ETS representation of fairy tales

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Abstract. This paper presents a preliminary application of the ETS formalism to the structural representation of Russian fairy tales. We were led to this application through our interest in information retrieval. In addition to introducing a natural multi-level representational view of fairy tales, the ETS formalism suggests an explanation for the mechanism behind plot anticipation by an experienced reader as well as various levels of fairy tale conceptualization.

> The word morphology means the study of forms. In botany, under morphology one understands the study of constituent parts of plants, of their mutual interrelationships and the whole, in other words the study of plant structure.
>
> No one thought of the idea and the term [fairy] tale morphology. However, in the area of folk or folklore tale, consideration of form and the establishment of composition laws is possible with the same accuracy with which morphology of organic compositions allows.
>
> . . . . . .
>
> Since the [fairy] tale is exceedingly diverse and probably cannot be studied all at once in its entirety, the material should be subdivided into parts, i.e. classified. Proper classification is one of the first steps in a scientific description, the correctness of further study depends on the correctness of the classification.
>
> Vladimir Propp, Morphology of the Folktale, 1928 [our translation from Russian]

1 Motivation: information retrieval

We chose the domain of fairy tales since it appears that both the structure and semantics of fairy tales as "documents"[1] is more pristine compared to those of many modern documents (e.g. newspaper articles, web pages, and other documents). One of the obvious reasons why fairy tales are more enduring and more universal as compared to practically all present documents is that their structure is less contaminated by various non-essential expository elements so prevalent in modern documents. For example, a typical North American newspaper article is full of insignificant details appearing almost randomly in the text. Since all structural elements of fairy tales are semantically meaningful, they provide a very good database for the investigation of various formalisms for information retrieval (IR). Similar

[1]The term "document" is used in this paper as a generic name for a record in a generic information retrieval database.

observations have been made by other researchers [1, 2].

Currently, by far, the dominant representational formalism in IR is the vector-space-based formalism. The reason is not difficult to discern: it is the choice formalism when it comes to the classification of documents. What are the main deficiencies of this classification formalism? They have to do with the inability of the vector-space formalism to deal with the fluent nature of most documents. Moreover, most documents can only be understood if the sequence of *interconnected* (often implicit) "events"—which are encoded in these documents—is properly perceived: e.g. for a typical professor's webpage, these events are awarding of Phd, courses taught, grants received, paper's published, conferences chaired, etc. The fluent nature of documents manifests the following two facts.

The first fact has to do with one's inability to enumerate, *in advance*, all possible *interrelationships* that could exist between various events or features. This fact implies, in particular, that one cannot deal reliably with the classification of new documents involving new interrelationships between the events. This results in the brittleness of the classification system: new interrelationships present in the document to be classified often lead to misclassification of this document (see Figure 1).

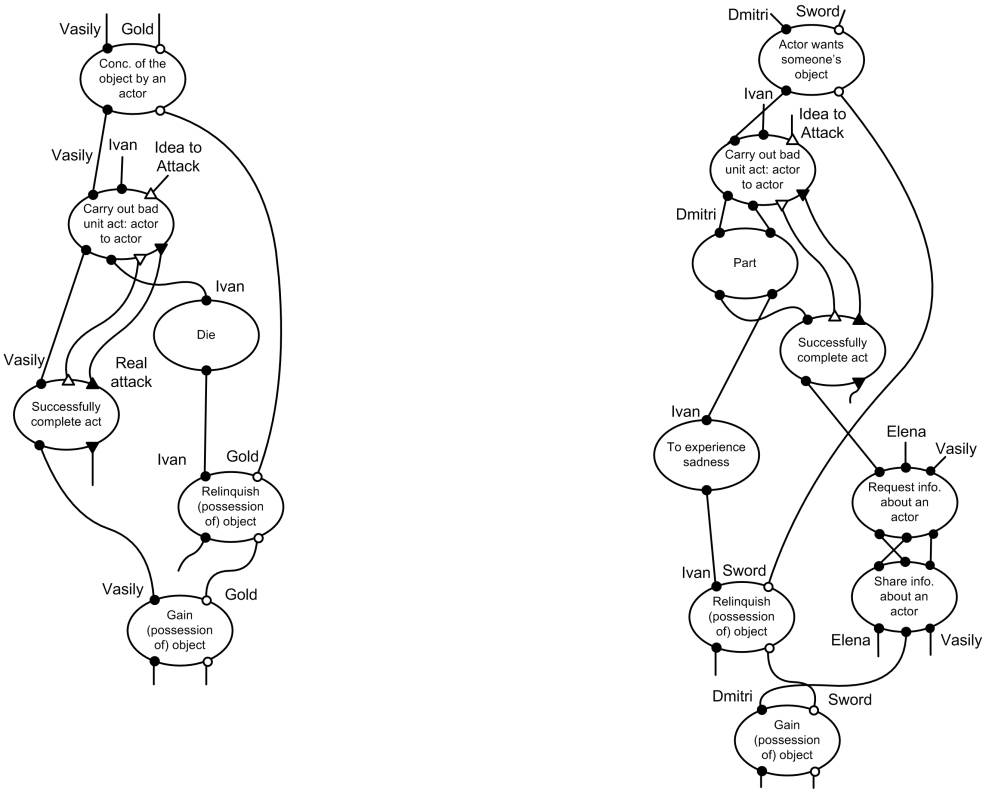

Figure 1: Two semantically similar but structurally different fairy tale segments (also encapsulated in Figure 12).

The second fact is related to the first one and has to do with the resulting necessity to deal with enormously large dimension (which still cannot "capture" all *possible* interrelationships). The implication of this fact is that one must now deal with enormous computational

complexity of the algorithms involved.

The Evolving Transformation System (ETS) is the first formalism specifically designed to address structural representation in a more universal setting and with emphasis on classes of objects/events as the main underlying concepts [2]. As was mentioned in [3], "[o]ne can develop an initial intuitive understanding of the proposed [ETS] representations by simply generalizing the process of construction/generation of natural numbers: replace the identical structureless 'primitives' out of which numbers are build by various structural ones." Also,

> [t]he concept of class representation—which inspired and directed the development of this formalism—differs radically from the known concepts of class. Indeed, the evolving transformation system ... is the first one developed to support that concept; a class representation is a finite set of weighted and interrelated transformations ("structural segments"), out of which class elements are built.
>
> The formalism [also] allows for a *very natural* introduction of representational levels: a next-level unit [i.e. primitive] corresponds to a class representation at the previous level. [3]

We demonstrate that the ETS representational levels correspond and clarify the levels of comprehension of the fairy tale reader.

In contrast to the vector-space-based formalism, the combinatorial explosion of various structural relationships is handled within ETS in a natural way: it is the class description, i.e. class supertransform [3], that absorbs the combinatorial explosion of the corresponding vector-space "features". The class supertransform is composed of constituent transforms, which are, roughly speaking, *closely related* structural segments in the object representation. In other words, the constituent transformations encapsulate all inductive structural variation that one encounters in the document segments.

One of the most important features of the ETS formalism is that it erases the differences between the syntax and semantics of the objects representation. Thus, for each primitive, its syntax and semantics are indistinguishable and in view of the structure of the formalism, this feature carries over to all of its concepts, i.e. to structs, transforms, and other levels of representation. We believe this to be the first formalism that possesses this feature.

Next, it is important to mention here several general observations made by a well known Russian folklorist and author of the book *Morphology of the Folktale*, Vladimir Propp, regarding the classification of fairy tales. His observations are fully consistent with the ETS approach. First of all, Propp proposed to view a fairy tale via a sequence of events, where the structure of each event should be independent as much as possible of a particular actor or the details involved. Second, he insisted on *structural* classification via *structural similarity* of fairy tales (and their segments) as the main framework in which one should think about the "representation" [4] of fairy tales. Third, in modern terminology, he insisted on structural "representation" as compared to other forms of representation and strongly criticized non-structural approaches and their classification. He also insisted on structural "composition"

[2] In what follows below, we will be using terminology introduced in [3].

[3] The class supertransform is constructed on the basis of the supertransform (see section 4 below) by abstracting away the supertransform's site labels.

[4] Here, we are interpreting him in IR language.

as the basis for classification, i.e. "[d]ifferent plots can have the same composition" [4, p. 41]. In other words, the structural composition can be used as the description of the class of related fairy tales. Moreover, Propp proposed 31 functions, each denoting "the action of the character from the point of view of its significance for the progress of the narrative" [4, p. 74].[5] One should note however that his functions belong to different levels of story comprehension and many of them are not implementable since they require a relatively high level of story comprehension.

Similarly to Propp, we also propose a small number of primitive events, however, in contrast to Propp's functions, they are much more implementable since they are more consistent with the initial level of processing. We have chosen our events based on the atomic cognitive events that should occur in the mind of the "generic" fairy tale listener/reader. Although we spent less than 3 months on this work, we believe that the reliance on the ETS methodology allowed us to progress quite efficiently with the design of the proposed representation (which of course, should be considered as tentative).

Finally, it is interesting to note that the proposed framework should help both expositors and translators of fairy tales to tailor more reliably the exact form of exposition/translation to various age and cultural groups. This can be accomplished by a carefully tailored choice of primitives as well as transformations. For example, a software program with a graphical user interface should allow a translator to visualize the translation in an iconic (ETS) form and based on this iconic representation make the necessary modifications in the translation if some of the primitives or transforms are not appropriate for the target audience.

2 Initial level primitives

In this section we present our initial level primitive events/transformations. As was mentioned in the introduction, we tried to select as primitives those events that are "atomic" mental events of the listener/reader of fairy tales. In other words, a primitive transformation encapsulates the *structure* of the corresponding mental event. When an ETS primitive models/stands for an atomic mental event, it means that the corresponding event transforms input (or "initial") sites into output (or "terminal") sites. Roughly speaking, a site is some conceptual entity involved in the perception of the story, which could be thought of as a reference point in the flow of the events.

In Figure 2, we show the site types used, including a generic site type that is used for convenience to denote any site.

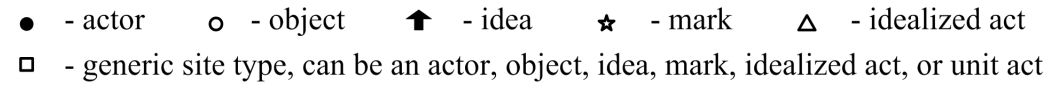

Figure 2: Site types used.

The information about our initial primitives is summarized in Figure 3 and 4. They were chosen on the basis of the fairy tales contained in [5, 6].

[5] "The content of the task varies, but the presence of a task is something stable. I called such stable elements the functions of the characters." [4, p. 73]

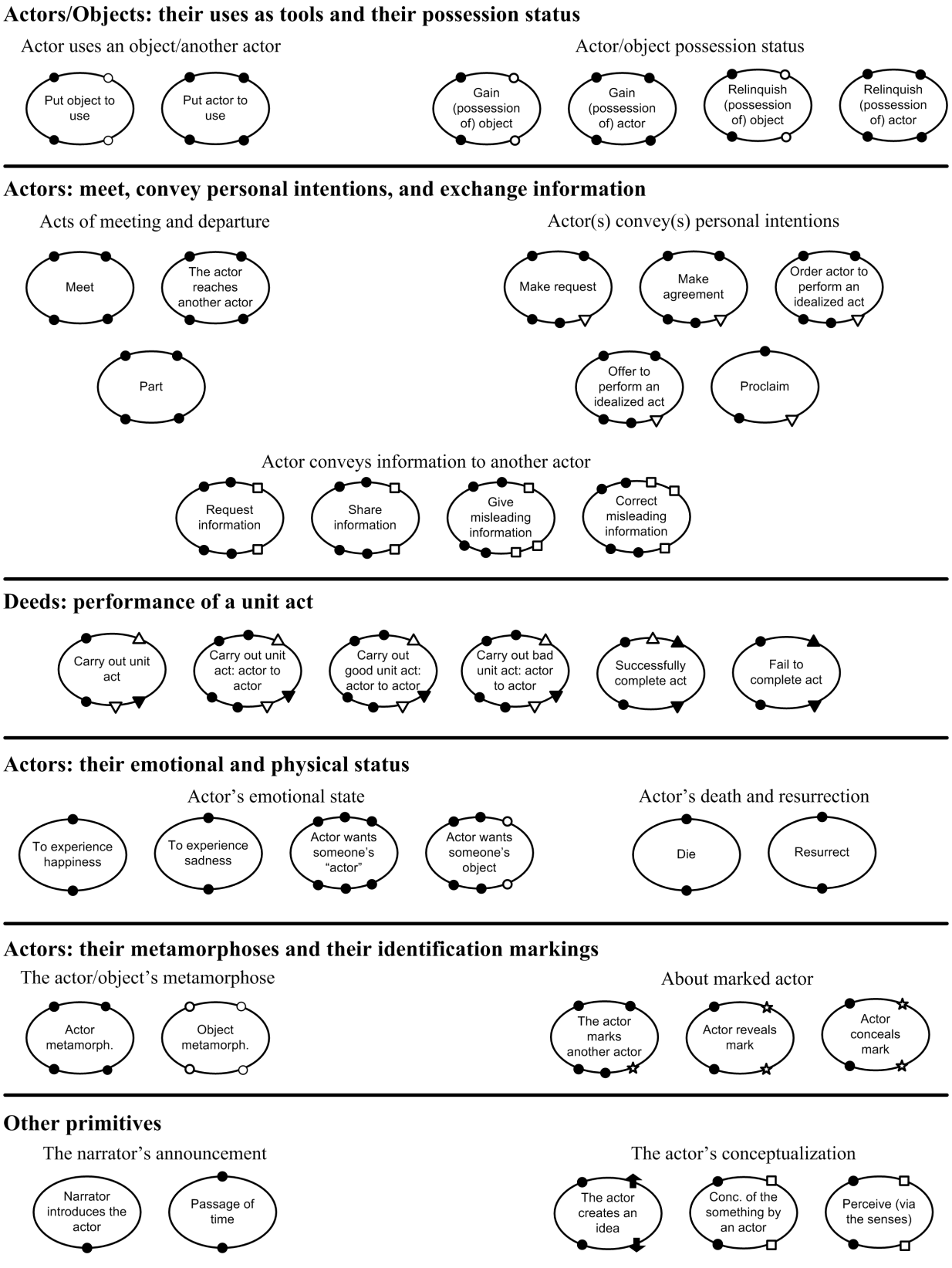

Figure 3: Initial level primitives subdivided into their related groups.

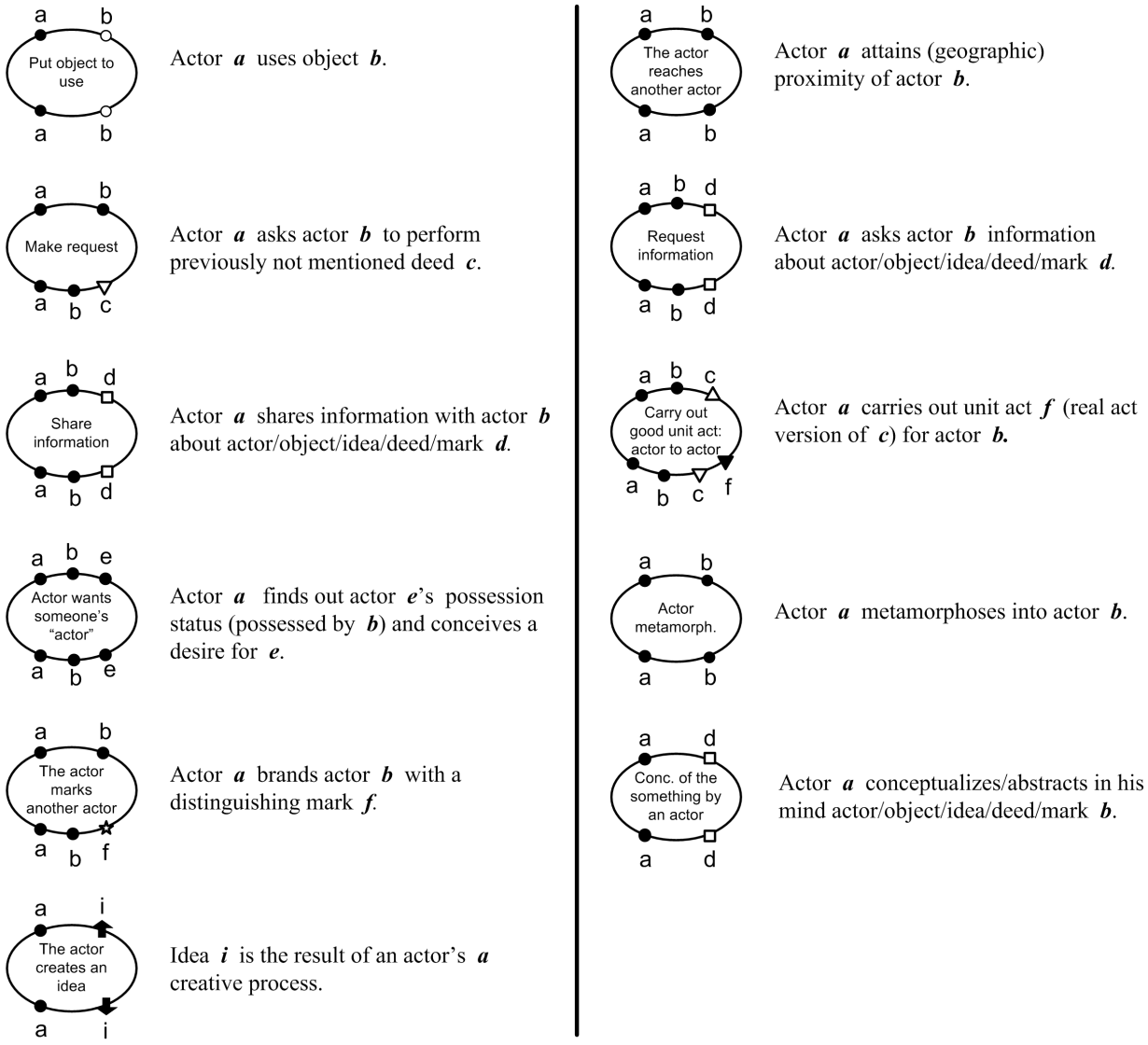

Figure 4: A more detailed description of some initial level primitives.

3 Examples of (initial level) structs

In this section, we show how the segments of the fairy tales are represented, i.e. we show the structs corresponding to such segments. Thus, such structs represent the sequence of the basic mental events generated during the reading/listening of the original fairy tale segments.

The structs shown in Figures 5, 6, and 7 represent segments from three typical Russian fairy tales taken from [5, 6], "Salt", "The Three Kingdoms, Copper, Silver, and Golden", and "Tsarevich Ivan and the Grey Wolf", respectively. These segments were chosen as belonging to the same *class of segments*. At a high level, this class could be described as follows: a hero is returning from the main quest and is intercepted by his brothers, who rob him of all the spoils that he has obtained during the quest.

The sites of the structs acquire now the names of the concrete actors/objects/ideas/idealized act/unit act/marks mentioned in the corresponding fairy tale segment. The "through" sites, i.e. when the initial and terminal sites coincide, are not always labelled to improve the readability. The vertical positioning of the primitives corresponds to the actual order of the events in the fairy tale, thus, the parallel primitives signify simultaneous events. The thick vertical lines are used as space saving devices: the struct on the right is the continuation of the struct on the left. The lines at the top of each figure depict the *initial sites* of the struct [3]. They "lead" to other primitives/events that are not part of the corresponding segment. The same applies to the bottom lines, which depict the *terminal sites* of the struct.

Note that the size of the structs directly correlates with the size of original story segments. Moreover, it is important to observe the explicitness/transparency of the ETS representation: "what you see is what you get". This is a critical feature of the ETS representation, since it captures completely and faithfully the content of the fairy tale.

3.1 Fairy tale: Salt

For some time, a long time or a short time, Ivan sailed on the sea with the princess. Then his elder brothers overtook him, learned of his audacity and good fortune, and greatly envied him. They came on board his ship, seized him by his arms, and threw him into the sea; then they cast lots between them and divided the booty: the eldest brother took the princess, and the second brother took the ship full of silver and gold.

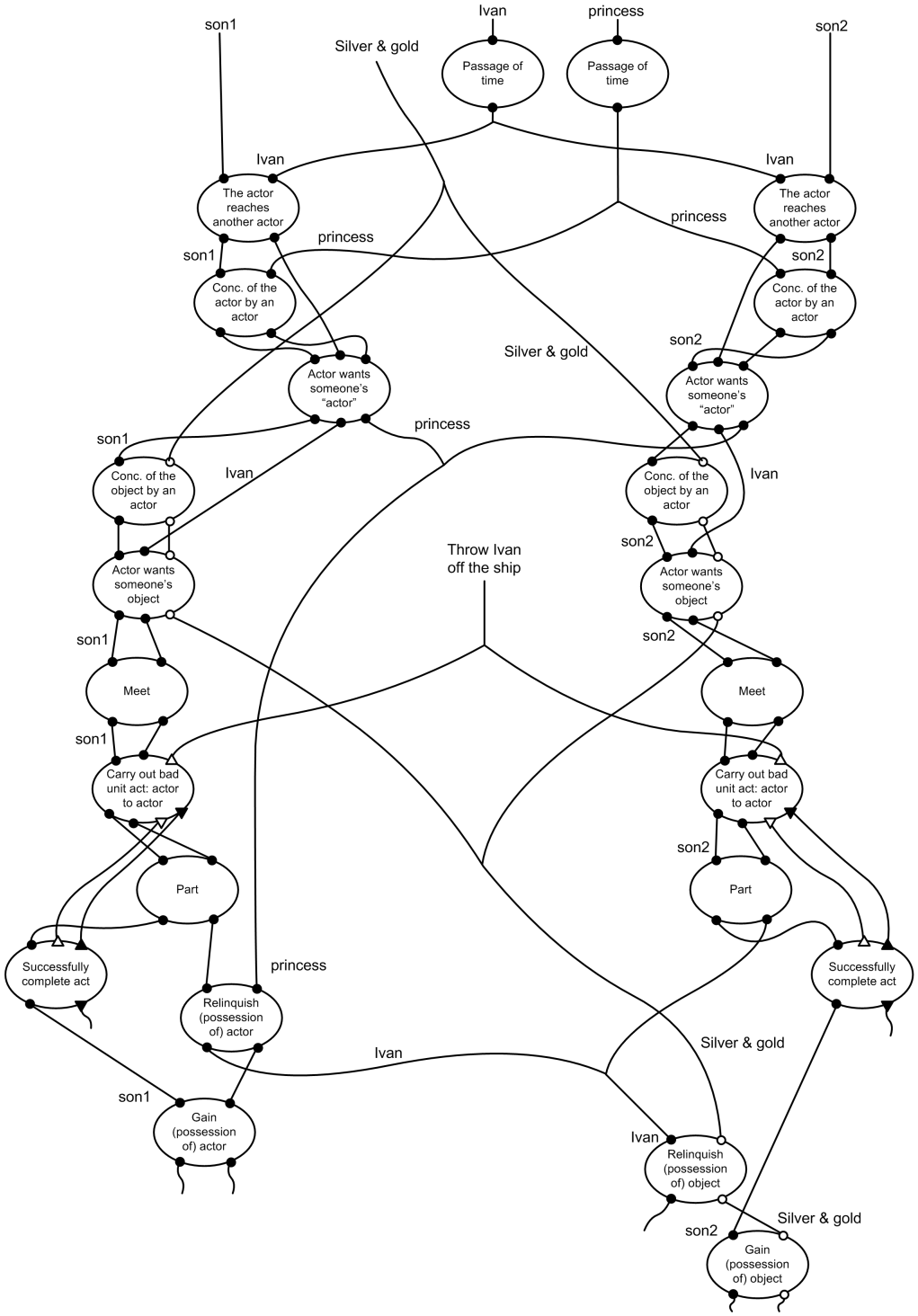

Figure 5: ETS representation of the fairy tale segment shown at the beginning of this figure.

3.2 Fairy tale: The Three Kingdoms, Copper, Silver, and Golden

... and in a short time they [Prince Ivan, Nastasya (Ivan's mother), Elena the Fair, and her two sisters] came to the place where they had to climb down the mountain. Prince Ivan let his mother down first on a linen cloth, then Elena the Fair and her two sisters. The [Ivan's] brothers stood below waiting and thought to themselves: ``We will leave Prince Ivan up there, and will take our mother and the queens to our father and tell him that we found them." ``I shall take Elena the Fair for myself," said Prince Piotr. ``You, Vasily, will take the queen of the silver kingdom, and the queen of the copper kingdom we will marry to some general."

When Prince Ivan's turn came to descend the mountain, the older brothers seized the cloth, pulled it, and ripped it off. Prince Ivan remained on the mountain. What could he do? He wept bitterly and turned back ...

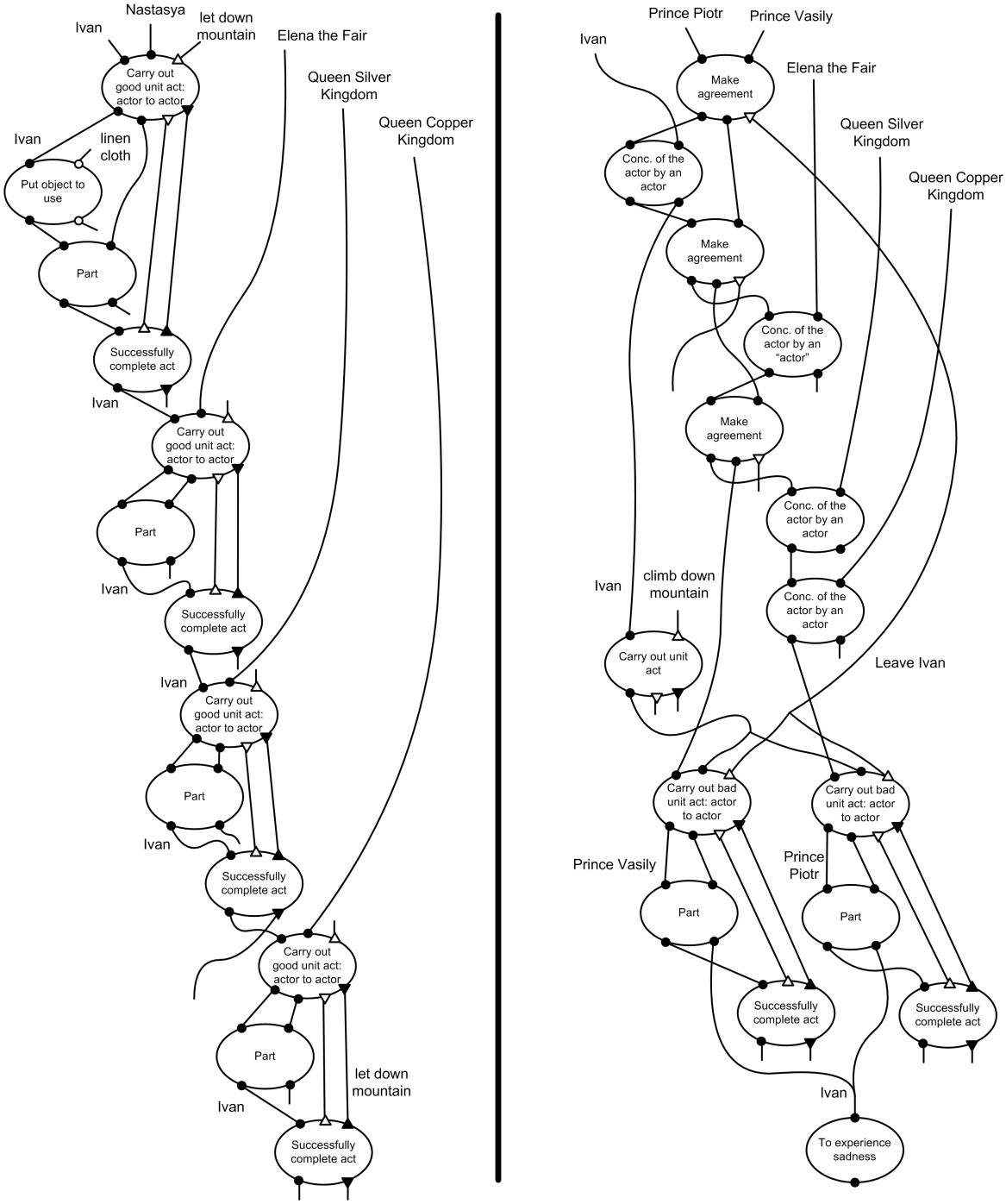

Figure 6: ETS representation of the fairy tale segment shown at the beginning of this figure.

3.3 Fairy tale: Tsarevich Ivan and the Grey Wolf

By and by they [Tsarevich Ivan and Yelena the Fair] reached his native land, and Tsarevich Ivan decided to stop for a bite to eat. He had a little bread with him, so they ate the bread and drank fresh water from the spring, and then lay down to rest.

No sooner had Tsarevich Ivan fallen asleep than his brothers came riding up. They had been to other lands in search of the Fire-Bird, and were now coming home empty-handed.

When they saw that Tsarevich Ivan had got everything, they said:

``Let us kill our brother Ivan, for then all his spoils will be ours."

And with that they killed Tsarevich Ivan. Then they got on the horse with the golden mane, took the Fire-Bird, seated Yelena the Fair on another horse and said:

``See that you say not a word about this at home!"

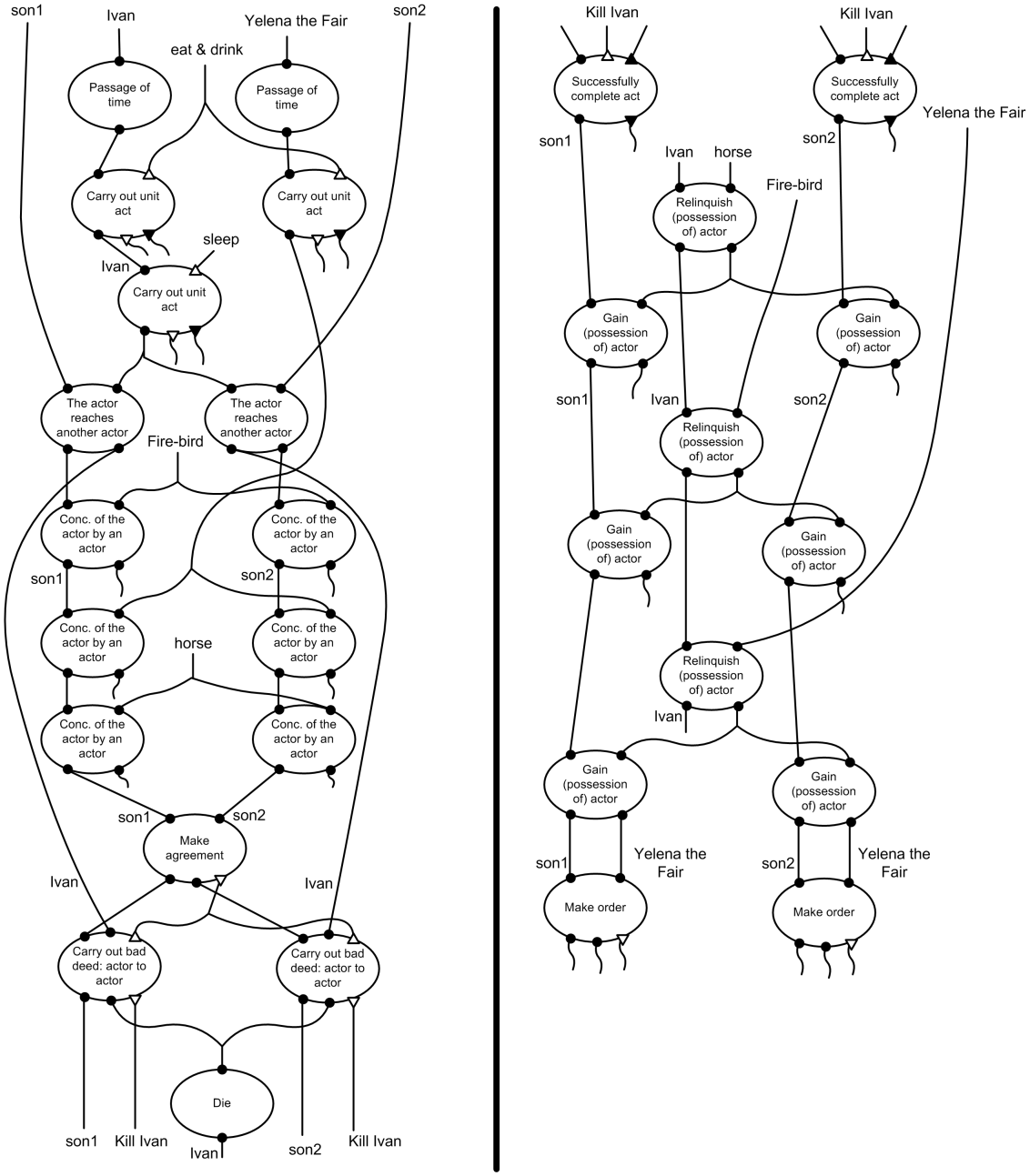

Figure 7: ETS representation of the fairy tale segment shown at the beginning of this figure.

4 Examples of (initial level) transformations

In this, central, section, we show several examples of the initial level transformations, or simply transforms, common to several stories (not all the relevant stories and segments are presented in this paper, see [7]). Each of these transforms consists of two parts, the context and the body. As the term suggests, the *context* of a transform consists of those primitives that embody the "preconditions", i.e. events, necessary (but not sufficient) for the appearance of a body in a struct. The body of a transform captures a segment of the struct that can now be thought of as *segmented into such bodies*, where each body corresponds to a next level event in the comprehension of the fairy tale and becomes a next level primitive [3]. Obviously, a context of a transform must be contained in the struct segments preceding its body. Thus, it is quite natural to associate with the transform the same "name" as that of its body.

In Figure 8, we show a single transformation, whose body is a particular instantiation of a typical (for the chosen fairy tales) small story segment that can be described at a higher level as "good act and its immediate consequences". The $\times$'s at the end of some site lines signify that these are *detached* sites. The term detached sites comes from the procedure that constructs the context by excising/detaching it from the enveloping struct (at these sites). A variable part of a context will be called a sub-context and it is introduced as a convenient tool for specifying (not shown in the figure) an exact range of variability for this particular part of the context. Note that the context, i.e. the preconditions for the appearance of the body, is in some sense more "disjoint" than the body itself, since the body is an "integral" segment of the struct.

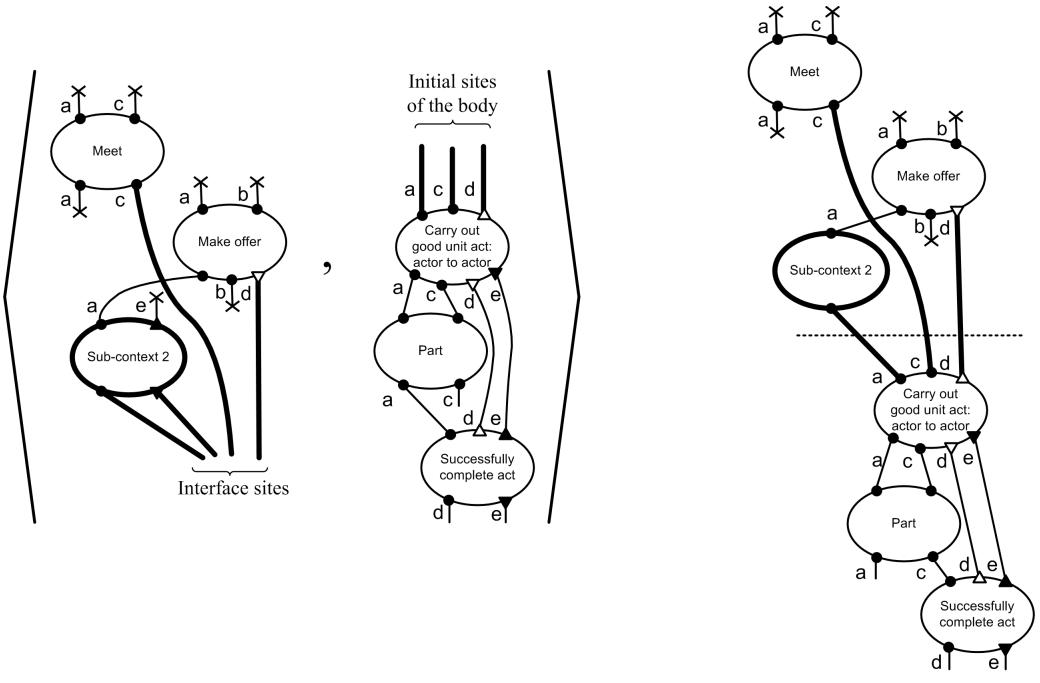

Figure 8: An example of a transform. The right hand side of the figure depicts the assembled transform corresponding to a more appropriate interpretation/understanding of the transform.

The concept of supertransformation is a generalization of the concept of a transformation: it can be thought of as an abstraction of the set of several closely related transforms acquired during one's inductive experience. This concept is the central one in the ETS formalism since it encapsulates the concept of *class description*. A supertransform is defined, basically, as a set of (related) transformations, called *constituent* transformations, with similar bodies and common interface sites [3]. The contexts are suppose to capture all the necessary "preconditions" for the appearances of the corresponding bodies and are typically more varied than the bodies themselves. The supertransform's bodies are suppose to capture various instances of the corresponding next level event, including those events that include "noise".

It is interesting to note that Propp, in his "Transformations of the Wondertale", speaks of "reduction" and "expansion" as associated with the corresponding modifications that could occur in various retelling of the same sequence of events [4, p. 86]. In other words, he allows for a certain variability range for a particular fairy tale segment. The concept of the supertransform formally accounts for such, as well as other, inductively encountered variability.

The supertransforms shown in Figures 9, 10, 11, and 12 encapsulate the following four events: "discovery of an actor, its possession status, and the desire to get that actor", "good act and its immediate consequences", "premeditated bad act and its immediate consequences", and "premeditated taking away an object". They were constructed on the basis of the above structs. Upon closer examination of the corresponding structs, it is easy to see that the constituent transforms indeed appear more or less regularly in the structs. Note that to improve the readability of the above mentioned figures not all constituent transforms are depicted for each supertransform.

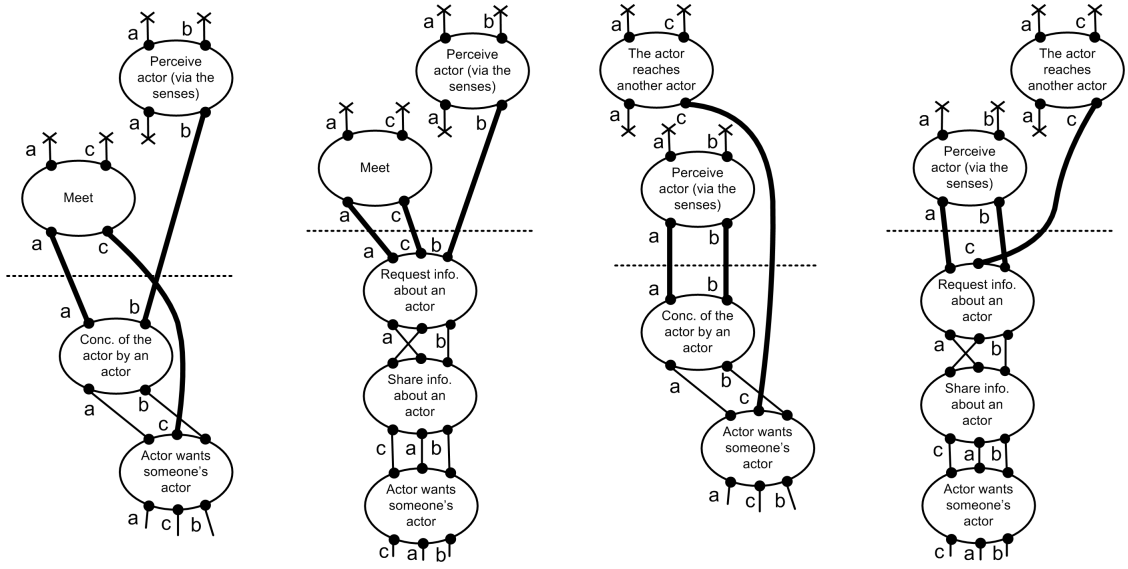

Figure 9: Some of the constituent transforms from the supertransform named "discovery of an actor, its possession status, and the desire to get that actor".

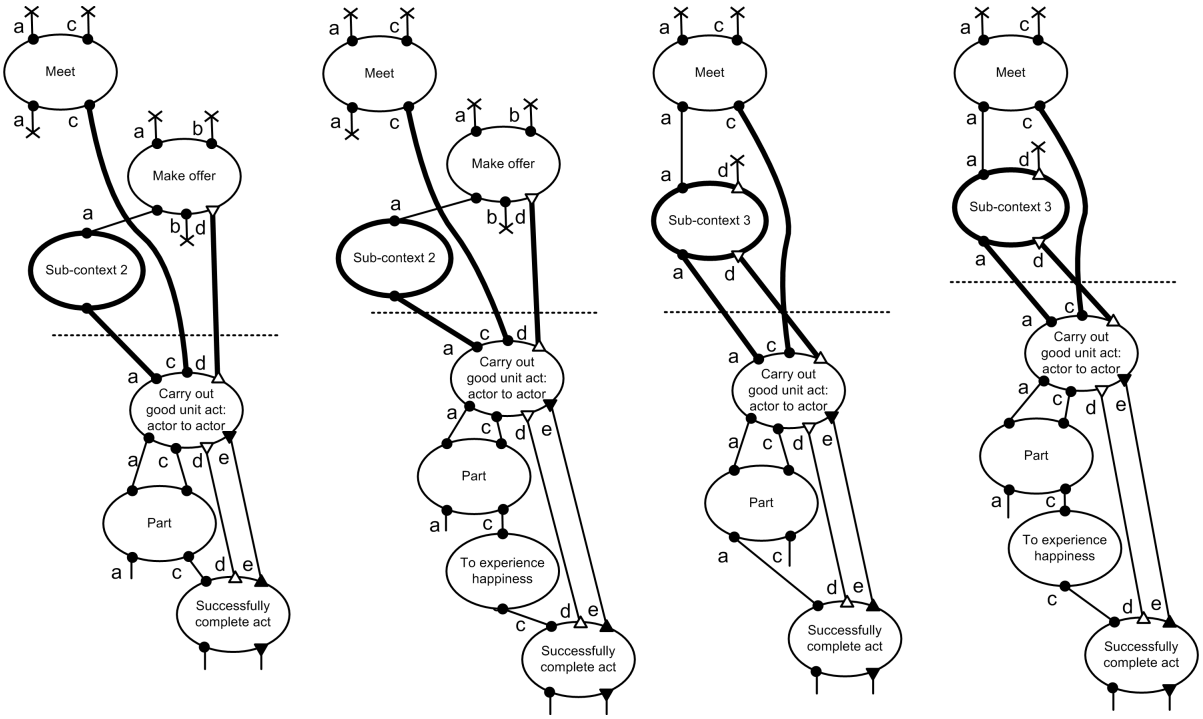

Figure 10: Some of the constituent transforms from the supertransform named "good act and its immediate consequences".

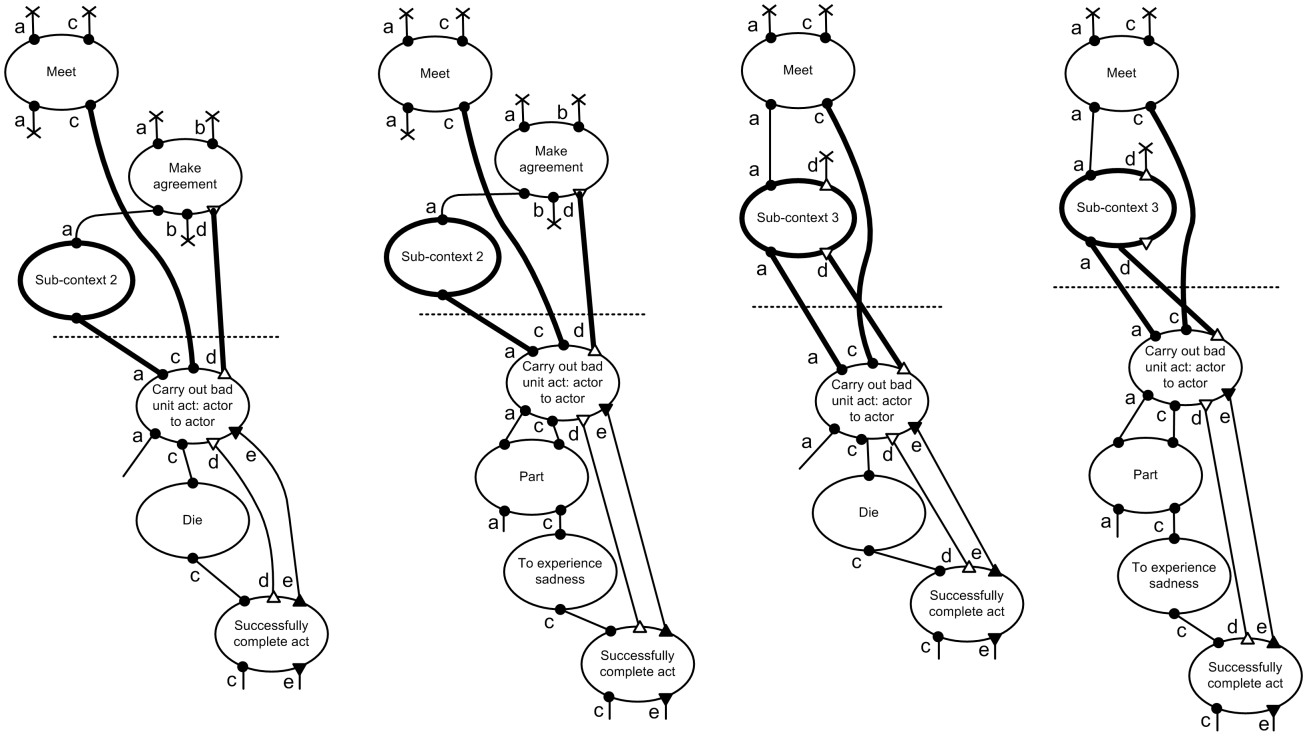

Figure 11: Some of the constituent transforms from the supertransform named "premeditated bad act and its immediate consequences".

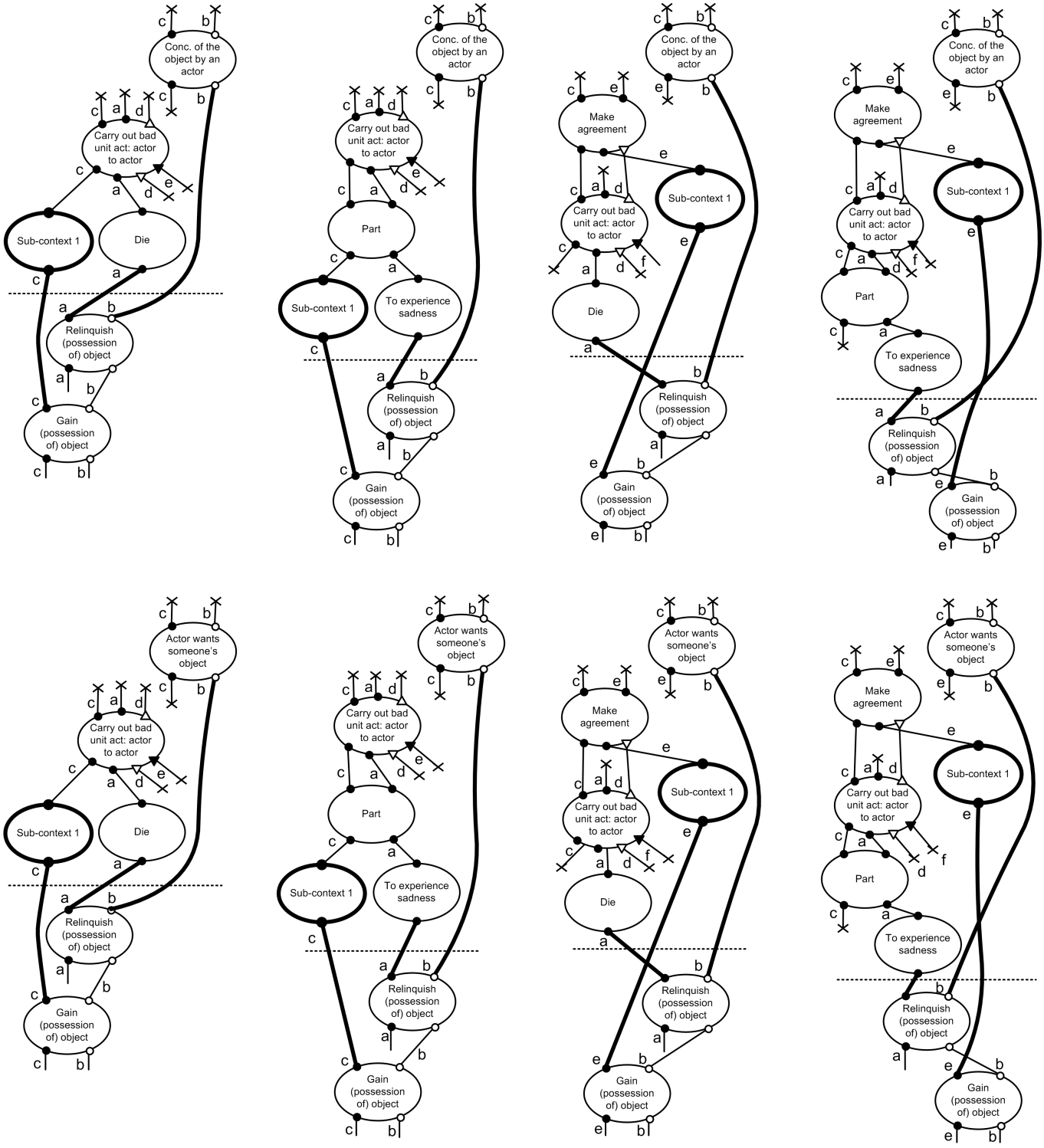

Figure 12: Some of the constituent transforms from the supertransform named "premeditated taking away an object".

We believe that any reader of fairy tales accumulates his/her cognitive experience in the form of (inductively learned) supertransforms. In particular, the appearance of a context

(from some previously learned supertransform) in a new fairy tale may trigger the anticipation of the corresponding body, thus, explaining the nature of anticipation.

Finally, one should note the fundamental differences between the Chomky's formal grammar model and the ETS formalism. The differences are manifold and it is sufficient to mention here just the most obvious but important one. It is related to the transparency of the ETS representation as compared to the conventional string representation: the transformations are directly present in the corresponding structs while production rules are not present in the string representation, since the non-terminal alphabet is not transparent at all.

5 The second level primitives

We believe that the formalism's capability to address effectively various levels of fairy tale comprehension is decisive feature in favor of the formalism. How is a new level of representation introduced in the ETS formalism? Figure 13 explains the basic idea behind the ETS level ascension postulate, which shows how to convert a supertransform into the next level primitive transform [3]. Thus, the supertransform's interface sites (i.e. sites connecting the context to the body) become the primitive's initial sites while the body's terminal sites become the primitive's terminal sites.

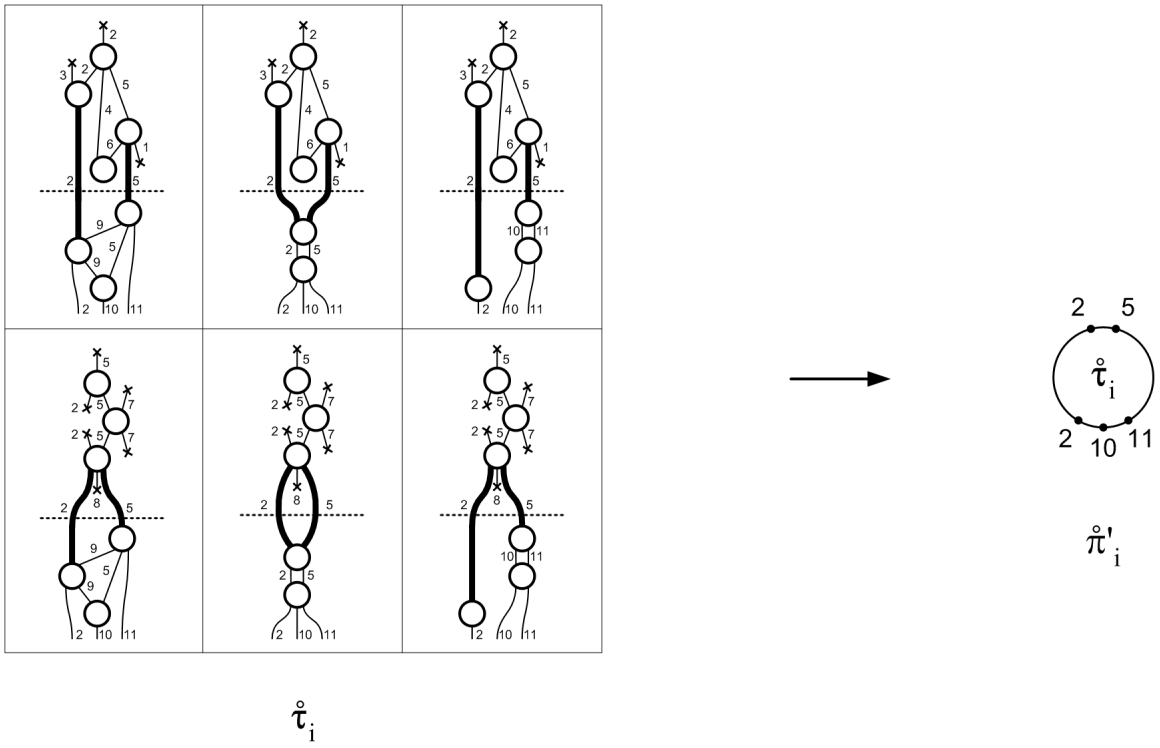

Figure 13: A *canonical supertransform* and the corresponding next level original primitive [3].

The next level primitives corresponding to the chosen initial level supertransforms are shown in Figure 14.

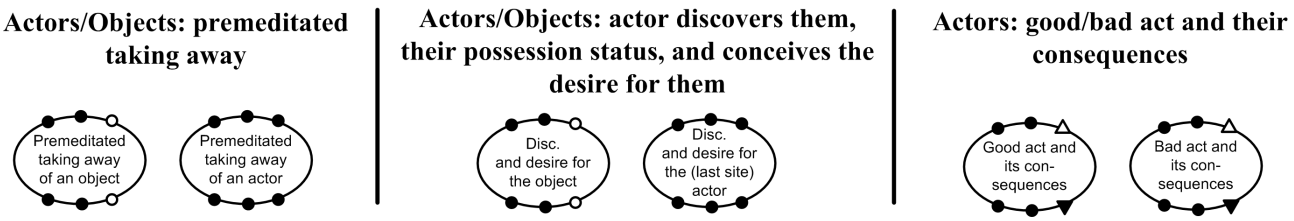

Figure 14: Next level primitives corresponding to the above initial level transforms obtained in the manner shown in Figure 13.

In light of the above, it is not difficult to see how the compression of information in ETS is accomplished. For example, the primitive "bad act and its consequences" now encapsulates several events that include the bad act itself as well as its immediate consequences, e.g. death, parting of the main actors, and the experience of sadness by the actor on the receiving end. The concept of the supertransform allows one to realize this compression by accumulating the transform's variations encountered in the read fairy tales.

It is important to note that the quality of a fairy tale's comprehension by a reader is directly affected by his/her reading experience and ability to generalize from this experience. According to the ETS formalism, the latter ability is directly related to one's aptitude to form the relevant supertransforms, or which is the same, the next level primitives.

6 An example of a second level struct

In Figure 15, we show the next level struct for the first fairy tale segment from section 3. Observe that there are less details present but, at the same time, the higher level plot becomes more recognizable.

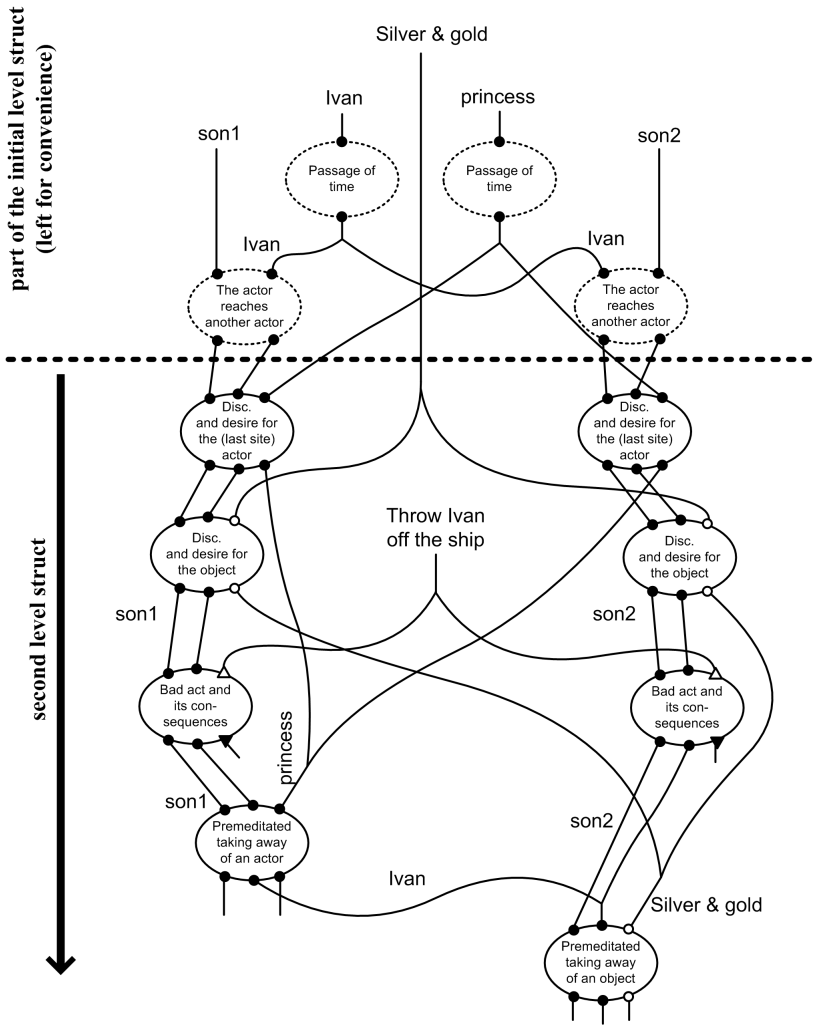

Figure 15: Second level representation of a segment from the fairy tale Salt given in Figure 5.

7 Examples of two second level transformations

Figure 16 shows two related second level transforms/events: "premeditated bad act followed by its goal of taking possession of the desired object" and "premeditated bad act followed by its goal of taking possession of the desired actor". They were constructed on the basis of the corresponding three *second level* structs: one of them is shown in Figure 15 and the other two (not shown) are the representations of the remaining above two story segments. Again, as was mentioned in section 4, these constituent transforms indeed appear more or less regularly in the three structs. It is also easy to see that, indeed, at this higher level, the overall plot becomes more transparent as compared to the previous level, and this should precisely be the goal of a good representational formalism for document classification and retrieval, since, ideally, one wants to allow the document query to relate to *any* semantic level.

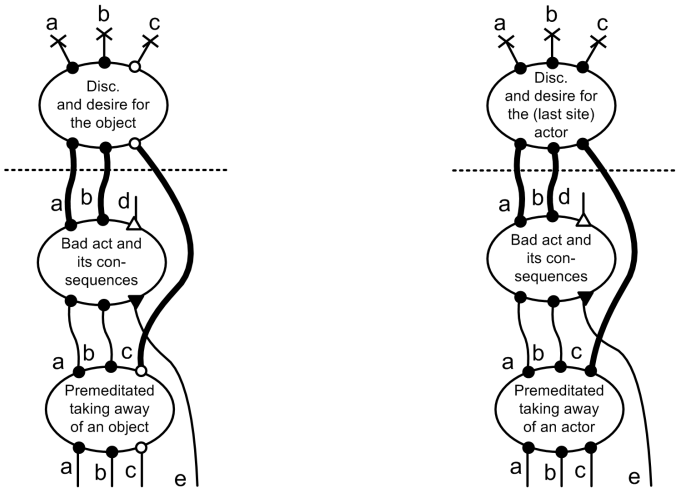

Figure 16: Examples of just two (of several) constituent transforms belonging to different supertransforms: "premeditated bad act, followed by its goal of taking possession of the desired object" and "premeditated bad act, followed by its goal of taking possession of the desired actor".

Finally, Figure 17 summarizes the hierarchial ETS representation of the corresponding third level primitive.

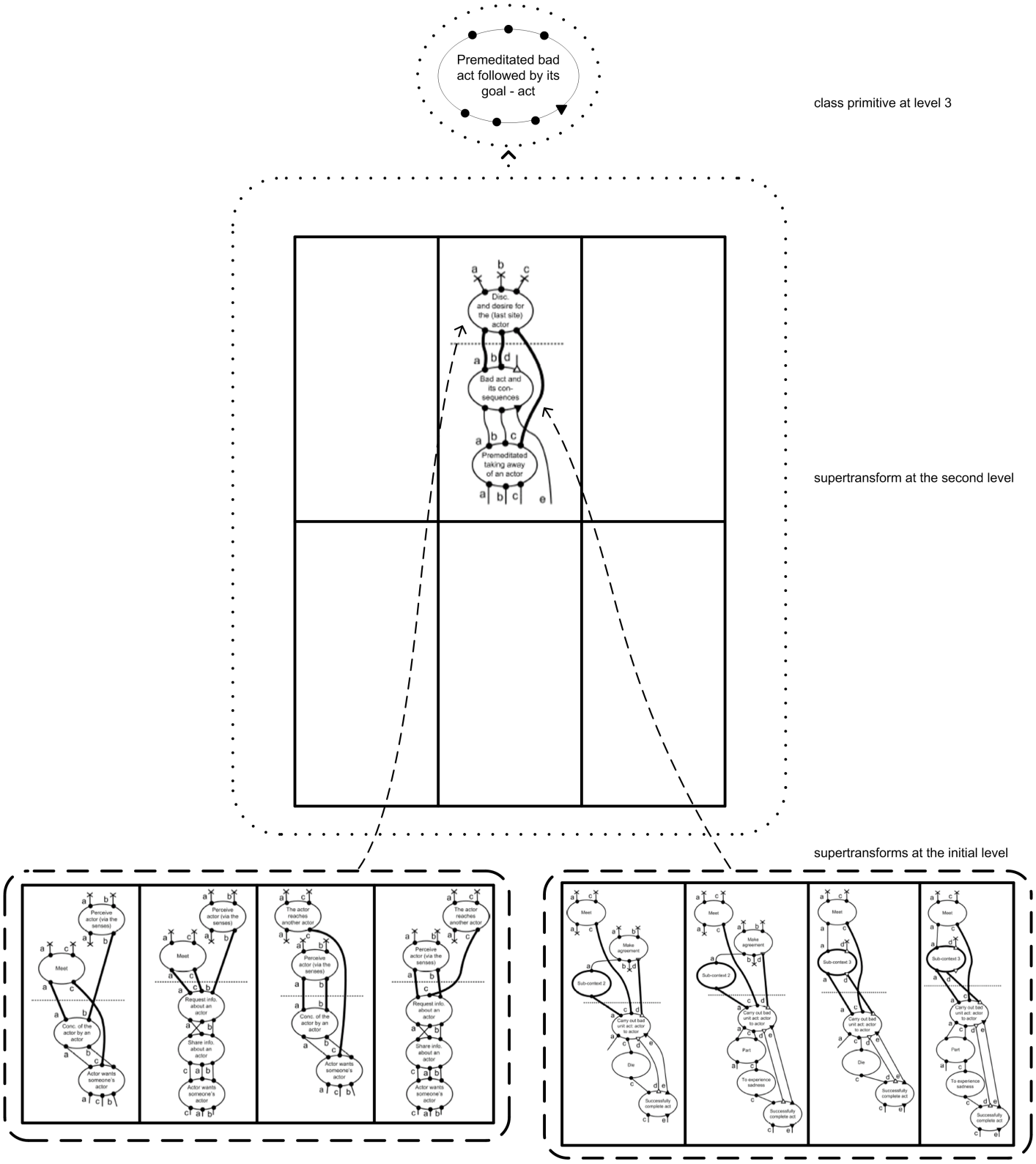

Figure 17: Pyramid view of a third level primitive: the pyramid should be thought of as being formed by the subordinate class supertransforms.

8 Conclusion

There are several points we want to emphasize. At this, still early stage, it appears to us that the ETS (event-based) representation is eminently suitable for representing fairy tales. This is mainly due to a good match between the ETS primitives and the fairy tale's elementary events, as well as due to the resulting explicitness of the representation. The good match is assured by the fact that the ETS formalism is *event-based* and allows one to capture temporal and structural relationships between events. Moreover, the concepts of transformation and supertransformation allow for a very natural introduction of levels of fairy tale representation, without which, it appears, no intelligent information system is possible. The structure of ETS, including the presence of levels, makes the advantages of this formalism over other conventional information retrieval formalisms quite apparent: the query can now be directed towards the right level and the right class.

How does one address the conventional information retrieval issues for the fairy tale database within the proposed framework? In other words, how does one proceed to retrieve the relevant fairy tale segments based on some query? First of all, a preprocessor should convert the query into an ETS struct, and second, the system would retrieve all relevant fairy tale segments/structs stored in the system. We believe that this (online) retrieval should be based on the structure of the set of classes present in the database (constructed offline). In other words, the retrieval should be class based: the system should display ordered class elements from the relevant classes. Although the details of such ETS algorithms have not been developed yet, a preliminary outline is presented in Part III of [3], and is a topic for future research.

Finally, we believe that the proposed initial level primitives are simple enough for a preprocessing system to build the ETS representation based on the fairy tale text. Otherwise, the structure of the primitives could be modified to match the capability of the existing preprocessing system.

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