# The Evolution of Interpretive Contexts in Stories

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**Abstract**

Modeling the effect of context on interpretation, for the purposes of building intelligent systems, has been a long-standing problem: qualities of logic can restrict accurate contextual interpretation, even when there is only one context to consider. Stories offer a range of structures that could extend formal theories of context, indicating how arrays of inferred contexts are able to knit together, making an ontological reference that is specific to the particular set of circumstances embodied in the tale. This *derived ontology* shifts as the text unfolds, enabling constant revision and the emergence of unexpected meanings. The described approach employs dynamic knowledge representation techniques to model how these structures are built and changed. Two new operators have been designed for this purpose: *governance* and *causal conceptual agents*. As an example, a few lines from the story *Red Riding Hood As a Dictator Would Tell It* are used to demonstrate how a story interpretive framework can be continually re-made, in a way that produces unexpected interpretations of terms.

**1998 ACM Subject Classification** 1.2.7 Natural Language Processing, Discourse

**Keywords and phrases** Story dynamism, contextual interpretation, ontological interoperability, retroactive revision, narrative progression in discourse processes, derived ontology, situation theory, integrating multiple inferences

**Digital Object Identifier** 10.4230/OASIcs.CMN.2015.23

## 1 Narrative and Formal Models of Context

### 1.1 Introduction

It is difficult for humans to make accurate interpretations across changing contexts, let alone for machines to do so. Bruner observes that for logic, the "world remains invariant" [4, p. 50], and Devlin explains how logical qualities can restrict accurate contextual interpretation, even when there is only one context to consider [11]. This research examines how the structures of stories enable multiple contexts to be managed, proposing two mechanisms (*governance* and *causal conceptual agency*) to account for key aspects of the process. Systematic diagrams represent the formal model [8] and display the mechanisms in animated form [7]. In this paper, a few pivotal frames are provided to indicate their characteristics.

The original aim of this work was to inform the design of a computerized system for intelligence analysis, that captured the way subjective (non-logical) perspectives evolve as they influence each other, rather than how explicit facts add up [6]. Progress has been made towards that system, which is still in development. Its formalisms are not covered here, except to allude to the general mathematical choices made. Instead this paper presents a model of some of the cognitive semantic dynamisms involved in understanding real-world fiction. A companion paper reports on details of the implementation [15].

At the core of this paper are two mechanisms designed for that project: *governance* and *causal conceptual agency*. These operators sit within a description of conceptual integration

6th Workshop on Computational Models of Narrative (CMN'15).
Editors: Mark A. Finlayson, Ben Miller, Antonio Lieto, and Remi Ronfard; pp. 23–38

OpenAccess Series in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

that is philosophically similar to established approaches in Discourse Processes, such as Kintsch's Construction-Integration Model, in which top-down and bottom-up inferences negotiate [29]. Like that work, this model assumes that the text constrains and informs the memory-based inferences that support reasoning about it. However, this approach departs from previous models in that it is drawn from the issues concerning the composition of compelling fiction. It began with a fiction writer's question: how does a reader anticipate the end of a story she or he cannot predict?

In order to render this artistic concern in the very different field of knowledge representation, a survey of approaches was made, to identify gaps in current models of conceptual structure [8]. Within that domain, the focus was ontological interoperability, which has some known, long-standing problems [40]. One of these issues is directly relevant to the phenomenon of interest: it is difficult to design a system that can automatically bridge incompatible conceptual networks, such as the kind that exist in different knowledge bases. One ontology cannot evolve into another, so that non-logical structures emerge that seem like a natural evolution. I use this problem to frame how stories enable progressive reasoning in ways that differ from current formal models of contextual interpretation.

To clarify this phenomenon, consider the title and first lines of the following story:

> *Red Riding Hood as a Dictator Would Tell It*
> Once upon a time, there was a poor, weak wolf. It was gentle and kindly and had a heart of gold [49, p. 230].

Reading from the first phrase, *Red Riding Hood*, to the last phrase *heart of gold*, the reader is led through several different states of expectation regarding themes and events: from a fairytale scenario, to the anticipation of humor and irony mixed with that fairytale scenario (when addition of the dictator is mentioned), and then to the unexpected focus on the wolf with gentle qualities. In order to maintain sense as these expectations shift, some conceptual structures remain stable while others alter. How does this dynamism occur? This paper will outline the way conceptual structure can be built, integrated and revised through mechanisms central to fiction writing.

The resulting model is represented using animations that use conventions of knowledge representation, and extended with approaches such as those of Fauconnier and Turner [13], and Holyoak and Thagard [24] to include dynamism. An animated version of this example can be found online [7]. Figure 1 is a screenshot from this animation, which depicts some of the inferences involved in interpreting the example.

As an introduction, simply notice the bands running across the frame of Figure 2; there are two groups: those at the top, which represent general knowledge structures, and those at the bottom, which represent new, emerging interpretive structure. Connections are woven between them as the text progresses. *Governance*, a new operator, is one of the facilitators of this movement. In Figure 1, a governing node is indicated by the color blue, with lines indicating the direction of effect. *Causal concept agents* are collected in the third situation band from the bottom, fulfilling criteria that will be described in a moment. These new features record the stages of the shift from the general (top) to the specific (bottom), where the new derived ontology is built and changed.

A story's ability to adjust its own frame of reference could offer fresh insight into managing conceptual conflict in systems such as knowledge bases. It could also address the "significant gap" in research on narrative inference identified by Arthur Graesser, who asks "how does the point of a story systematically emerge from the configuration of important goals, actions, obstacles, conflicts, and resolutions expressed in the plot?" [16, p. 239]. This paper proposes that part of the answer can be found in the mechanisms used by a story to handle incompatible

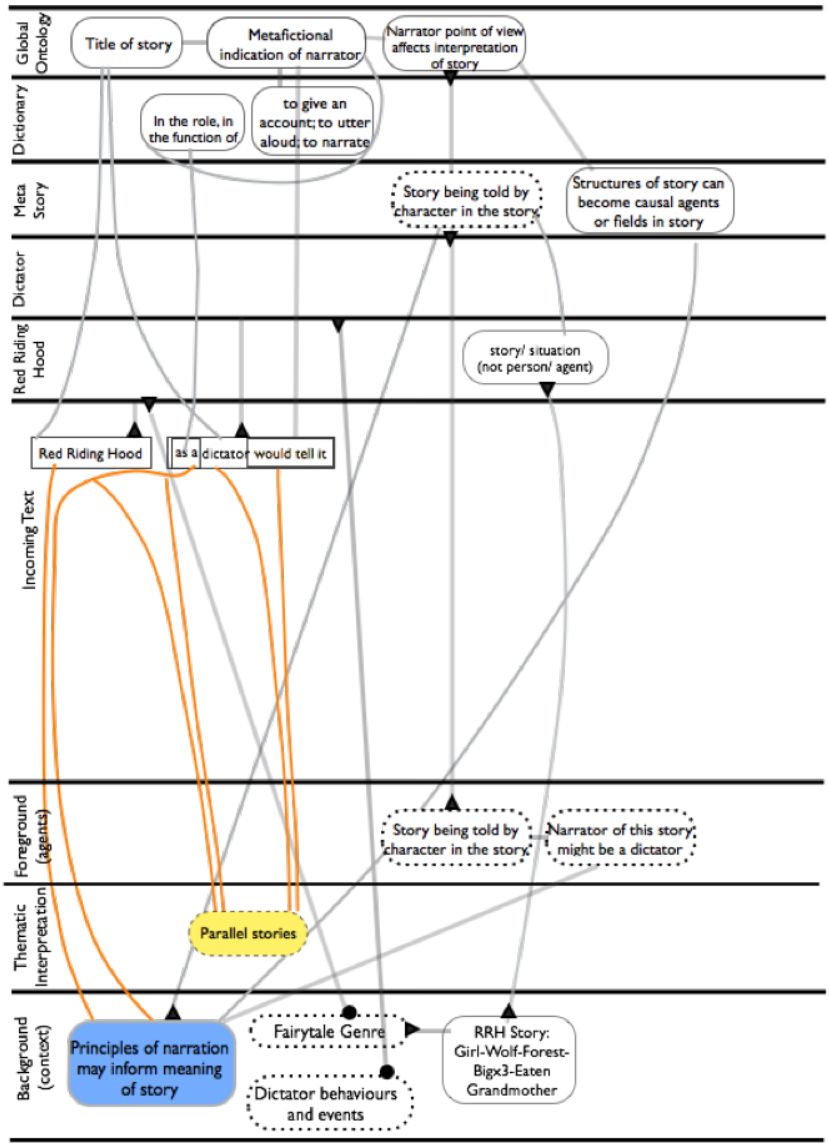


**Figure 1** Conceptual structure built by the title of *Red Riding Hood as a Dictator Would Tell It* weaves aspects of general inferences (top) into a new, derived interpretive structure (bottom).

conceptual structures. It will indicate how new referential structure is progressively derived, enabling changes in the interpretation of the terms it supports. Sowa states that a dynamic notion of ontology such as this is needed, to reflect the way the meaning of a word "is unstable and dynamically evolving as it is used in different contexts" [41, p. 245]. This work models some of the structures used by a story to achieve this.

## 2 Composing the Problem

### 2.1 Ontology in knowledge bases and stories

The first departure from current literature is the units considered to be fundamental to stories. Formal analyses of narrative often revolve around events and characters in the storyworld

[46, 35, 23], and while these aspects are important, and can be entailed in the abstractions I use, they are not the focus. Instead, this work concerns how stories build and transform the *conceptual structure* used to make inferences during its own interpretation. I refer to this framework as a *derived ontology* [15].

A *derived ontology* is the story's reference framework, one that contains the operating parameters of the story itself, including causal information that enables a reader to understand not only what is happening, but *what can happen*. It includes but goes beyond the notions of *suyet* or *discours* [26], because it entails non-explicit inferences along with the explicit textual devices, and zooms into the granularity of how such structure is built and changed at a conceptual level, so some ideas are deliberately rendered as more important than others. The term *derived ontology* captures these qualities and also indicates fundamental similarities with the computer science notion of ontology. The two instances differ in a few important ways, however.

The term *ontology* was first used in philosophy by Aristotle to refer to the study of being [34, p. 3], and has since been adapted to serve computer science. Here, an ontology is a frame of reference that accounts for a certain view of the world [34, p. 3], and this is also my definition in relation to stories. In both cases, an ontology provides the reference framework used to define terms, similar to a built-in dictionary. It is a "systematic account" of the entities assumed to exist in a domain of interest, as well as the relationships between them [19]. Both stories and knowledge bases can be seen as interpretive machines, in the sense that each relies on an ontology (or something like it) to churn out interpretation. In both stories and knowledge base design, ontology is the reference framework used to make accurate interpretations.

These similarities can lead to confusion regarding the differences. The first distinction concerns generality versus specificity. In computer science, even though an ontology can manifest in a range of different forms [38, p. vi], the common denominator is that it is a static corpus of general reference terms, which have a formal expression [37, p. 61][38, p. vi]. The more this kind of ontology is tailored to a particular domain, the less compatible it will be with those in other systems, a quality termed *heterogeneous* [1, p. 190],[48, p. 164]. In practical terms, this makes a formal ontology similar to a context, because the more specific it is, the more it will be limited to that particular circumstance, and its information less easy to preserve as it is carried to other instances. For this reason, the terms in formal ontologies are chosen to have as "much generality as possible to ensure reusability" [38, p. v]. In this work, systems such as this are thus referred to as a *general ontologies*.

A story does use general references such as this, but then goes further. It draws on numerous general references, and then manipulates elements from them, adding structure until the resulting interpretive framework is unique to the tale. This is a novel contribution of this research: identifying the way that stories construct a new, refined reference situation.

Interestingly, the new derived reference will contain some non-logical structure that does not exist in its sources. To a reader of narrative, these concepts might seem *unexpected* and be less easy to predict [4, p. 12]. There are numerous ways the notion *unexpected* can be defined, it is framed here in relation to paradigms of general assumed knowledge, such as that found in a general ontology. An unexpected conceptual structure is one that is incompatible with commonly known assumption: the sort of structure embodied in a general ontology. The importance of such digression in narrative has been noted across Narratology [23, 3], Discourse Processes [47], and Narrative Psychology [5, 44]. My definition of unexpected includes the way a breach in assumed knowledge can be disruptive, in the manner of Kuhn's "anomaly" which provokes transformation of scientific paradigms [30, p. 6].

Such breach is significant due to the different way systems of logic and story handle anomalous information. In prescriptive logical systems, problems arise when general ontologies encounter unexpected information, and these are so common that a number of approaches have emerged to address them [32]. Most involve some sort of standardisation of terms to eliminate conflict between conceptual structures [38, p. 5]. John Sowa states, "Any incompleteness, distortions, or restrictions in the framework of categories must inevitably omit the generality of every program or database that uses those categories" [40, p. 51]. However, such limits and distortions are an integral aspect of a story's ability to make sense, and then re-make that sense differently.

Stories can handle unexpected information due to mechanisms that manage the barriers of *context*. A *context* is defined as a limited characterization of reality, which is specific to the peculiarities of a particular circumstance, and contains elements that could not be found easily in other situations. It is information that "is embedded in a specific domain or situation" [39, p. 51], in such a way that information from outside that context might be anomalous. Due to our use of Keith Devlin's formal system, *Layered Formalism and Zooming (LFZ)* [11], we refer to a context as a *situation* when it takes the form of a discrete conceptual structure. This kind of *situation* has features in common with a heterogeneous ontology, in that its limits can make it difficult to preserve information when it is transferred. In knowledge base design, this can cause problems when different systems try to interact. This is usually addressed through the creation of a large, comprehensive ontology in which all reference frameworks can be situated [32] or the standardization of divergent conceptual structure so that it does not lead to "inconsistent interpretations and uses of knowledge" [20, pp. 381-382]. By contrast, stories leverage such inconsistencies to emulate the flux of the open, real world. Rather than being supported by a single general ontology, or eliminating incompatible ideas, a story's reference framework enables numerous, limited and diverse conceptual networks to temporarily agree, before changing to accommodate the next chunk of text.

A final area of potential confusion between ontology in the two fields concerns their relationship to logic. In computer-orientated methods, the semantic aspect of the ontology is usually managed by logical rules [40, p. 12], [22, p.30]. In the fictional instance, semantics are structured according to the associative priorities of the story. This structure might contain logical elements, but will also contain many that are not – as Bruner notes, story and logical structures are different modes of thought, "irreducible to one another" [4, p. 11]. When text is interpreted in computer science, the semantic and logical aspects of an ontology are usually the same entity, whereas my model separates them. In the design of a knowledge base, a possible way to handle this would be to build three levels: 1) the semantics of the story ontology, which is structured according to the relations expressed by the story and its reference frameworks; 2) the constructive processes that underpin formation of the story ontology; 3) the logical formalisms that make it computational [15]. Only the first two levels are explored here.

## 3 Supporting Literature

Modeling contextual inference in unfolding narrative involves several fields, so the supporting literature was drawn from a range of research areas. The following emerged as pertinent: narratological studies on the progressive effects of an unfolding story [44, 27], theories of narrative inference [18, 45, 17], theories of context interpretation and inference [2, 36, 11], current approaches to conceptual integration in knowledge systems [41, 1, 32], and formalisms

that concern the representation of narrative conceptual structure [24, 13], as well as their transformation [42, 30]. Of these, a few theories were fundamental to this research.

Foremost was the work of Keith Devlin, whose development of situation theory provided a philosophical foundation and a possible formal framework for its realization. His extension of situation theory, *Layered Formalism and Zooming* (LFZ), is a formal means of expressing the limits of context and the transfer information between them [10]. Devlin's work was extended by our collaborator Goranson to include the narrative properties described here [15]. Devlin's foundations allows for more robust formal methods to be employed in this work.

Discourse Processes was also important, to show how specifics at the perceptive level trigger and restrict generic knowledge inferences [29, p. 125]. Like Kintsch's Construction Integration (CI) model, this work describes continuous conceptual retrieval and adjustment, where only a few nodes actively contribute to the meaning of a node, yet can be easily expanded due to a persistent connection with larger memory structures [28, p. 74]. Although memory and explanation-based processes [21] could both be read into this work, my abstractions are different, so forms of retrieval such as this will manifest and be triggered in relation to different factors. The key difference is ontological conflict; when these models account for contradictions in text [21, p. 244][28, p. 181], they are referring to factual inconsistencies rather than shifts in fundamental definitions of terms. Due to this, and the narrative mechanisms needed to manage it, my expression of these processes differs.

This approach also diverges from Narratology, which usually considers events and characters to be the main features [43, 27, 35, 46]. Michael Toolan examines how text can retroactively attribute importance to particular events, making them cohere in ways that were "unforeseen but foreseeable" [43, p. 215]. In a more formal approach that also focuses on events, Tom Trabasso diagrams the causal dependence of actions in narrative [46, 33], and collaborates with Graesser to consider the forms of inference that produce them [17]. In these cases, the focus on events and activities in the storyworld overlooks a key feature of unfolding narrative: the way the incremental nature of reading can radically change the interpretation of its terms. Cognitive scientist Paul Thagard has argued that further attention to progressive revision is needed to explain "why some revisions are harder to make than others and why some revisions have more global effects" [42, p. 20]. Thagard's diagrams of conceptual change thus provided insights about how contexts evolve [42].

To capture the finer operations of story inference, this approach also draws from Fauconnier and Turner's models of conceptual blending, in which one analogical space supplies conceptual structure, while another is projected into it, making its structures interpretively dominant [13, p. 321]. Fauconnier and Turner do not model the dynamics in the case of an unfolding narrative, however. This means their analogical structure can rest on a fixed general ontology, and the modifications of one situation towards another can be accounted for switching complementary nodes on and off [13, p. 321], rather than the imposition of one structure onto another, so that new structures are formed.

From this survey, several properties of inference in stories emerged as being potentially useful additions to computational models.

## 4 A Model of Contextual Reinterpretation

Several new mechanisms enable the integration and shift of multiple contexts. Following is an overview of that process, along with a summary of its taxonomic elements.

As a story unfolds, it provokes:

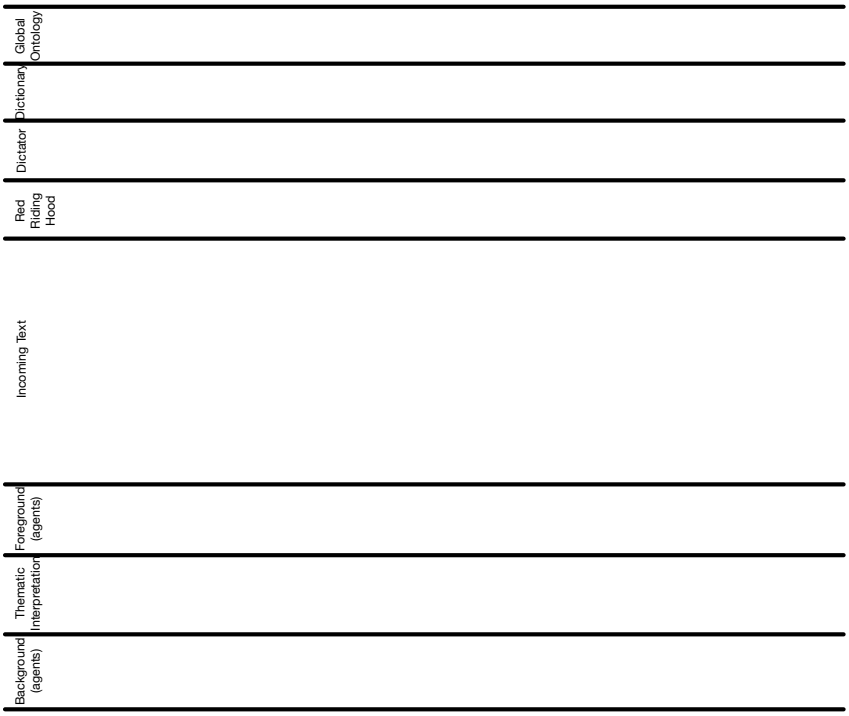


**Figure 2** Example of layout, with general and interpretive situations grouped together.

1. **Multiple, limited inferences** which each exhibit properties of context that can make their structures incompatible. These inferences can be connected by
2. **Causal Conceptual Agents**, which contain new structure capable of bridging incompatible inferences. Those new relationships are recorded in a
3. **Meta-situation**, in which the ontological structures supporting the various inferences are organized in relation to each other: an ontology of ontologies. This arrangement follows relationships of
4. **Governance**, which enables situations to impose their structures on each other to modify the terms of one network towards another. Altogether, this produces a new reference framework.

Together, these structures form a derived ontology. A summary of the graphical method follows.

In Figure 2, bands are grouped at the top and bottom of the diagram. These are all situations, but the two groups do not perform the same role. Their division represents complementary aspects of interpretation: at the top are situations drawn from general ontologies (the Ontology Space), while at the bottom, the agent network is recorded (the Interpretation Space). The incoming text of the story appears across the middle, so that operators can easily weave structure outwards from it, across the two domains.

The following operators build structure over this framework:

| Name / Function | Representation | Graphic |
|---|---|---|
| Incoming Text Token | Rectangular box with incoming text inside | Red Riding Hood |
| Node | Rounded box with concepts inside | Title of story |
| Link | Line | |
| Situation | Encircling box | |
| Pusher | Hammer shape | |
| Puller | Suction shape | |
| Funnel | Open V shape | |
| Dot | Dot | |
| Dot (suspended situation) | Dot with white center | |
| Wedge | Black triangle, pointing in direction of connection | |

Of these taxonomic items, the first three (**Incoming Text Token**, **Nodes**, **Links**) are common to conventional methods of knowledge representation. The next three operators (**Situation**, **Pusher**, **Puller**) are new, and capture the behavior of conceptual situations. The first is an encircling box that groups entities to show how their combined structure operates as a single functional unit. The pusher and puller depict the dynamic extraction of subset reference situations.

The **Funnel** instigates change, and as such, is the central structure-building device in this model. In terms of narrative apprehension, it represents an associative connection between actual text and the inferences it provokes. In the graphical depiction, it behaves like a moving arrow, drawing a link between any two objects and creating an attachment between them. Contact with a funnel can change the position and arrangement of concepts, leaving behind an association between the areas of transference. That persistent connection is demonstrated by a grey line. Dots and wedges are superficial indicators that make it easier to decipher the graphical depictions. Dots show where a line starts and ends, like an anchor. Wedges show the direction in which a connection is made, if it is difficult to discern.

There are also eight key states. A *state* indicates what sort of influence a taxonomic element has over its surrounding objects. In order to record the simultaneous development of many elements, states are represented by colors, and can apply to all graphical objects. The colors are not intrinsic to the process being represented, but the differentiation between kinds of activity is important. The states are:

- Neutral (white)
- Suspended (encircled by a dotted line)
- Persistent (grey)
- Activation (light yellow)
- Association-Forming (orange)
- Conflict (red)
- Transformative (purple)
- Governing (blue)

*Neutral* (black on white) indicates that the object exists. A dotted black line indicates *suspension*, which means the object *tentatively* exists. A node is registered as tentative when an inference is made that could be salient, but is not yet confirmed (*suspension* is another novel feature). Grey signifies that an object has been built and is now inactive but *persistent*. Yellow signals the *activation* of an existing object. Orange can *associate* objects. Red indicates a *conflict* between associations. At the far end of the spectrum, purple signifies the *resolution* of conflict, while blue indicates *governance*. Both can modify existing structures.

This architecture was used to map the title and first lines of the story *Red Riding Hood as a Dictator Would Tell It* [49] (see above for these lines of text). The story is narrated from the perspective of a sensitive wolf that complains about being persecuted by a girl and her grandmother [49, p. 230]. He explains that one day he wandered into the old lady"s home and was so startled by her that he was forced to eat her. The full story can be found in *The Trials and Tribulations of Little Red Riding Hood* [49]. The animated analysis of these lines can be found online [7].

## 4.1 Multiple, limited inferences

My example begins when the title *Red Riding Hood as a Dictator Would Tell It* is apprehended. In discourse process models, comprehension begins with a trigger that calls up memory structures [21]; here, such information is drawn from a form of general cultural memory instead. The distinction reflects the phenomenon of interest: part of the skill of professional writing is to judge which inferences can reasonably be assumed of any reader, based on what sort of information is generally known, and what is not. This general knowledge is akin to Arthur Graesser's "generic knowledge structures" [17], and is also similar to the artificial intelligence notion of "common ground"[9, p. 320], where the assumed shared knowledge is the kind a writer can expect of fiction readers they have never met: an example is the kind of information contained in Wikipedia. For ease of reference, that assumed mass audience is referred to as the *reader*, and the shared general cultural memory is collected in the *global ontology*.

In knowledge base design, commonly known examples that might populate the *global ontology* could include *Cyc, WordNet* [40, p. 412] or the coming standard that will enable the *semantic web* [25, pp. 58-59]. Whether for humans, my model, or a computer implementation, this is only the starting point of interpretation, the place from which most foundational reference situations are drawn. Graphically, I depict this collection as a single situation band, running across the top of the frame.

When the first phrase is apprehended, "Red Riding Hood", an inferred cluster of terms associated with the fairytale *Red Riding Hood* is extracted from the *global ontology*. A phrase such as this only activates a limited selection of terms from a general reference framework - this was observed by Kintsch [28, p. 74]. Graesser has referred to a partial inference such as this as a subset of generic knowledge [17, p. 374], and I develop the idea further, to emphasize its properties of context. For example, *Red Riding Hood* is supported by limited conceptual networks regarding the fairytale, and few others. The notion of *dictator* is supported by a few inferences regarding political control and self-aggrandisement. If the supporting ontologies of these terms do not accommodate each other, it might be difficult to relate them on any level. The story will show how they can be linked in this particular circumstance, by adding new structure.

In the graphical example, the extraction of a subset situation occurs when a situation band titled "Red Riding Hood" is pulled out of the global ontology and its dictionary, and

rests beneath them, to serve as the first point of reference for further text. The dictionary provides simple dictionary definitions for individual words, whereas the global ontology provides higher-level common knowledge, such as the associations commonly related to the phrase "Red Riding Hood". The subset titled "Red Riding Hood" is now characterized in terms of the network of terms it contains (I refer to this overall characterization as a *scope*). In this case, the *scope* concerns the fairytale *Red Riding Hood*. The graphical node bears this title, standing in for the terms related to it.

When the term "dictator", is apprehended, it is tested against the "Red Riding Hood" situation, and no exact match of terms are found. Another subset must be extracted from the *global ontology*, to support it. Finally, with the phrase "would tell it", a third round of inferencing is provoked. This time, a subset that supports the meta-fictional idea of a "narrator" is extracted. In Figure 1, these subset inferences are depicted as three situation bands, each layered under the next.

When the "Meta Story" situation becomes activated, possible connections become available between the Red Riding Hood and Dictator inferences. Nefarious qualities of the dictator might connect with the role of narrator, after more information is gathered. Perhaps the fairytale plot will feature events from World War II. The focus of this story, both explicitly and implicitly, concerns the bridging of two incompatible situations, but more information is needed to understand how. To confirm which elements will be used and connected, another feature is needed: conceptual agents.

## 4.2 Causal conceptual agents

Causality is famously difficult to quantify, and the survey of causal philosophy conducted in relation to agency in narrative is covered elsewhere (see [8]). From that literature, Einhorn and Hogarth's *Judging Probable Cause* was foundational, for the way it describes how causal agency emerges in relation to a contextual field of reference [12, p. 5]. In narrative-related theory, it is common to conceive of agents as characters, and causality as a counterfactual dependence of actions or events (see literature review, above, especially [46]). However, in this work, agency occurs in the context of differing ontological structures. The focus is therefore an aspect of causality more salient to poetics: where causality in story is not a chain of dependence, but a domain of transitions that fit. In this framework, agency is conceptual structure that is able to act on one ontological structure so that it turns into another.

Einhorn and Hogarth's description of causal agency is embodied in two parameters: *Foreground (causal agents)* and *Background (causal fields)*. These characteristics replaced the single focal situation in Devlin's formal model of contextual interpretation, *LFZ*, which provided a logical foundation for the formal expression of this work. Graphically, these parameters are represented as horizontal situation bands that run along the bottom of the page (Figure 2). The ***foreground*** band contains nodes that have been identified as conceptual agents, because they exhibit new linking structure. A graphical example in Figure 1, above, would be the node "Narrator might be a dictator". The central band in this cluster, ***thematic interpretation***, records the most dominant of these, to indicate the overall themes of the story. The bottom-most situation band, ***background***, is composed of nodes that stand in for each inferred reference situation. I refer to these as ambassadors, which will be discussed in the next section.

Agents emerge from the field by virtue of their novel structure (that is, novel compared with what already exists in the reference situations). Their degree of agency is determined by their novelty, as well as how much conceptual structure they are able to link. For example, when the "Meta Story" situation is applied to the whole field, the "Red Riding Hood" and

"Dictator" subsets are cast as separate yet "parallel" situations, ones that will be compared as part of the storytelling. This parallel quality is indicated by the text, with the linking phrase "as a ... would tell it" but does not exist in any of the subset reference ontologies in isolation. The notion has been derived in relation to their combination. In this case, the node "parallel stories" is an agent because it connects all three subset situations with structure that is novel (compared with what exists in the subset reference situations).

In the implementation, new and transformative structure is informed by Michael Leyton's work on geometric transformation, which illustrates how the evolving topological structures can indicate causal connection [31, p. 3]. When represented as a conceptual network, an ontology endows a story's semantic perspective with structure. When the system searches for structure that will enable transitions between incompatible conceptual structures, it will use semantically-guided topologies to reason about it [14]. Logically, this is expressed as a two-sorted logic, where the second sort uses categoric arrows to reason over situations. This allows semantic-free representation of situations, including those whose explicit facts are unknown.

Causal conceptual agents emerge in relation to the background context being established by the text. In order to examine how that background is composed, let us turn to the *meta-situation*.

## 4.3 The *Background*: contextualizing contexts

The meta-situation is like an orrery, in the sense that its tokens stand in for a more complex system. Here, in microcosm, relationships between general reference frameworks are built and changed. This miniature is established through gradual honing: general reference frameworks become subsets, which in turn are abstracted as individual nodes, which I refer to as *ambassadors*. Ambassador nodes contain only the most essential elements of the sources from which they were drawn, and are arranged in the meta-situation. Kitsch remarks on the way activated nodes concern only the few elements of general knowledge that are relevant [28, p. 74]; this idea goes further to note how these fragments are positioned in relation to each other by the story. As the text progresses, these tokens are manipulated to reflect the structural priorities of the tale. They carry the relevant aspects of their sources, but have the advantage of being composed of limited conceptual networks, rather than massive general ontologies (although they remain persistently connected to each other), and so are easier to manipulate and modify.

The arrangement of ambassadors, in the form of a meta-situation, serves as an ongoing reference for the incoming text. Agency is relative to a causal field [12, p. 6], and the meta-situation serves as that field. It informs and situates the emerging agents. In implementation, the system will identify nodes as ambassadors for the *Background* situation band if they represent a subset of a reference situation but contain no new structure. Their purpose is to record how the text is building relationships between the reference situations, including which are dominant (dominance will be discussed in a moment). Due to the way the meta-situation shifts as the text progresses, it enables the same word to be interpreted differently as the story unfolds.

Consider the interpretation of "wolf" that would be inferred at different stages of the example story. By itself, the word wolf might be defined as a wild woodland creature with some doglike qualities, and a system using a single ontology would then use this definition as the basis of a composition of facts. In narrative, when the first phrase of the title is parsed, "Red Riding Hood" a quick contextualization occurs: any wolf mentioned at this point would be subject to the terms of the "Red Riding Hood" situation, which would produce the

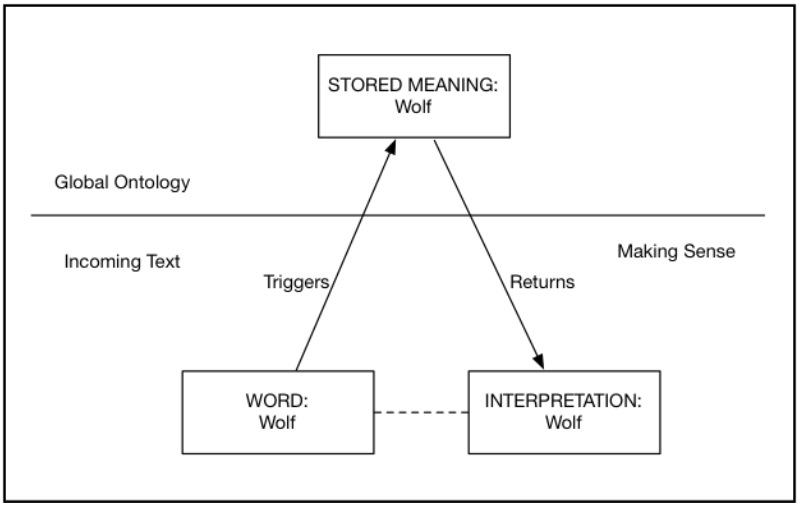


**Figure 3** Looking up a word when a single general ontology is the reference.

definition that the wolf is a predatorial character who plans to eat a little girl, perhaps with sexual menace. Below are two illustrations by a collaborator to contrast two different ways "wolf" can be interpreted in this situation [14]. Figure 3 shows the look up when there is a single ontology. Figure shows how the subset situation *Red Riding Hood* could impose its structure to create a more nuanced definition of wolf.

In Figure 3, the definition of 'wolf' is always the same; Figure 4 shows a system in which the terms used to interpret a word can shift with every subset added. The second instance reflects this research, to imitate the way story comprehension can involve many subsets, acting simultaneously.

In *Red Riding Hood as a Dictator Would Tell It*, the nuance does not stop there. The newly defined fairytale 'wolf' is then redefined by the dictator's situation, so that it becomes a character in a story (with predatorial menace) which is of interest to a dictator. By the end of the sentence "It was gentle and kindly and had a heart of gold" [49], the wolf is a dictator, who is narrating the story, and endowed with the dictatorly quality of perverting the truth.

The meta-situation makes co-operation between inferences possible because it records the relationship between them. The variety of means by which this occurs is a large topic of enquiry in itself, and is the subject of ongoing investigation. The basic foundation includes the dynamic that when situations relate to each other, they follow properties of governance.

## 4.4 Governance

The term *governance* refers to a form of structural imposition. As many inferred situations might compete to have their structures used by the story, a method is needed to designate which take priority; governance fulfills this role. But it is not simply a prioritization method. It also accounts for the adjustments that conceptual structures can perform on each other, modifying conceptual structures so they can connect. In the graphical method, governance is indicated by the color blue (see Figure 1). When one node governs another, the governing node flashes blue and connects to it, and its effect is recorded in the addition or alteration of structure.

Governance can operate at a range of degrees. Its most far-reaching form is demonstrated by the final version of the derived ontology. When a story reaches its end, the final version of

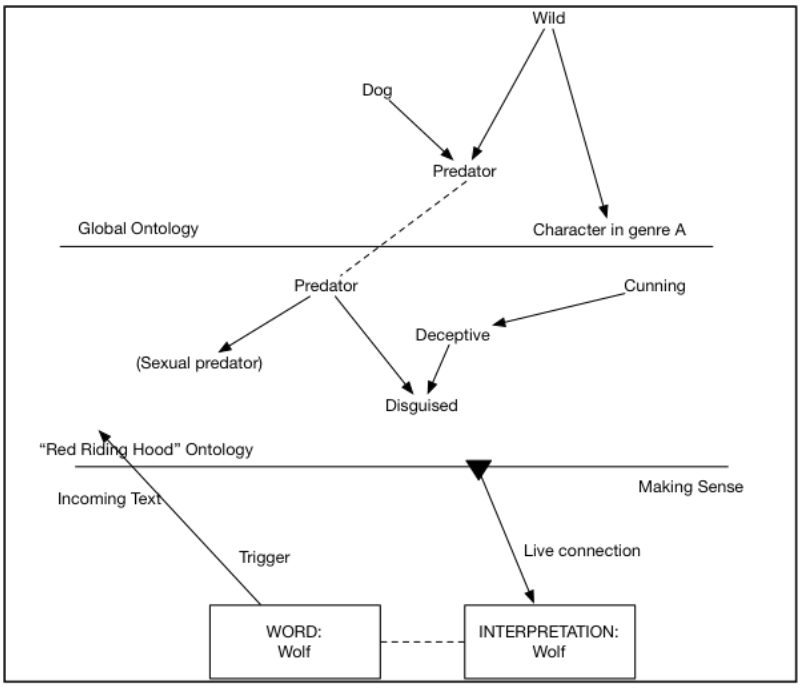


**Figure 4** Looking up wolf when each subset reference has different parameters.

the derived ontology acts on the entire tale, retroactively imparting its associative priorities on all previous structures. This can result in major, meaning-altering revisions of the entire network.

In its most local form, governance can act through an individual word, such as the way "wolf" can be considered in relation to the phrase "there was a poor, weak wolf." Here, the words "poor" and "weak" are interpreted on the terms of the governing word, "wolf". Their associative range thus conforms to a scope of qualities appropriate to a fairytale wolf.

Between these two extremes is the most frequently used governance operation. Every time a text chunk appears, a subset situation is used to interpret it. This subset governs the incoming text chunk, in order to provide source structure for that interpretation.

The notion of governance is novel, but is informed by Paul Thagard's research on conceptual change. In *Conceptual Revolutions*, Thagard discusses the transition between two competing theories of combustion, which share the common concept "wood burns" [42, p. 105]. This common node operates as a limited point of attachment between the two incompatible paradigms, and in Thagard's diagrams, acts as a pivot between them.

In narrative, a conceptual agent performs this pivotal role. As the old conceptual framework turns into a new one, the pivot pulls the old structure onto new terms. In a story, there are numerous pivotal points such as this, acting in concert to indicate how one temporarily fixed point can become the next, until the end. Some conceptual structure remain stable while others change. Interpretation can thus evolve and yet comprehension persists, with each temporarily stable point helping to carry the reader to the end.

In a practical sense, governance modifications can occur in numerous ways: one situation might surrender to the associative priorities of the other, or some of its terms might be bent in order to connect to it. The kinds of modification, and under what circumstances they activate, requires further work. More investigation is also required in relation to other

aspects of the model: more examples are needed, to explore and refine the taxonomy. In terms of the graphical expression, a richer representation is required for the structure of ambassadors, so it is easier to assess the way they bridge, overlap or conflict with each other. These issues are the subject of ongoing work and collaboration.

In the meantime, this model offers two novel mechanisms towards the issue of bridging incompatible contexts in computable models. It describes how causal conceptual agents use principles of governance to build unexpected conceptual structures. Their dynamic connections thread the narrative transitions together, enabling a reader to track how the themes and central ideas in a story evolve. At each step, the interpretation of the terms of the story alters, as the inferred situations adjust their relationship with each other.

## 5 Conclusion

This paper presents a novel system to model how narratives manipulate meaning in dynamic and complex ways. Four features of evolving interpretation in stories were identified.

As a tale unfolds, it provokes **multiple inferences** which have properties of contextual limitation. These are connected together by **conceptual agents**, which emerge when different subset situations are applied to incoming text, in such a way that new structure emerges. In order to determine how their differing reference networks should relate, principles of **governance** organize and modify tokens drawn from them. This creates a **meta-situation**, in which tokens of the supporting ontological structures are prioritized and arranged, shifting as the story unfolds. Overall, this constructs a new reference framework, one that is a derivation of the general reference frameworks used, and is specific to a particular set of circumstances embodied by the tale.

These factors combine to give a sense that the interpretative framework of the story is evolving. Narrative mechanisms such as this could offer new insight into problems of interoperability found in knowledge base design. Further study will be pursued to further refine the details of how this process occurs, and shed further light on how an assumed reader is able to anticipate structures they cannot predict.

## References


1 G. Acampora, V. Loia, S. Salerno, and A. Vitiello. A hybrid evolutionary approach for solving the ontology alignment problem. *International Journal of Intelligent Systems*, 27:189–216, 2012.

2 B. Britton and A. Graesser. *Models of Understanding*. Psychology Press, New York, NY, 2014.

3 P. Brooks. *Reading the Plot*. Oxford University Press, Oxford, UK, 1984.

4 J. Bruner. *Actual Minds, Possible Worlds*. Harvard University Press, Cambridge, MA, 1986.

5 J. Bruner. The narrative construction of reality. *Critical Inquiry*, pages 1–21, 1991.

6 B. Cardier. Seismic semantic federation: The view from Machu Picchu. In S. Louchart, M. Mehta, and D. L. Roberts, editors, *Intelligent Narrative Technologies II: Papers from the 2009 AAAI Spring Symposium*, pages 12–19, Menlo Park, CA, 2009. Association for the Advancement of Artificial Intelligence.

7 B. Cardier. `https://s3-us-west-2.amazonaws.com/topoiesis.org/Animation+A.mp4`, 2013. [online: accessed April 2015].

8 B. Cardier. Unputdownable. School of Culture and Communication and the Department of Computing and Information Systems. Melbourne, University of Melbourne, 2013.

**9** H. H. Clark and T. B. Carlson. Context for comprehension. In J. Long and A. Baddeley, editors, *Attention and performance IX*, pages 313–330. Lawrence Erlbaum Associates, Hillsdale, NJ, 1981.

**10** K. Devlin. *Logic and Information*, pages 1–328. Cambridge University Press, Cambridge, MA, 1995.

**11** K. Devlin. Modeling real reasoning. In G. Sommaruga, editor, *Formal Theories of Information: From Shannon to Semantic Information Theory and General Concepts of Information*. Springer-Verlag, Berlin, Heidelberg, 2009.

**12** H. Einhorn and R. Hogarth. Judging probable cause. *Psychological Bulletin*, 99:3–19, 1986.

**13** G. Fauconnier and M. Turner. *The Way We Think: Conceptual Blending and the Mind's Hidden Complexities*. Basic Books, New York, NY, 2002.

**14** H. T. Goranson. Topoiesis document. `http://www.sirius-beta.com/Topoiesis/TopoiesisDocument.html`, 2012. [online: accessed April 2013].

**15** H. T. Goranson and B. Cardier. A two-sorted logic for structurally modeling systems. In *Progress in Biophysics & Molecular Biology*, pages 141–178. Elsevier, 2013.

**16** A. Graesser, B. Olde, and B. Klettke. How does the mind construct and represent stories? In M. Green, J. Strange, and T. Brock, editors, *Narrative Impact: Social and Cognitive Foundations*, pages 231–263. Lawrence Erlbaum Associates, Mahwah, NJ, 2002.

**17** A. Graesser, M. Singer, and T. Trabasso. Constructing inferences during narrative text comprehension. *Psychological Review*, 101(3):371–395, 1994.

**18** A. J. Greimas. *Structural Semantics: An Attempt at a Method*. University of Nebraska Press, Lincoln, NE, 1983.

**19** T. Gruber. Towards principles for the design of ontologies used for knowledge sharing, Knowledge Systems Laboratory, Stanford University, 1993.

**20** M. Gruninger, K. Atefi, and M. Fox. Ontologies to support process integration in enterprise engineering. *Computational & Mathematical Organization Theory*, 6:381–394, 2000.

**21** S. Gueraud. Updating situation models: The memory-based contribution. *Discourse Processes*, 39(2-3):243–263, 2005.

**22** J. Hendler. Agents and the semantic web. *IEEE Intelligent Systems*, 16:30–37, 2001.

**23** D. Herman. *Story Logic*. University of Nebraska Press, Lincoln, NE, 2002.

**24** K. Holyoak and P. Thagard. *Mental Leaps: Analogy in Creative Thought*. MIT Press, Cambridge, MA, 1995.

**25** I. Horrocks. Ontologies and the semantic web. *Communications of the ACM*, 51:58–67, 2008.

**26** P. Hühn, J. Christoph Meister, J. Pier, and W. Schmid (Eds.). *Handbook of Narratology*. Walter de Gruyter GmbH & Co, 2014.

**27** K. Ireland. *The Sequential Dynamics of Narrative*. Associated Uni. Presses, Plainsboro, NJ, 2001.

**28** W. Kintsch. *Comprehension: A Paradigm for Cognition*. Cambridge University Press, Cambridge, UK, 1979.

**29** W. Kintsch. An overview of top-down and bottom-up effects in comprehension: The ci perspective. *Discourse Processes*, 39(2-3):125–128, 2005.

**30** T. S. Kuhn. *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago, IL, 1973.

**31** M. Leyton. *Symmetry, Causality, Mind*. MIT Press, Cambridge, MA, 1992.

**32** L. Li and Y. Yang. Agent-based ontology mapping and integration: Towards interoperability. *Expert Systems*, 28:197–220, 2008.

**33** D. McNamara and J. Magliano. Toward a comprehensive model of comprehension. In Brian Ross, editor, *The Psychology of Learning and Motivation, Vol. 51*, pages 297–384. Academic Press, Burlington, MA, 2009.

**34** A. Pretorious. Introduction and overview, semantic technology and applications research laboratory. `https://www.starlab.vub.ac.be/teaching/Ontologies_Intr_Overv.pdf`, 2004. [Online: accessed August 2013].

**35** M.-L. Ryan. *Possible Worlds, Artificial Intelligence and Narrative Theory*. Indiana University Press, Bloomington, IN, 1991.

**36** R. Schank and R. Abelson. *Scripts, Plans, Goals and Understanding*. Lawrence Erlbaum Associates, Inc., Hillsdale, NJ, 1977.

**37** B. Smith, W. Kusnierczyk, D. Schober, and W. Ceuters. Towards a reference terminology for ontology research and development in the biomedical domain. *Biomedical Ontology in Action*, 222:57–65, 2006.

**38** B. Smith and C. Welty. Ontology: Towards a new synthesis. In C. Welty and B. Smith, editors, *Formal Ontology in Information Systems*, pages iii–x. ACM Press, Ongunquit, ME, 2001.

**39** J. Son and R. Goldstone. Contextualization in perspective. *Cognition and Instruction*, 27:51–89, 2009.

**40** J. Sowa. *Knowledge Representation: Logical, Philosophical and Computational Foundations*. Brooks/Cole, Pacific Grove, CA, 2000.

**41** J. Sowa. The role of logic and ontology in language and reasoning. In R. Poli and J. Seibt, editors, *Theory and Applications of Ontology: Philosophical Perspectives*. Springer, Berlin, Germany, 2010.

**42** P. Thagard. *Conceptual Revolutions*. Princeton University Press, Princeton, NJ, 1992.

**43** M. Toolan. Graded expectations: On the textual and structural shaping of readers' narrative experience. In J. Pier, editor, *The Dynamics of Narrative Form*, pages 215–238. Walter de Gruyter, Berlin, New York, 2004.

**44** M. Toolan. *Narrative Progression in the Short Story*. John Benjamins Publishing Company, Philadelphia, PA, 2009.

**45** T. Trabasso. Goal plans of action and inferences during comprehension of narratives. *Discourse Processes*, 39(2-3):129–164, 2005.

**46** T. Trabasso and L. Sperry. Causal relatedness and importance of story events. *Journal of Memory and Language*, 24:595–611, 1985.

**47** T. van Dijk and W. Kintsch. *Strategies of Discourse Comprehension*. Academic Press, New York, NY, 1983.

**48** P. Visser, D. Jones, T. Bench-Capo, and M. Shave. An analysis of ontology mismatches; heterogeneity versus interoperability. In *AAAI 1997, Spring Symposium on Ontological Engineering*, pages 164–172, Palo Alto, CA, 1997. Association for the Advancement of Artificial Intelligence, Stanford University.

**49** J. Zipes (Ed.). *The Trials and Tribulations of Little Red Riding Hood*. Routledge, New York, NY, 1993.