TOWARDS A DISCOURSE LEVEL COHERENCE STRUCTURE

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Abstract: In this paper we argue that coherence relations between discourse units are ultimately based on mentioned discourse entities embedded in the units participating in the relation. Coherence relations as discussed in most literature ((Mann and Thompson, 1988), (Hobbs, 1985), (Grosz and Sidner, 1986) inter alia) are defined between text segments, where a text segment could range from a single utterance to the whole discourse. We show that these coherence relations are formed either directly or indirectly between embedded discourse entities. Other semantic entities might be derived via inference/s based on the mentioned entities and the complexity of these inferences determines some of the types of relations defined in literature. Hence, the coherence relations as defined by (Mann and Thompson, 1988), (Hobbs, 1985) inter alia, existing between text units is essentially an abstraction of these fundamental relations formed between embedded entities. We argue that any representation of discourse coherence structure should entail representation of information down to the resolution level of these embedded entities in order for such structures to be useful for automated language processing tasks. We also show that the commonly accepted tree structure ((Hobbs, 1985),(Marcu, 1996) inter alia) is not sufficient to represent discourse relations to such a resolution level, and propose a semi constrained directed graph as the alternative.

1 INTRODUCTION

A natural language discourse consists of a sequence of utterances which convey a meaning with the help of relations between the utterances, rather than solely on the basis of meanings of individual words and sentences. Hence, in order to fully comprehend the meaning, it is crucial to be able to identify these relations and then draw inferences based on them for meaning–making. This does not necessarily mean that the producer (writer or speaker) or the consumer (reader or the listener) is consciously aware of the these relations while progressing with the discourse. As the discourse progresses, relations are necessarily formed among a subset of embedded entities in the discourse which act as *discourse markers* in the minds of both the producer and the consumer. The producer has access to previously mentioned entities which he can use to overlap with new entities in order to build on the achievement of the discourse objective. The overlap of entities can be direct as in the case of the use of referrals or it could be indirect, embedded in layers of inferences as in the case of intention based relations described by (Grosz and Sidner, 1986). Even when coherence relations are based on semantic objects via inferences, the originating point for the inferences is one or more embedded discourse entities which we will refer to as *grounding entities*. This concept of entity based coherence relations is partially portrayed by backward looking links in the centering theory described by (Grosz et al., 1995) albeit only for consecutive utterances. Coherence relations in other studies (eg. (Mann and Thompson, 1988), (Hobbs, 1985),(Marcu, 1996), (Grosz and Sidner, 1986), (Webber et al., 1999)) are based on relations between some form of text units. Discourse continuity using overlap of entities has been demonstrated to be crucial in comprehension, as measured by reading times and recall, when successive sentences refer to the same entities (Gordon and Scearce, 1995). This affirms the theory that entities play a significant role in derivation of relations between discourse units to aid in comprehension. Studies in language production show that producers use reduced forms of entities such as pronouns and ellipsis to refer to entities that are locally in focus and use unreduced forms that are not ((Marslen-Wilson et al., 1982), (Fletche, 1984)). This aspect of continuity of reference and coherence is captured by (Grosz et al., 1995)'s theoretical framework for local coherence as centering theory. This theory defines semantic ob-

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jects as centers in discourse units (referred to as utterances in the theory) and these centers are linked between utterances to define coherence relations in the neighborhood. It applies an even stronger constraint of ”overlap” of the defined grounding entities to classify successive utterance as *shift*, *retain* or *continue* of local focus. (Grosz et al., 1995) use a notion of coherence relation between entities in successive utterances where an entity in a previous utterances is ”realized” (by a pronoun) in the next utterance. However, their centering theory framework does not provide any further categorization of these relations or provide any mechanism for extending it beyond successive utterances. On the other hand, (Mann and Thompson, 1988), (Hobbs, 1985) inter alia describe categories of relations existing between text units solely based on inferences acting on the semantics of the text unit as a whole. We propose that even though these relations hold between two text units, it has to be based on embedded entities therein, and should be identified in the inferencing process used to arrive at the relation.

Since the basis of relations in our theory is the presence of entities as discourse markers placed at the mercy of the discourse producer, we cannot assume a highly constrained hierarchical structure such as that used by proponents of tree structure (see (Marcu, 1996) for a discussion). The popularity of discourse representation using a tree structure seems to stem from the fact that trees are easier to process and formalize, however in doing so we are essentially trying to fit the contents of a container to its shape rather than designing a container to fit the contents. On the other hand we can represent a discourse using a purely unconstrained directed graph as suggested by (Wolf and Gibson, 2005), in which case, we can have infinite number of nodes and edges making it difficult and complex to process and formalize the graph. We believe that we need to have a representation which is in the middle, a constrained directed graph. In section 2 we discuss the entity based coherence relations and illustrate a constrained directed graph representation of some relations using a naturally occurring discourse in section 4.

2 COHERENCE RELATIONS AND ITS REPRESENTATION

For the purpose of this discussion let us define an utterance to be an independent clause, hence a sentence can consist of one or more utterances. A discourse consisting of multiple utterances is a linear arrangement of these utterances in some order as determined by the producer in a written discourse or both the producer and the consumer in an interactive discourse. The formed order of these utterances is determined by the relations between the utterances. We will classify a relation to be local if it exists between utterances in the same sentence or between utterances in adjacent sentences. Relations formed between utterances in sentences further then the previous sentence will be referred to as global relations. Relations will be represented with nodes as text units and directed lines (called edges) with the direction of the arrow pointing from the source to the destination entity/ies corresponding to the relation as shown in figure 1. Hence a coherence relation can also be expressed as a tuple:

rel_type (Source_Entities),(Destination_Entites)

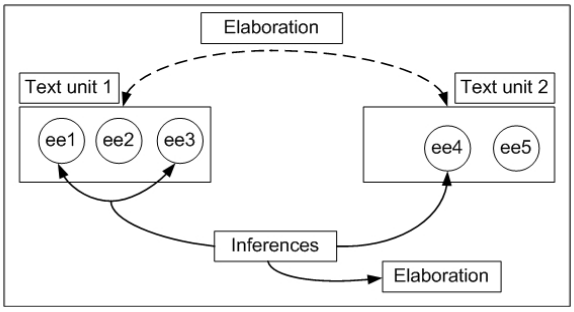

Figure 1: New and old (dotted line) definition of coherence.

Let us consider some utterances and derive coherence relations already established by studies such as (Mann and Thompson, 1988), (Hobbs, 1985), (Marcu, 2000) inter alia. In the simplest of cases the Source_Entity could be a name and the Destination_Entity could be a pronoun as shown in example (1).

1) (a) John did not go to school today.
   (b) He went to town with his friends.

In this example, according to (Hobbs, 1985), (Mann and Thompson, 1988) inter alia, there is an elaboration relation between text spans (1a) and (1b). We go on further to specify that the elaboration relation is based on the grounding structures ”John” and ”He” embedded in the text units. The elaboration relation is based on the ”John” and the second utterance is an explanation as to why he did not go to school. Identification and representation of the grounding entities ”John” and ”he” is crucial in relating these two utterances in the context of the whole discourse. For extract (1), the candidates for grounding entities are ”John”, ”school”, ”He”, ”town” and ”friends” and one has to use one or more rules to identify the grounding entities for the relation. The most common basis of coherence relations is overlapping of entities which can be used as the first rule for grounding entity identification, however as we will see in later examples, this is not necessarily the case all the time. In such cases we can define the rule to be; ”grounding entities are those that if removed from the text units would make it impossible to draw inferences used to arrive at the coherence relation”. This is a broad criteria for identifying the grounding entities for coherence relations that can be used in all cases and is illustrated throughout the paper with case examples.

2) (a) There were a lot of nails on the driveway.
   (b) John’s car’s tyre got punctured.

Although it is common to have pronouns, reduced noun phrases and repeated noun phrases as grounding structures, we can also have semantically different entities forming the grounding entities as shown by example (2) which would be defined to have a *cause-effect* relation. This *cause-effect* relation is built on the fact that nails on the driveway caused the puncture of the car’s tyre. Removing either nails or car’s tyre would make the *cause-effect* relation untenable and hence would form the grounding entities for the relation. Any other combination such as John and nails, car and driveway, car and nails etc. would not support the *cause-effect* relation hence, can not be considered as the grounding entities.

(Hobbs, 1985) poses a fundamental question, ”What makes a sequence of sentences in a span of text coherent?”. Frequently, a textual unit is considered coherent because it discusses about a series of events in the world. Is it enough for two sentences describing two events to be coherent if they are related temporally? (Hobbs, 1985) uses the example in 3 to illustrate that temporal succession on its own is not enough to establish a coherence relation.

3) (a) At 5.00 a train arrived in Chicago.
   (b) At 6.00 Ronald Reagan held a press conference.

Example 3 does not appear coherent in the first instance on the shear basis of temporal succession, however further assumptions can be made in order to make the units 3a and 3b coherent. For instance, Ronald Reagan could be holding a press conference regarding a maidan voyage of a new bullet train, or someone arrived in the train that had something to do with the press conference. In any case, the consumer has to make assumptions about the *grounding entities* in the text units before any coherence relation can be established. In the case when the grounding entities are not immediately apparent, the consumer has to try out the different combinations of entities like *train* and *Ronald Reagan*, *Chicago* and *Ronald Reagan* etc. and make inferences based on context and world knowledge. He can then choose the combination which the consumer considers most plausible which may not necessarily be the same as the one intended by the producer.

Consider the utterances in 4 from (Hobbs, 1985):

4) (a) Did you bring your car today?
   (b) My car is at the garage.

(Hobbs, 1985) describes the relation between 4a and 4b as *evaluation* where he defines an evaluation relation to be ”From S0 infer that S1 is a step in a plan for achieving some goal of the discourse.” Hence, for the case of 4, we can infer from sentence 4b that the normal plan for getting somewhere in a car wont work, and therefore the first sentence is a step in an alternate plan for achieving that goal. The *evaluation* relation formed between the two sentences (text units) is sufficient when analyzed in isolation as above but would present difficulties when it is analyzed embedded in a whole discourse among numerous other *evaluation* relations. Apart from shear identification of coherence relations it would not be possible to formulate any abstractions of these relations to the discourse level. For instance, there might be more coherence relations involving one or both instances of ”cars” further in the discourse as part of other coherence relations and these need to be identified as either same or different from the ”cars” in the previous coherence relations. Hence we define that coherence relations are based on one or more discourse entities embedded in the text units participating in the relation, which we will call *grounding entities*. In the case of the *evaluation* relation in extract 4, the grounding entities would be *car1* (your car) and *car2* (my car) which would be the two instances of entities from the superset *cars*. Identification of these grounding entities would enable us to distinguish this evaluation relation from other evaluation relations in the discourse and formulate constraints and rules on grounding entities for this relation participating in other relations in the discourse.

Grounding entities need to be embedded entities in the text units which includes ellipses as in the case of extract 5 from (Wolf and Gibson, 2005).

5) (a) If the new software works,
   (b) everyone should be happy.

In this case there is a *condition* relation between 5a and 5b. The entities that the *condition* relation is based upon is ”software” in both text units, but it is not mentioned explicitly in 5b. Hence grounding entities can also be elliptic objects.

Grounding entities need not be overlapping objects as shown in the example 6. There is a *cause-effect* relation as defined by (Wolf and Gibson, 2005) and the grounding entities are ”bad weather” in 6a and ”flight” in 6b.

6) (a) There was bad weather at the airport
(b) and so our flight got delayed.

The linear nature of a discourse constrains a producer to progress the discourse as a sequence of utterances. It might not always be possible to produce a complete discourse as a sequence of utterances with relations either to the previous utterance or the utterances in the previous sentence. In other words, the producer will need to shift from the continuation of the current theme and start off from another arbitrary point in the discourse. (Grosz et al., 1995) capture this notion of coherence in a very specific context by use of the term *instantiation* of a *center*. They classify the links between adjacent utterances in terms of *retain*, *continue* and *shift* in the local attentional state. If the subsequent utterances are about same centers (we call them entities) at the local level then the links between the utterances are either *retrain* or *continue* and if a subsequent utterance is about new center then there is a shift in the attentional state. We propose that this may be a shift at the local level but at the discourse level the utterance may form a link with an utterance which is an arbitrary number of utterances back in the discourse. These global links between non-adjacent sentences needs to be identified (in addition to the local ones) for one to be able to fully understand a discourse. This study uses a much broader set of relations based on the (Hobbs, 1985), (Mann and Thompson, 1988), (Webber et al., 2003) rather then the notions of *retain*, *continue* and *shift* by (Grosz et al., 1995).

3 ANATOMY OF COHERENCE

The coherence relations used in section 2 to illustrate significance of grounding entities have already been defined in various studies such as (Hobbs, 1985) and (Mann and Thompson, 1988), however there needs to be further refinement of these relations in order for them to be used for language processing tasks such as anaphora resolution. Consider the utterances in 7 consisting of two text units all of which can be defined to be in a *cause-effect* relation. Although the coherence relations in the utterances 7 are all same there are differences in the main entity/ies forming the basis of the relation which needs to be identified and represented in order for a discourse wide *entity map* to be constructed.

7) (a) John drove to the hospital because he was sick
(b) John drove to the hospital because Peter was sick
(c) John drove to the hospital because his son was sick
(d) John drove to the hospital because Peter asked him to.
(e) John drove to the hospital because everyone else was.

The cause-effect relations in 7 can be represented as the following tuples corresponding to each of the utterances from 7a to 7e :

Type A *cause-effect*{(e_1),(e_1)}

Type B *cause-effect*{(e_1),(e_2)}

Type C *cause-effect*{(e_1),(belong(e_1),(e_2))}

Type D *cause-effect*{(e_1),(event(e_1),(e_2))}

Type E *cause-effect*{(e_1),(part-of(e_1),(e_2))}

Type A describes the simplest of the cause-effect relations where the effect is caused by some action of the fsame entity. ie the "causer" is the same as the "experiencer". In the case of 7a, John being sick (cause) led John (experiencer) to drive to hospital. In the second case (*Type B*) "Peter", a unrelated entity, causes an effect on the experiencer, John. We will consider two entities to be related if the relation can be derived from surface level semantics without use of external, world or contextual knowledge. It can be argued that ultimately a relation can be defined between all entities in the universe and hence a coherence relation can be formed between any two text units. The complexity of inferences required to derive the relations can be used as a measure of the strength of relations between two entities (hence between text units) and is left as an open issue for further research. In the case of 7b, we need not know the explicit relation between "John" and "Peter" in order to be able to derive the *cause-effect* coherence relation, hence we will assert that "John" and "Peter" are unrelated and hence this forms *Type B* relation. In utterances 7c, 7d and 7e the *cause-effect* relation is effected indirectly via other entities related by entity-to-entity (*e-e*) relations. For instance, in 7c, the embedded "son" forms the basis for the *cause-effect* relation on the back of the *e-e* (*belong*) relation between the entities "John" and "son". Two other *e-e* relations (event and part-of) are illustrated but it is evident that this is not an exhaustive list as it is envisaged many others will be derived with more extensive case studies. In addition some entities are intrinsically related such as "tea" and "cup" and should be included in the list of *e-e* definitions.

The next logical step is to ask if the *Type* definitions for *cause-effect* relations extend to other types of coherence relations. To be able to illustrate it, we need to first define the set of coherence relations. The studies focussing on coherence and discourse structure (such as (Hobbs, 1985), (Mann and Thompson, 1988), (Webber et al., 1999), (Marcu, 2000) and (Wolf and Gibson, 2005)) broadly agree on a core set of coherence relations. The minor variations are mostly due to consideration of generality/specificity, for example, *evaluation* and *background* defined by (Hobbs, 1985) are both considered as *elaboration* by (Wolf and Gibson, 2005)). In other cases inclusion and exclusion of some types of relations such as inclusion of *attribution* by (Wolf and Gibson, 2005) The core set of relations as identified in most of the mentioned studies are *cause-effect*, *elaboration*, *condition*, *violated expectation*, *example*, *generalization* and *temporal*. Extract 1 discussed earlier is an example of exhibiting elaboration coherence relation where the grounding entities are "John" and "He", defined to be *Type A*. Similarly, extract 2 has grounding entities "nails" and "tyres" which don't have any relation without deeper level inferencing, hence would be a *cause-effect* relation of *Type B*. The *evaluation* relation in extract 4 would be a *Type D* since "My car" and "your car" are part of the superset "cars". Our analysis of coherence relations so far suggests that most coherence relations can be categorized into the *Type* definitions except some special case ones such as *attribution* defined by (Wolf and Gibson, 2005) which is meant to identify producers of direct and reported speech. Section 4 uses a naturally occurring discourse to illustrate representation of coherence relations, their *TYPE* and the corresponding grounding entities.

4 INTER-SENTENTIAL COHERENCE

A natural discourse such as a newspaper article is unstructured and is quite heavily dependent on the producer's writing style, context, the publishers beliefs among numerous other factors. Therefore, if we attempt to represent such an unstructured phenomenon with a highly structured data structure such as a constrained tree, we are bound to make approximations and as a consequence suffer loss of information in the process. (Wolf and Gibson, 2005) have provided empirical evidence of the unstructured nature of natural discourses in the form of nodes with multiple parents and crossed dependencies between nodes. In their research, (Wolf and Gibson, 2005) deal with identification and representation of coherence relations either within sentences or between text units in adjacent sentences. This did not necessitate any definition of any constraints as the number of relations between text units were limited. However, if we extend to representing relations between arbitrary text units in a discourse, we need some constraints in order to prevent combinatorial explosion of relations between text units. In other words, we are proposing definition and representation of a discourse structure which is less constrained then the commonly accepted tree structure but which is also not completely constraint-free as suggested by (Wolf and Gibson, 2005). Hence, lets define text units as nodes and directed arrows as edges connecting the nodes with a relation. The direction of the arrows will be used to identify, for instance, the cause and the effect in a *cause-effect* relation. Let us define the direction of the edges, similar to (Wolf and Gibson, 2005), as the following :

cause-effect direction from cause to effect.

elaboration direction from elaborated segment to elaborating segment.

condition direction from condition to consequence.

violated expectation direction from expectation to the violated effect.

example direction from segment being exemplified to the example.

generalization direction from the specific segment to the generalized segment.

temporal direction from the event occurring first to the event occurring next.

attribution direction from producer to the attributed segment.

Extract 8 is the beginning 5 sentences of an online article from New Zealand Herald which is segmented into text units along similar lines as (Wolf and Gibson, 2005). We also used coherence relations from the set used by (Wolf and Gibson, 2005) which is based on a superset proposed by (Hobbs, 1985), however the actual set of coherence relations is immaterial for the purpose of this paper.

8) (a) A man has been charged with aggravated robbery and wounding with intent to cause grievous bodily harm after
  (b) an 85-year-old war veteran was attacked last week.
  (c) Veteran Eric Brady was left with severe bruising and broken jaw bones after
  (d) the attempted carjacking in Papatoetoe.
  (e) Detective Sergeant Shaun Vickers of the Counties Manukau Crime Squad said
  (f) an 18-year-old Manukau City resident was arrested yesterday on unrelated charges and
  (g) later charged over the assault.

(h) He will appear in Manukau district Court on Monday morning.
(i) Mr Vickers said
(j) Mr Brady's family had been informed and
(k) he was grateful for a "great deal of valuable information from the public"

The directed graph in figure 2 show local (r1 to r5) as well as global (R6 to R11) relations for the text units in 8. The coherence relations defined are based on embedded entities in the text units hence it is possible to distinguish between the elaboration relations R7 which is based on the grounding entity "veteran" while the elaboration relation R8 is based on "man". Figure 2 also shows the set of coherence relations with *unification* of the grounding entities. Unification was done by identifying and labeling all the unique entities with a name (usually with the name used for its first occurrence). This effectively involves resolving all referrals in the discourse. In figure 2, all instances of "man", "resident", and pronouns referring to "resident" were replaced with "man". This enables one to identify threads of text units which participate in the same type of coherence relations throughout the discourse. For the case of figure 2, there is a thread consisting of units a, f, g and h about the entity "man" and another thread consisting of units b, c and j about "veteran".

The coherence relations in figure 2 also illustrate the need for some level of constraints. For instance, the relation R9 is from the immediately previous text unit (g) instead of the other possible units (f and a). Hence we define the first rule to be :

Rule 1. A coherence relation should be defined between nearest text units.

This rule effectively forms a chained link between text units traversing through the discourse hence restricts multiple coherence relations of the same type based on the same grounding entity/ies in a text unit. For instance, there can not be two text units elaborating on the same grounding entity. In the case where there are multiple elaboration relations of the same grounding entity, Rule 1 would force the text units to be chained rather then form multiple branches from the same node. Therefore rule 2 is :

Rule 2. There can not be more than one coherence relation of the same type from a text unit based on the same source grounding entity.

It should be noted that Rule 2 does not restrict one to have a coherence relation of a different type based on the same grounding entity. For instance there could be a *cause-effect* relation as well as an *elaboration* relation based on the same grounding entity/ies, however these relations need to be extending to different text units. We cannot have two different coherence relations between two text units which are based on the same grounding entity/ies. In some cases more than one type coherence relations might be apparent, in which case we will choose the more specific one out of the lot. As we will discuss later, the set of coherence relations can be categorized into a taxonomy where for instance, the relation *elaboration* is a superset of all other types of relations. Hence Rule 3 can be defined as :

Rule 3. There can not be more than one coherence relation between two text units.

5 DISCUSSION

Although the existence of coherence relations is generally accepted among linguists and computational linguists, the number, nature and the taxonomy of the relations are controversial issues. Coherence relations vary from deep relations buried under multiple layers of inferences to surface level syntactic ones. In addition the relations could be located on approaches such as the intentions the writer had when he wrote the text ((Grosz and Sidner, 1986)), the effect the writer intends to achieve ((Mann and Thompson, 1988)) and the cognitive resources the reader uses to process the discourse ((Sanders, 1992) among others. Even though the approaches to coherence structure may vary between the discourse theories, most of them either explicitly or implicitly propose using a tree as a good mathematical abstraction for coherence representation. Although we subscribe to a tree being an appropriate structure to represent a well organized and planned discourse such as an essay or a book, it is inadequate for shorter discourses such as newspaper articles and dialogues. Semi-planned discourses such as newspaper articles are usually based around a limited set of entities and these entities keep reappearing, usually abruptly, in multiple places in the discourse. Representing this characteristic with a hierarchical tree structure is infelicitous. The first 5 sentences used to illustrate the directed graph representation in figure 2 is also represented as a tree in figure 3 for comparison. The sub-trees *a–b*, *e–g* and *i–k* can be considered to be representation of local coherence relations which contains the same information as the directed graph structure. The difficulty arises in the representation of global relations R6 to R11 in figure 2. If the text unit *h* is considered to be an elaboration of units *e–g*, then it is represented as such in the sub-tree *e–h*. This might well be sufficient for some discourse processing applications but for other applications such as pronoun resolution we need a finer grained represen-

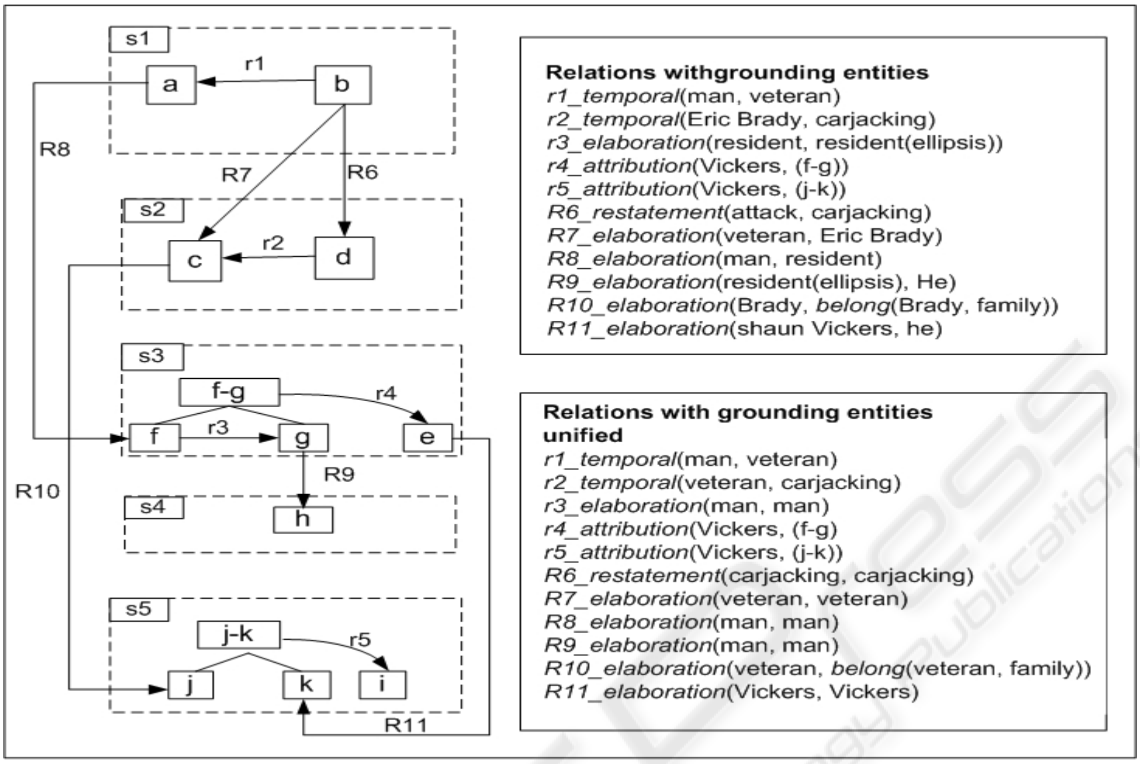

Figure 2: Directed graph representation of the extract in 8. The sentences are labeled from S1 to S5 broken into text units corresponding to extract 8.

tation. The directed graph on the other hand is able to represent the elaboration relation with a focus on unit *h* and *g* instead of the much bigger source text unit, *e–g*. The directed graph on the other hand represents the elaboration relation with a focus specifically on unit *g* and *h*. The tree representation is essentially hierarchical with subsequent sub-trees joining as new branches to the existing tree embedding the text units deeper in the tree. Hence, the relations are formed between larger and larger conflated text units. For a large document the level of this embedding may be so deep neutralizing any usefulness the information. The popularity of discourse representation as a tree seems to be due to the familiarity of the data structure in terms of its generation, traversal and analysis of its efficiency calculation because of its use in numerous other applications. This is not to say that the tree structure is absolutely infelicitous to the discourse coherence3 representation. In fact larger, more planned discourses are fairly well modeled along hierarchical lines and a tree would be an adequate representation if the goal of the application demands coherence relations only between larger spans of text units. Shorter discourses such as newspaper articles are more chaotic in terms of planning and organization and making a a highly organized data structure such as a tree. (Wolf and Gibson, 2005) have also discussed the felicity of directed graphs for coherence data structure, however, they advocate a completely constraint-free graph. The absence of any constraints can explode the number of relations, especially at a global level making it almost impossible to formalize the processing and traversal of the graph. They provide empirical data for showing the existence of crossed dependencies between text units as well as text units being part of multiple destination coherence relations (they call this nodes with multiple parents). Their results show that while crossed dependencies is prevalent in small amounts in most types of relations, it is especially high for *similarity* (33.18 %) and *elaboration* (50.52 %) of relations. Wolf et al argue that a possible explanation for this could be that the two types of relations are more frequent hence have a high participation in cross dependency relations. (Knott, 1996) on the other hand hypothesizes that this is due to the *elaboration* relation being less constrained then the other types of relations. In fact both Wolf's and Knott's hypothesizes indirectly evaluate to the same thing. That is, if a relation is less constrained then we can define more of them between a given set of text units hence the increase in its frequency as well as the frequency of participation in crossed dependen-

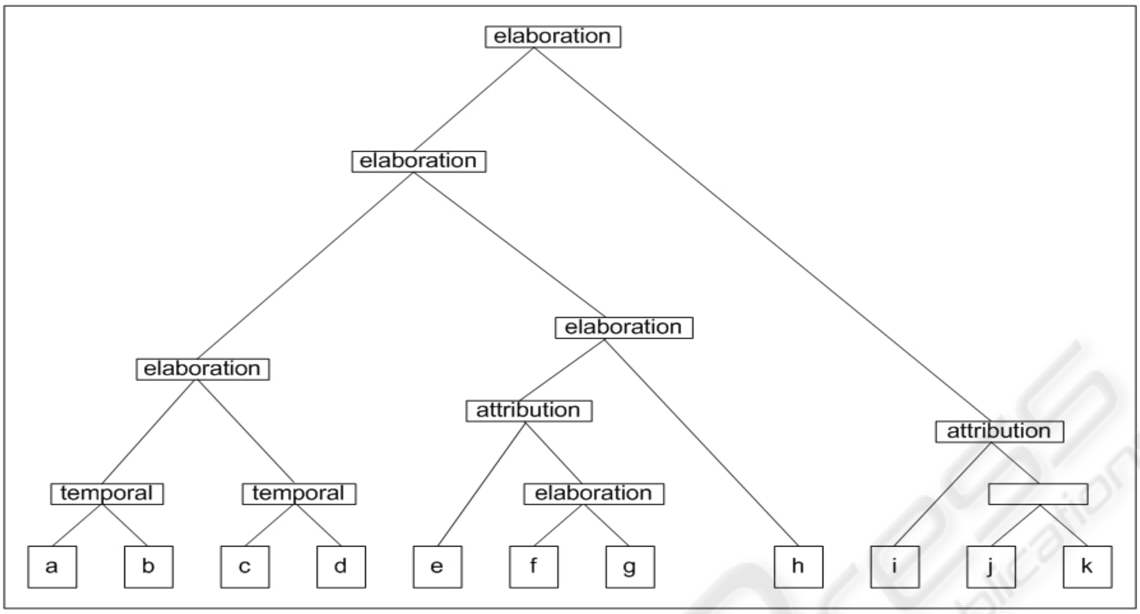

Figure 3: Tree representation of the extract in 8.

cies. The existence of crossed dependencies can well be represented using directed graphs (as illustrated by (Wolf and Gibson, 2005)) but difficulties arise when using these for natural language processing tasks such as traversal from a node with multiple outgoing paths. The three rules defined in section 4 restricts Wolf's definition of constraint-free graph to a chained structure of similar relations based on same *grounding entities* traversing through a discourse. This enables one,for instance, to trace all elaborations of an entity through a discourse. These threads can be used for tasks such as document summarization and pruning of candidates in pronoun resolution tasks.

6 CONCLUSIONS

We have presented the case for representation of a discourse coherence structure using a directed graph instead of the commonly accepted tree structure. However the directed graph cannot be completely constraint-free as presented by (Wolf and Gibson, 2005) since this can lead to an explosion of crossed coherence relations especially at the global level. Hence, we have presented an approach in the middle, with definition of three rules and inclusion of *grounding entities* which enables us to derive and store coherence relations with sufficient level of resolution required for language processing tasks such as pronoun resolution and document resolution. We have also shown that coherence relations can also be divided into various categories depending on the source and destination grounding entities.

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