Steps Towards a Formal Ontology of Narratives Based on Narratology*†

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Abstract

Narrative is emerging as a notion that may enable overcoming the limitations of the discovery functionality (only ranked lists of objects) offered by information systems to their users. We present preliminary results on modelling narratives by means of formal ontology, by introducing a conceptualization of narratives and a mathematical expression of it. Our conceptualization tries to capture fundamental notions of narratives as defined in narratology, such as fabula, narration and plot. A validation of the conceptualization and of its mathematical specification is ongoing, based on the Semantic Web standards and on the CIDOC CRM ISO standard ontology.

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1 Introduction

Information systems are object repositories of many different kinds, ranging from digital libraries (DLs) to institutional repositories, archives, and more. A common trait of these systems is their discovery functionality, based on the production of ranked lists of objects in response to queries in a natural language. This discovery functionality has been serving the users of these systems since a few decades now and there is common agreement that information systems, and DLs in particular, should move beyond it, offering a more sophisticated service. A way of doing so is to introduce narratives as first class objects in these systems. Narratives are natural candidates for advancing the performance of DL services for two fundamental reasons: (i) a narrative brings more information to the user than a simple list of unrelated objects; (ii) the introduction of the entities required for modelling narratives, *i.e.*, events and their contextualization properties, will enrich the information space of DLs, thereby producing beneficial effects on the functionality of DL systems. For

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instance, it will be possible to obtain the events that happened in a defined range of time, as well as the events linked with a particular relation (*e.g.*, all the sub-events related to a main event through a hierarchical relation), or to compare different narratives on the same topic in order to identify similarities and differences.

As a necessary step towards the introduction of narratives in DLs, in this study we present a formal model of narratives. The model is derived from an analysis of the literature in classical narratology, and it is independent of any specific functionality one might desire to implement on narratives. In this sense, it aims at being an ontology of narratives. The model is also independent of any specific way of populating it: narratives conforming to the model may be constructed in a purely manual way, or with the support of automatic methods for extracting the involved knowledge from texts or other media.

In compliance with the theory of narratology, we view a narrative as a complex object spanning three main dimensions. The first one is the *fabula*, the network of events that the narrative purports to narrate. The second dimension is the textual *narration* of these events. The last one is the *association* between the narrated events and the narrating text.

Being rich in structure, narratives include many relationships between the entities composing them: relationships between events (*e.g.*, temporal and mereological), and between events and the objects that contextualize them, such as people, places, things, topics, and more. In this study we provide a first modelling of narratives, focussing on representing the factual aspects and the corresponding relations that characterize an event: *Where* an event happens, *Who* (persons) and *What* (things) are involved in it [23]. Our approach is to give a mathematical expression to these entities, to be used as a conceptualization for an ontology.

The paper is organized as follows: Section 2 presents a brief overview of the notions that we formalized from the (very vast) literature on narratives. The model is subsequently developed in two steps: a conceptualization step (Section 3) laying down the structure of the model, and a formalization step (Section 4) in which the structure is expressed in mathematical terms. Section 5 discusses further developments, while Section 6 reports our final remarks.

2 Background

In literary theory, narratology is a discipline devoted to the study of the narrative structure and the logic, principles, and practices of its representation [19]. The earliest antecedent to modern narratology can be found in the classical Aristotle's theory of aesthetics. Indeed in *Poetics*, Aristotle defines a narrative as the imitation of real actions (*praxis*) that forms an argument (*logos*) whose fundamental units, or events, can be arranged in a plot (*mythos*) [2].

For Russian formalism the narratology is based on the idea of a common literary language, or a universal pattern of codes that operates within the content of a work. A narrative can thus be conveyed through several different means of communication and a wide range of media, including speech, writing, gestures, music, etc. In particular, Vladimir Propp's *Morphology of the Folktale* (1928) [22] proposed a model to represent folktales as combinations of basic building blocks, including thirty-one "narrative functions" and seven roles, or "spheres of action", of the characters.

The theory of narratology was further developed by mid-20th Century structuralism. Claude Lévi-Strauss, in *Structural Anthropology* (1958) outlined a grammar of mythology; in *Structural Semantics* (1966) [13] A.J. Greimas proposed a system of six basic structural elements of narratives called *actants*; Tzvetan Todorov was the first to coin the term *narratologie* [25]. Later on, Gérard Genette [12] codified a system of analysis that studied both the narration and the act of narrating, considering them separately from the story and content of the text.

Since 1980, post-structuralist perspectives of narratology have been developed. In particular, Cognitive Narratology [14], which considers narratology a psychological phenomenon, and proposes a study of narrative aspects from a cognitive perspective. Empirical results from cognitive psychology highlight that most common-sense concepts cannot be characterised in terms of necessary/sufficient conditions. Monotonic description logics capture the aspects of compositional conceptual knowledge, but are insufficient in representing prototypical knowledge. However, a general description logic to represent concepts in prototypical terms does not exist yet [11, 16].

2.1 Fabula and Syuzhet

Russian formalism distinguishes between a *fabula*, defined as a series of events taking place at a certain time at a specific location, and a *syuzhet*, which is the particular way the story is narrated. Contrary to the order of the fabula, that is strictly chronological, the order of the syuzhet corresponds to the way the events are presented in the narrative by the author [22] [24]. A similar distinction is drawn in structuralism by Chatman [5], who identifies the opposing concepts of *story*, *i.e.*, the content that is transmitted, and *discourse*, *i.e.*, the particular organization of that content.

Currently, there is no universally accepted definition of the narrative structure. For instance, Crawford [6] posits that a narrative is a high-level structure based on causality, not on temporal or spatial relations. Genette [12] identifies five concepts that characterize the syntax of narratives: order, frequency, duration, voice and mood. In addition to the fabula and the syuzhet, Bal [3] defines a third level that constitutes the concrete representation of the content that is conveyed to the audience (e.g., the text in a novel).

2.2 Computational Narratology

The computational narratology studies narratives from a computational perspective. In particular, it focuses on "the algorithmic processes involved in creating and interpreting narratives, modelling narrative structure in terms of formal computable representations" [17].

The computational narratology is based on engineering disciplines aiming at developing Artificial Intelligence (AI) systems for reproducing human-like narrative behaviour and intelligent interfaces and game environments for interacting with narratives [18].

Computational narratology can assume different meanings according to different research contexts. In the AI perspective [4] we are interested in, computational narratology refers to the story generation systems, *i.e.*, any computer application that creates a written, spoken, or visual presentation of a narrative. Indeed, one of our aims is to develop a semi-automatic tool that allows users to construct a narrative, on top of the formal model we developed.

3 Conceptualization

In this Section, we present our formal computable representation of narrative, as derived from the above background, in an informal way. In particular, we envisage a *narrative* as consisting of three main elements:

1. the *fabula*, directly representing the fabula as defined by the Russian formalism, *i.e.*, the sequence of the events that composes the story in chronological order;

2. one or more texts that narrate the fabula, that we call *narrations* and that correspond to the Bal's definition of *presentation*;
3. a *reference* function that connects the narrations to the fabula and allows us to derive the *syuzhet* (or plot) as defined by the Russian formalism.

Fabula. The fabula is built on top of events, an event being an action or occurrence taking place at a certain time at a specific location. This definition of event is at the basis of the Event Calculus (EC) [15, 20, 21], a logic language developed in Artificial Intelligence for reasoning on the actions of a robot. In EC the terms Actions and Events are interchangeable and represent changes performed over time, whereas Davidson [8] defines actions as a particular subclass of events, that is the events endowed with intentionality. We subscribe to this view and consider actions as a special kind of events.

The narratives we are interested in are those found in the digital humanities. Therefore the events in one of our fabulae may be (a) real, such as those witnessed by a scholar using an information system, and recorded for communication purposes, or (b) hypothetical, such as those recorded by a historian in the process of reconstructing a particular piece of history, or (c) fictional, such as those created by writers in the literature.

In a fabula, events are connected to each other by three kinds of relations:

- a *mereological* relation, relating events to other events that include them as parts, *e.g.*, the birth of Dante Alighieri, the major Italian poet of the late Middle Ages, is part of the life of Dante;
- a *temporal occurrence* relation, associating each event with a time interval during which the event occurs. An event occurs before (or during, or after) another if and only if the period of occurrence of the former event is before (or during, or after) the period of occurrence of the latter. We formalize this relations between events using the Allen's temporal logic [1];
- a *causal dependency* relation, relating events that in normal discourse are predicated to have a *cause-effect* relation in the narrator's opinion, *e.g.*, the eruption of the Vesuvius caused the destruction of Pompeii. It is important to notice that in the Digital Humanities we are not interested in modelling the mechanical causal relationships that connect, for instance, events in a physical or chemical process. We are rather interested in a more generic notion of causality, whereby the connected events may be years apart in time (or centuries, like in history) and the causal connection may be indirect, *i.e.*, established through other events, which may be unknown or not represented as relevant. For this reason we prefer to speak about causal dependency as opposed to causality *tout court.* Technically, causal dependency can be thought as a generalization of scientific causality, produced by the transitive closure of the atomic relationships that constitute scientific causality.

Narrations. Each narration of a fabula consists of one or more narrators and a text, which is *authored by* (another relation in the conceptualization) the narrator(s) and constitutes the narration proper. Although the modelling of text is an active field of investigation at the crossroads of many disciplines, and there are many models of literary text that can be used in the present context, at this stage we focus on the only aspect that is functional to our model of narrative, namely *textual content,* that is the language expression that constitutes the content of a piece of text. We will therefore use textual content as identity of text, thereby adopting a purely extensional view. Notice that in this view the structure of a text, which is the decomposition of a text in *textual units* as established by the author(s), can be derived as a containment relation between individual texts.

Reference. The reference function connects each portion of text that narrates an event to the narrated event. In order to model reference we need to identify textual units, which we call *narrative fragments* (or simply fragments), each of which narrates a single event. The underlying assumption is that it is always possible to partition a text of a narrative into disjoint fragments. Based on our experience so far, this stands as a reasonable assumption, nevertheless it can be removed by modelling reference as a relation, whereby a fragment can be associated to more than one event.

Notice that the reference function allows deriving the plot of the narrative. Indeed, by visiting the text of the narration in its natural order, it is possible to access the *narrative fragments* and, via these, the events in the fabula, *in the order established by the narrator*, which may be different from the chronological ordering of the events in the fabula.

4 A Mathematical Specification of the Conceptualization

In this Section we provide a specification of the above conceptualization in mathematical terms. This will allow us to concentrate on the proper capturing of the notions highlighted above, postponing any language consideration to a later stage, once the mathematical specification will have brought forward the required machinery. As it will be shown, the elementary notions of set theory (see for instance [7]) will suffice for our purposes.

We start from three disjoint countable sets:

- events, denoted as E, members e, e_1, e_2, ...
- time points, denoted as T, members t, t_1, t_2, ..., totally ordered by a time precedence relation $<$
- texts, given by the strings of finite length over an alphabet S, $S^\star$, members s, s_1, s_2, ...

A fabula f is a 5-tuple $\mathsf{f} = \langle E_\mathsf{f}, p_\mathsf{f}, b_\mathsf{f}, d_\mathsf{f}, c_\mathsf{f} \rangle$ consisting of:

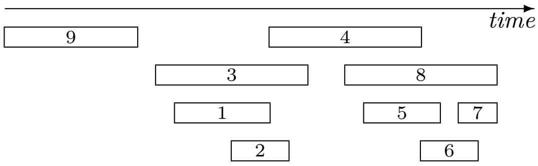
- A finite set of events, $E_\mathsf{f} \subset \mathsf{E}$
- The *event composition* function $p_\mathsf{f} : E_\mathsf{f} \to E_\mathsf{f}$ associating *some* event e_1 in E_f with a different event e_2 in E_f, such that e_1 is a part of e_2. In this case, we say that e_1 is a sub-event of e_2 or that e_2 is a super-event of e_1.
- The *event beginning* function $b_\mathsf{f} : E_\mathsf{f} \to T$, associating each event e in E_f with a time-point $t = b_\mathsf{f}(e)$ in T, such that event e starts at time $b_\mathsf{f}(e)$.
- The *event ending* function $d_\mathsf{f} : E_\mathsf{f} \to T$, associating each event e in E_f with a time-point $t = d_\mathsf{f}(e)$ in T, such that event e ends at time $d_\mathsf{f}(e)$.
- The *causal dependence* relation $c_\mathsf{f} \subseteq E_\mathsf{f} \times E_\mathsf{f}$, such that $e_1, e_2 \in c_\mathsf{f}$ if and only if event e_2 causally depends on event e_1.

For simplicity, we will omit subscripts from fabula components, when there is no ambiguity.

For each event $e \in E$, the pair $(b(e), d(e))$ is said to be the *period of occurrence of* e.

A well-formed fabula is a fabula satisfying the following conditions:

1. The event composition function p is acyclic, so that no event can be, at the same time, a sub-event and a super-event of some other event. Technically, acyclicity can be expressed as the condition that the transitive closure of p, $p^\star$, be an irreflexive relation.
2. No event finishes earlier than its beginning: for each event e in E, $b(e) \leq d(e)$.
3. The period of occurrence of a sub-event is always included in the period of occurrence of its super-event: for each event e in the domain of p, $b(p(e)) \leq b(e)$ and $d(e) \leq d(p(e))$.
4. Causal dependency is a reflexive and transitive relation.



level i	Units in $\sigma(i)$
1	[1,2000]
2	[1,1500] [1501,2000]
3	[1201,1500] [1901,2000]

Figure 1 Events in a fabula (left) and the structure of a narration (right).

From now on, we will tacitly consider only well-formed fabulae.

Notice that we allow events in the same fabula to overlap in time in an arbitrary way, enabling even the sub-events of the same event to do so. Also, we do not place any other condition on causal dependency other than the obvious reflexivity and transitivity.

Figure 1 left gives a pictorial representation of a fabula consisting of nine events, identified with the first nine positive integers, each represented by a rectangle whose horizontal extension gives the temporal extension of the event on the time scale depicted at the top of the figure. The event composition function is depicted by placing sub-events immediately below their super-events. As it can be seen, events 4 and 9 do not have any sub- or super-events; event 3 has 1 and 2 as sub-events, overlapping with each other; event 8 has 5, 6 and 7 as sub-events, also partially overlapping.

A narration n is a triple $\mathsf{n} = \langle s, k, \sigma \rangle$ consisting of:

1. A text $s \in S^\star$ giving the *content* of the narration, of length $|s|$.
2. A positive integer k giving the *depth* of the narration, that is the maximum number of *levels* in which the narration is structured. For instance, a narration structured in books and chapters has depth 3: level 1 is the level of the entire narration, level 2 is the level of books, and level 3 is the level of chapters. A narration that has no structure has depth 1. Note that depth is defined as a maximum, in order to capture the idea that not all levels need to be populated, *e.g.*, not all chapters need to have sections: it is sufficient that one chapter has a section to have depth 3.
3. A function σ giving the *structure* of the narration. σ has the first k positive integers $\{1, 2, \ldots, k\}$ as domain and sets of intervals in $[1, |s|]$ as range. Each interval $[i, j]$ in the range of σ is called a *structural unit,* or simply unit, and its *content* is the sub-string of s from the i-th to the j-th character. $\sigma(1)$ is always the set containing only the unit $[1, |s|]$, since the first level is the level of the entire narration. For $2 \leq j \leq k$, $\sigma(j)$ is a set of pairwise disjoint intervals, each one contained in one interval i of the previous level $\sigma(j-1)$ and giving the subdivision of i at the level j. Figure 1 right gives an example of the structure of a narration consisting of a text s of two thousand characters ($|s| = 2000$), divided in two chapters, one of fifteen hundred characters, the other of five hundred characters. Each chapter has one section partially covering its content.

This model of narration is kept simple to illustrate the concept for narrations with an acyclic structure, such as books. The model is not adequate to deal with narrations with possibly cyclic structures such as hypertexts. However, this is no real limitation, as it is always possible to capture arbitrary structures using more sophisticated models. Indeed, all the structures that can be used in a narration are expression of some grammar, therefore they can always be captured by a formal structure defined in set-theoretic terms.

Finally, we model the reference function. Given a fabula f and a narration n, a *reference function between* f and n, $\mathsf{ref}(\mathsf{f}, \mathsf{n})$, is a pair (F_n, r) where:

- F_n, the *fragmentation* of ref, is a set of intervals called *fragments,* each of which is contained in a unit of n, called the *source* of the fragment. Each fragment identifies the

Fragment f	$r(f)$
$[1, 500]$	4
$[600, 900]$	3
$[600, 800]$	1
$[820, 890]$	2
$[1250, 1850]$	8
$[1250, 1440]$	5
$[1501, 1700]$	6
$[1710, 1870]$	7
$[1950, 2000]$	9

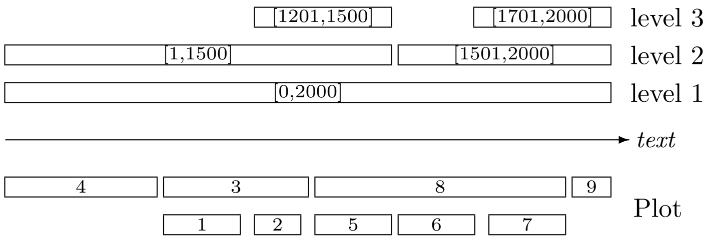


Figure 2 A reference function (left) and the resulting correspondence between narration structure (top right) and plot (bottom right).

portion of the narration that narrates an event of the fabula, and has as content the sub-string of the source's content delimited by the fragment.
- r, the *event association* of ref, is an injective function assigning to each fragment f in F_{n} an event $e = r(f)$ that is one of the events of the fabula f, that is $r(f) \in E$.

The above definition is meant to leave maximum freedom in constructing the plot of the narration. In particular:
- Fragments can be derived from any unit of the narration, not only from those that belong to the highest level.
- Fragments can be freely chosen, allowing them to arbitrarily overlap. Therefore the injectivity of the event association, which imposes that two fragments may not narrate the same event, does not represent a limitation to the creativity of narrators: a piece of text may narrate two or more events simultaneously.
- Similarly, we do not impose the event association to be surjective, so that each event in the fabula is associated to some fragment of the narration, leaving to narrators the possibility of omitting the narration of some events.
- Finally, we do not impose the narration of a sub-event to be a part (technically, a sub-string) of the narration of the super-event. This condition may well apply to history texts, in which, *e.g.*, the narration of the battle of Ludford is part of the narration of the War of the Roses. But it does not necessarily apply to other kinds of narrations, therefore it is not included in our model.

In this way, the plot of the narration can be displayed on a line, similarly to the fabula, except that in the fabula the line represents the flow of time, while in the narration it represents the sequence of characters that constitutes the content of the narration. Figure 2 illustrates this similarity between fabula and plot. The left-hand side of the Figure gives the reference function between the fabula and the narration presented in the previous examples (see Figure 1). The right-hand side shows the narration content against which both the plot (bottom) and the structure of the narration (top) are displayed.

Tying things up, we define a narrative N as a $(k+1)$-tuple, $k \geq 1$, $N = \langle \mathsf{f}, (\mathsf{n}_1, \mathsf{ref}_1), \ldots, (\mathsf{n}_k, \mathsf{ref}_k) \rangle$ where f is a fabula, and each pair $(\mathsf{n}_i, \mathsf{ref}_i)$, $1 \leq i \leq k$, consists of a narration n_i and a reference function between the fabula f and the narration n_i. This definition directly reflects the concept of narrative as spelled out in the conceptualization, that is as a fabula endowed with one or more narrations, each related to the fabula by a reference function.

5 Future Developments

In order to create an ontology for narratives, the above mathematical specification must be expressed in a logical language, providing (a) names for the notions in the specification, and (b) more importantly, axioms for encoding the various conditions on these notions.

We use the Semantic Web language OWL (Web Ontology Language)[1] for encoding narratives. We focus on this language for technical interoperability reasons, looking at Linked Data and at the Web as the ideal medium and the ideal infrastructure, respectively, for producing and consuming narratives.

In addition, we aim at semantic interoperability, based on the sharing of ontologies. Semantic interoperability is a two-way concept: on the one hand, we aim at widening the usage of our ontology for narratives by making it re-usable; on the other, we aim at re-using existing ontologies as much as possible in developing our own. A natural candidate of this latter category is the CIDOC CRM ontology [9], an ISO standard largely employed in the digital library domain. The CRM aims to be monotonic in the sense of Domain Theory. That is, the existing CRM constructs and the deductions made from them must always remain valid and well-formed, even as new constructs are added by extensions to the CRM. The CRM includes temporal entities for capturing time-dependent concepts such as events; moreover, its harmonization with the FRBR ontology, known as FRBRoo [10] provides fundamental notions for the modelling of text, such as expressions and expression fragments. Because the CRM's primary role is the meaningful integration of information in an Open World, it seems natural to embed our narrative ontology in the CRM, by introducing the required extensions into the current expression of this ontology. Furthermore, we have already started the validation of our model by partially expressing it in the CRM and by using it to formally represent the biography of Dante Alighieri as case study. Our representation of Dante's life is derived from a biography of the poet written by an authoritative Italian biographer of Dante, who collaborated with us constructing a narrative.

In order to support the construction of this narrative, we implemented a semi-automatic tool that allowed the biographer/narrator to define the events of the biography of Dante, and to connect these events to each other based on their temporal, mereological or causal relations, through a simple GUI. The objects that contextualize the events, *e.g.*, people, places, times, things, are automatically extracted from the Wikidata knowledge base[2], as well as manually added by the narrator. The resulting knowledge base is expressed in OWL. In order to allow the biographer to evaluate the created narrative, we included in our tool a visualization component that allows visualizing the narrative on a timeline. We then asked the biographer to evaluate the ability of the ontology to capture in a formal way the main aspects of the narrative. After the analysis of the events and their components shown on the timeline, the scholar expressed a positive evaluation confirming that the ontology was able to represent the events of the narrative, their relations, and their components, as described in his text.

Due to the encouraging results of this first experiment, we plan to make the tool available to a community of scholars in the context of an Italian national research project[3], in order to perform a larger scale evaluation.

[1] https://www.w3.org/TR/owl-features/
[2] http://wikidata.org
[3] http://perunaenciclopediadantescadigitale.eu

6 Conclusions

We have presented a conceptualization of narratives based on fundamental notions in narratology, and a first mathematical expression of it, to be used as a basis for the development of an ontology of narratives, encoded in OWL. Our model of narratives includes three dimensions: the fabula, the narration and the connection between them via a reference function, through which it is possible to derive the plot of the narrative. A validation of the model is ongoing. Indeed, using a CRM expression of the model, we have formally represented a narrative of the biography of Dante Alighieri. The fabula of this narrative is given by the main events in Dante's life reconstructed by an authoritative scholar from various primary sources. The narration of the fabula consists of the text written by the scholar and the reference function connects each portion of text that narrates an event to the narrated event. The validation has given positive results so far. We plan to conclude our study developing an ontology of narratives with an associated tool for building, visualizing, managing and sharing narratives.

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