune, M., Heylen, D..In Prendinger, H., Lester, J.C., Ishizuka, M. (Eds.): Intelligent Virtual Agents, IVA 2008, 8th International Conference, Tokyo, Japan, September 1-3, 2008. Proceedings Lecture Notes in Computer Science 5208, Springer (2008).
50. Swartjes, I.. Whose story is it anyway? How Improv informs agency and authorship of emergent narrative. PhD Thesis, University of Twente (2010). http://www.vf.utwente.nl/~swartjes/dissertation/