Integrating FrameNet in NIF

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1 Introduction

FrameNet (FN) [6] is a large-scale linguistic resource developed at Berkeley. It describes word senses and the situations they can play in ("valences") in terms of frames, frame elements and the links between them. **Frames** represent real-world situations (eg `frame:Statement` means to make a statement), the **lexical units** (LU) that invoke them (eg `lu:announce.v, lu:declare.v`), and the **frame elements** FE, i.e. things and entities that play a role in them (eg `fe:Speaker.statement, fe:Message.statement, fe:Time.statement`).

FN has been converted to Linked Open Data (LOD) by ISTC-CNR [4], together with a large corpus of text annotated with FN.

The Manually Annotated Sub-Corpus (MASC) [5] also includes FN and [3] describes plans to interlink it with LOD. However, the MASC download page does not include LOD (RDF) formats.

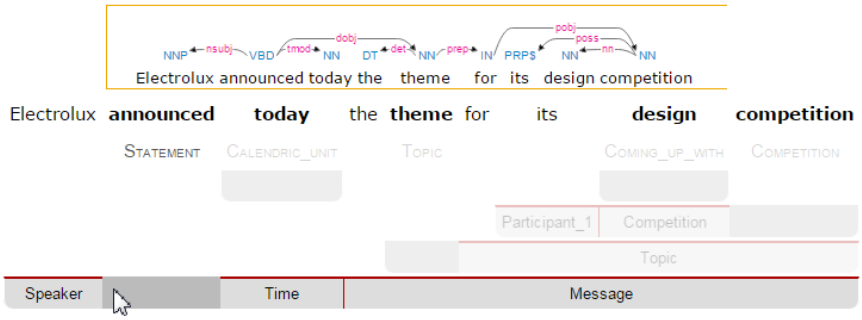
The MultiSensor project (MS) applies semantic technologies to analysis of media including news articles. MS has standardized on using the NLP Interchange Format (NIF) for data exchange, in order to faciliate interoperation and extensibility.

NIF [2] is an RDF based format for exchanging Linguistic Linked Data (NLP and related). It involves a number of ontologies, including NIF for binding to text and packaging, ITS for Named Entity Recognition (NER), OLIA for NLP information, MARL for sentiment/opinion, etc.

This paper reviews the FN-LOD representation and describes a possible way to integrate FN in NIF, proposed to be used in MultiSensor.

1.1 Sample Sentence

In this paper we'll consider the sample sentence "Electrolux announced today the theme for its design competition". 3 softwares are available for automatic FN annotation: Shalmaneser, LTH and SEMAFOR. We'll use SEMAFOR to perform automatic FN annotation of the sentence. SEMAFOR uses a dependency parse (shown on top) to generate candidate frames for the sentence (shown on the bottom). Here we have highlighted the `Statement` frame, invoked by `lu:announce.v` and having FEs `Speaker`, `Time` and `Message`. The other candidate frames are dimmed out.



It may be easier to see the candidate frames in SEMAFOR's vertical layout. Here each column represents a frame:

	Statement	Calendric_unit	Topic	Coming_up_with	Competition
Electrolux	Speaker				
announced	Statement				
today	Time	Calendric_unit			
the	Message				
theme			Topic		
for			Topic		
its					Participant_1
design				Coming_up_with	Competition
competition					Competition

SEMAFOR also offers a JSON format (`./SEMAFOR.json`) where one can see the candidate frames and their targets (LUs) and FEs. It also includes a `score` for each frame, which can help to pick the best frames

frame	Statement	Calendric_unit	Topic	Coming_up_with	Competition
score	113.2	30.4	25.4	50.7	54.6

Indeed in this case the two top-scoring candidates (`Statement` and `Competition`) are the best frames. `Calendric_unit` is too small (equal to `lu:Time.statement`), `Coming_up_with` is wrong, and `Topic` is also part of the bigger frame.

1.2 FrameNet

Frames are developed from real-world linguistic attestations. Eg the annotations of `lu:announce.v` include about 80 sentences of varying phrase forms.

Colors show the different FE's.

Frame Element	Core Type
Addressee	Extra-Thematic
Containing_event	Extra-Thematic
Degree	Extra-Thematic
Depictive	Extra-Thematic
Event_description	Extra-Thematic
Frequency	Extra-Thematic
Group	Extra-Thematic
Internal_cause	Extra-Thematic
Iteration	Extra-Thematic
Manner	Peripheral
Means	Peripheral
Medium	Core
Message	Core
Occasion	Extra-Thematic
Particular_iteration	Extra-Thematic
Place	Peripheral
Speaker	Core
Time	Peripheral
Topic	Core
Viewpoint	Extra-Thematic

Frames are extensively documented. Eg the documentation for Statement includes:

- Definitions for each FE (classified as Core, Non-Core and Extra-Thematic)
- "Coreness sets", i.e. which FE alternatives are required to realize the frame. In this case there are two core sets: `{Message, Topic}` and `{Medium, Speaker}`. This means that either `Message` or `Topic` is required; and either `Medium` or `Speaker` is required.
- Frame relations, which include inheritance, using, subframe, causative/inchoative, etc. These are similar to Use Case relations but richer.

Frame relations can be visualized with FrameGrapher:
`./img/FN-grapher.gif`

Eg this figure for `Statement` shows that:

- The frame `Statement` is inherited by: `Complaining, Predicting, Reading_aloud, Recording,` (red arrows)
- `Statement` uses: `Communication` (green arrows)
- `Statement` is used by: `Adducing, Attributed_information, Chatting, Judgment_communicat` (green arrows)
- The FE relations between `Statement` and `Telling` are also shown, together with their Core (c) or Non-Core (nc) status. Eg `fe:Addressee.statement` is Non-Core (you can make a statement without addressing anyone in particular), but `fe:Addressee.telling` is Core because you have to tell *someone*.

2 FN Ontologies

The OWL ontology representation of FN is described in the paper [4], but a lot of technical details are missing, so one has to read the FN Book [6] to understand the ontologies.

- There is a partial ontology diagram in the paper, but it doesn't show all classes and relations
- Some elements are comments extensively using texts from the FN Book, but I have found I understand them better by reading the book, since these comments don't capture the context.
- Many elements are not documented, eg class `fn:Header`, data property `fn:frame_cBy` (xsd:string), etc. One can only surmise that it's the ID of the person who created the frame.

In this section I describe the available FN ontologies and RDF data files, provide diagrams to facilitate understanding, and derived files that are easier to consume.

2.1 Prefixes

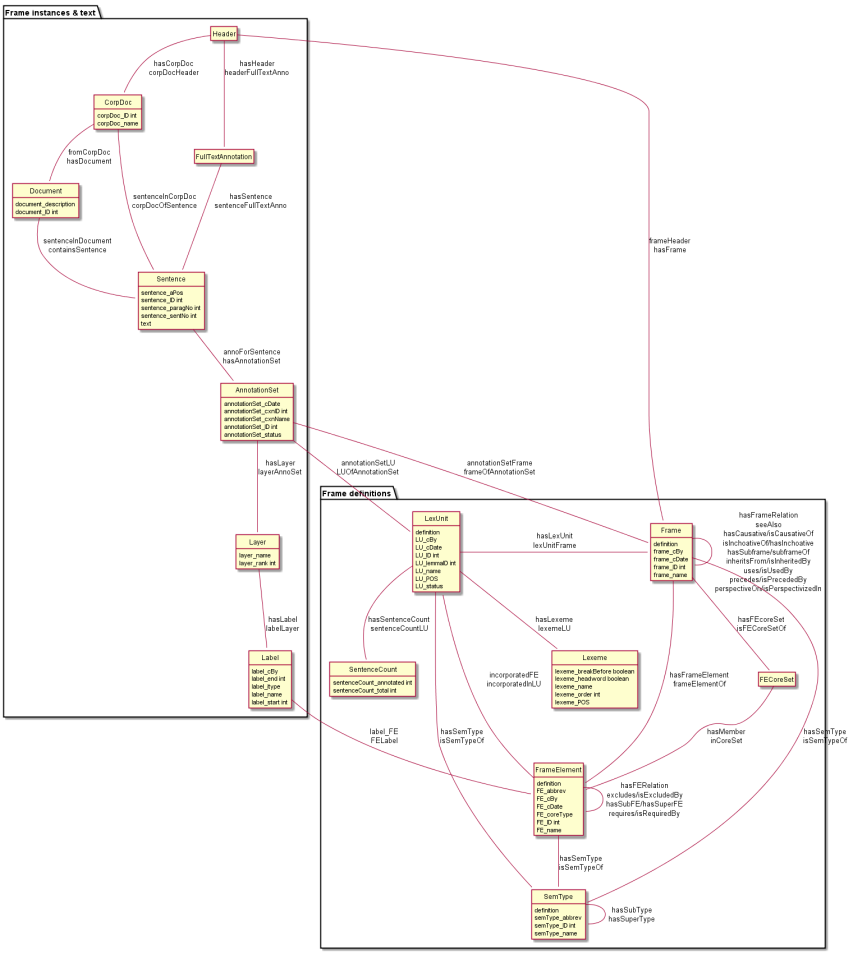
FN uses the following prefixes. I have started registering them in `http://prefix.cc` (one can submit only one prefix per day). All prefixes used by MS are available in `./prefixes.ttl`.

prefix	URL	description
fn:	`http://www.ontologydesignpatterns.org/ont/framenet/tbox/`	FN metamode
frame:	`http://www.ontologydesignpatterns.org/ont/framenet/abox/frame/`	frame
fe:	`http://www.ontologydesignpatterns.org/ont/framenet/abox/fe/`	frame element
lu:	`http://www.ontologydesignpatterns.org/ont/framenet/abox/lu/`	lexical unit
st:	`http://www.ontologydesignpatterns.org/ont/framenet/abox/semType/`	semantic type

2.2 fntbox ontology

Th FN "terminology box" fntbox is the FN metamodel. It's an OWL ontology that uses Restrictions extensively, and is easiest to understand in Manchester notation: `./fntbox.omn`. It has 16 Classes, 67 ObjectProperties, 49 DataProperties. Online documentation (made with OWLDoc) is available.

Most relations have inverses, which actually hinders the understanding of the "hierarchy" of data. I made a diagram showing all classes (source file `./fntbox.puml`), their relations (object properties) and fields (data properties). For some properties I figured out the range from Restrictions; properties having a Union as domain are shown several times on the diagram.



Some notes about the most important classes (mostly coming from the FN Book). We navigate top-down and split the classes in two groups. First are classes that represent texts and their annotation with frame instances and other linguistic info:

- `Header` holds together all `FullTextAnnotation` and `CorpDoc` about the same frame

- `FullTextAnnotation` represents a mode of annotation where sentences are "preselected" by a given text
- `CorpDoc` is a corpus comprising of documents and sentences that are carefully chosen by lexicographers to illustrate the possible valences of LUs, i.e. make various frames for each sense of each LU
- `Sentence` holds the `text` being annotated and some identifying information
- `AnnotationSet` is a set of annotations about one frame. One sentence may have several frames and they may even overlap
- `Layer` is a subset of annotations with a single purpose, indicated in `fn:layer_name`. Often used ones:
  - **Target**: LU that is target of the frame. Such layer has a single label
  - **FE**: frame elements
  - **PENN**: part of speech (eg VBD, VVN, dt, nn)
  - **PT**: phrase type (eg NP, AJP, PP, PPing)
  - **GF**: grammatical function (eg Ext, Obj, Dep, Comp)
  - **NER**: named entity recognition (eg person, location)
- `Label` is a word or phrase in an annotated `Sentence` (indicated by index `label_start, label_end`) that:
  - Plays the role of LU instance. This is indicated by `fn:label_name` being "Target", and it's the single `Label` in a layer having the same `fn:layer_name`
  - Or plays the role of FE instance. In this case `fn:label_FE` points to the FE definition (eg `fe:Speaker.statement`) and `fn:label_name` corresponds (eg "Speaker")
  - Or carries a grammatical or POS tag in `label_name`
  - Or indicates a lexically omitted FE (see [6] sec 3.2.3 Null instantiation) using `fn:label_itype` (eg "CNI", "DNI", etc), in which case `label_start, label_end` are omitted

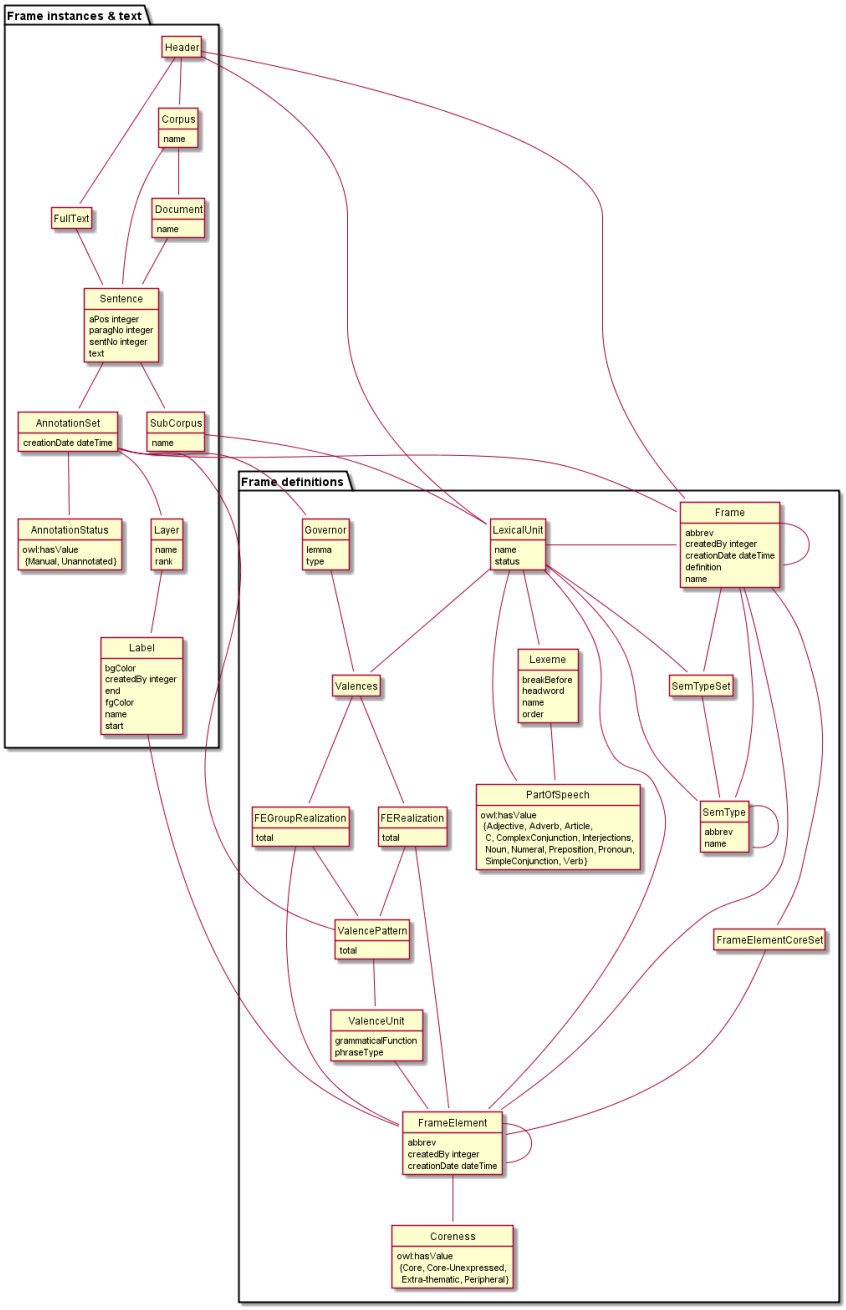
Then are frame definition classes:

- `Frame` is a structure that abstracts over real-world situations, obtained through linguistic attestation
- `LexUnit` is the head-word of a sentence or sub-sentence that invokes the frame. An important goal of the FN project is to capture the meaning of words through annotated examples, that's why the LU can point to an `AnnotationSet` that supports it. It can also carry simple statistics (`SentenceCount`) used for managing the work of annotators
- `Lexeme` is the linguistic representation of a LU. One LU can have several lexemes
- `FrameElement` are entities (things, actors, times, messages, etc) that participate in a frame. They are classified with `FE_coreType` into Core, Core-Unexpressed, Extra-Thematic, Peripheral
- `FECoreSet` describes a set of alternative FEs, one of which must be present in the frame. A frame can have several core sets
- `SemType` classifies frames, FEs and LUs by type. Eg some sem types are:
  - for Frame: Non-perspectivalized_frame, Non-Lexical_Frame
  - for FE: Sentient (an agent), Artifact, Message, State_of_affairs

2.3 framenet ontology

framenet is an alternative version of fntbox. It is significantly more complex: 33 Classes, 71 ObjectProperties, 23 DataProperties, and 18 Individuals. I converted it to Manchester notation (`./framenet.omn`).

I also made a diagram (source file `./framenet-nolabel.puml`), which elides the edge labels to avoid clutter:



The diagram with edge labels is also available but is nearly unreadable: ./img/framenet.png (source file `./img/framenet.puml`)

This ontology perhaps corresponds better to the FN Book. But since it

is not used in the two files described below, I do not give it further consideration.

2.4 fnabox ontology

The FN "assertion box" fnabox is an RDF representation of all frame definitions. It includes only individuals, not classes nor property definitions. It used some illegal URI chars (spaces and parentheses) that I converted to underscores (eg `lu:swing__into_.v` instead of `lu:swing_(into).v`). Then I converted it to readable turtle where all individuals are sorted by name and all statements about an individual are together.

Eg the statements about `frame:Statement` are:

```
frame:Statement
  fn:hasFrameElement fe:Time.statement, fe:Iteration.statement, fe:Medium.statement, fe
    fe:Means.statement, fe:Message.statement, fe:Speaker.statement, fe:Topic.statement
    fe:Degree.statement, fe:Addressee.statement, fe:Depictive.statement, fe:Internal_ca
    fe:Group.statement, fe:Occasion.statement, fe:Particular_iteration.statement, fe:Fr
  fn:hasLexUnit lu:gloat.v, lu:explain.v, lu:declaration.n, lu:talk.v, lu:admission.n,
    lu:contention.n, lu:statement.n, lu:proposition.n, lu:preach.v, lu:pronouncement.n
    lu:speak.v, lu:propose.v, lu:proclamation.n, lu:allegation.n, lu:exclaim.v, lu:conj
    lu:confirm.v, lu:add.v, lu:proclaim.v, lu:insist.v, lu:address.v, lu:report.n, lu:a
    lu:contend.v, lu:assert.v, lu:claim.n, lu:maintain.v, lu:denial.n, lu:conjecture.n
    lu:mention.n, lu:claim.v, lu:report.v, lu:hazard.v, lu:affirm.v, lu:assertion.n, lu
    lu:profess.v, lu:admit.v, lu:deny.v, lu:mention.v, lu:affirmation.n, lu:concession
    lu:suggest.v, lu:reiterate.v, lu:proposal.n, lu:comment.n ;
  fn:isInheritedBy  frame:Telling, frame:Reveal_secret, frame:Recording, frame:Complain
  fn:isUsedBy  frame:Unattributed_information, frame:Adducing, frame:Judgment_communica
    frame:Chatting ;
  fn:uses frame:Communication .
```

Statements about a couple of the core FEs in that frame:

```
fe:Speaker.statement a fn:FrameElement ;
  fn:hasSemType  st:Sentient ;
  fn:hasSuperFE  fe:Speaker.speak_on_topic , fe:Speaker.encoding , fe:Communicator.comm
fe:Message.statement a fn:FrameElement ;
  fn:hasSemType  st:Message ;
  fn:hasSuperFE  fe:Message.encoding , fe:Message.communication , fe:Message.body_mover
```

2.5 fndata

fndata_v5 is a corpus or FN annotations provided in RDF by ISTC-CNR. It's 540Mb RDF or 292Mb Turtle or 1.03Gb NTriples, and comprises 3.8M triples. It includes 5946 sentences and 20361 frame instances (`annotationSetFrame`), i.e. 3.4 frames per sentence. The info about each sentence takes 640 triples on average; about a quarter of these are pure frame instance info (45 triples per frame).

I extracted all triples about `iran_missile_fullTextAnnotation_sentence_52` into file `./iran_missile_sentence_52.ttl`. This is sentence 3 of paragraph 10 of a fullTextAnnotation corpus named "iran_missile" and says:

This project was focused on the development of a longer ranged (150 - 200 km) and more heavily armed version of the Israeli Gabriel anti - ship missile (not as sometimes reported with the development of a ballistic missile based upon Israeli Jericho surface - to - surface missile technology) .

Extracting the triples was easy to do since the URLs of nodes in these triples share the same base:
`http://www.ontologydesignpatterns.org/ont/framenet/abox/nti__iran_missile_fullTextAnnot`

This file played a crucial role in allowing understanding the structure of FN RDF data and the meaning of most fields (see the **fntbox** diagram and field descriptions above).

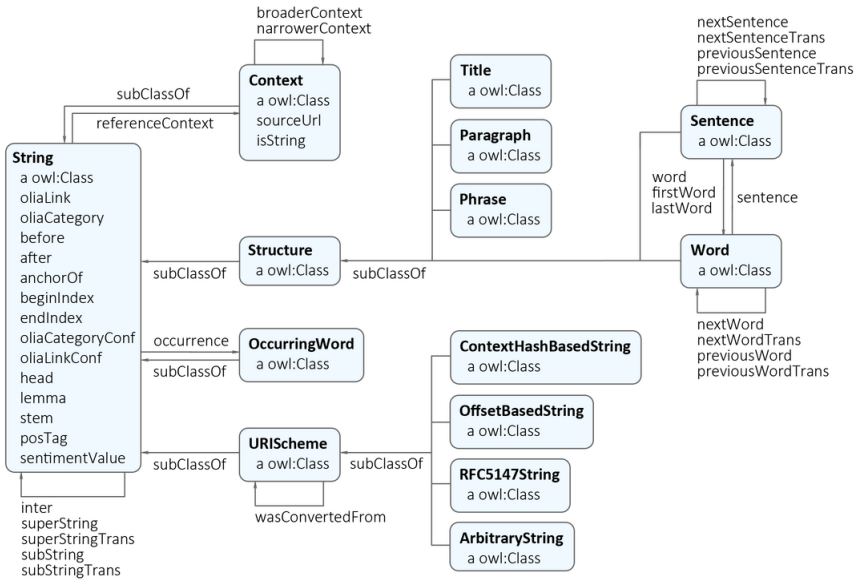
- This subset includes 6 manually annotated frames: *Gizmo*, Bearing_arms, Cause_to_make_progress, Cause_to_make_progress, Project, Type
- SEMAFOR reports these frames (except *Gizmo*), and a number of smaller frames (often consisting of a single word): Artifact Cardinal_numbers Degree Duration_attribute Frequency Increment Part_inner_outer Part_inner_outer Place_weight_on Range Statement Vehicle Weapon Weapon Weapon

"Gizmo" is invoked by this phrase: "*surface - to - surface missile **technology***". It is not recognized by SEMAFOR probably because it may have an older set of frame definitions.

3 Comparing FN to NIF

Since our goal is to integrate FN to NIF, we'll start with a comparison between the two. We presuppose the reader knows NIF. See [2] for a description of NIF, and [1] for a brief overview of NIF and related ontologies. An extensive bibliography is available on Zotero.

The basic NIF class and property diagram is below. Compare it to sec 2.2



Namespace nif: <http://persistence.uni-leipzig.org/nlp2rdf/ontologies/nif-core#>

3.1 Text Framing

Document is the basic level at which there is correspondence between FN and NIF: `fn:Document` and `nif:Context`. The text is stored in `fn:text`, respectively `nif:isString`.

Higher than document, FN has `fn:CorpDoc` or `fn:FullTextAnnotation` (two kinds of corpora). NIF uses `nif:Context` for this as well, using `nif:broaderContext` to point to higher-level contexts. However, I am not aware of NIF data actually using this property.

Below document, `fn:Sentence` is the basic FN level to which frames are attached. Then follow `fn:AnnotationSet, fn:Layer, fn:Label`. Char offsets are attached to `fn:Label: fn:label_start, fn:label_end`. NIF uses a generic class `nif:Structure` with subclasses `Paragraph, Sentence, Phrase, Word`, etc. Char offsets are specified at each level (`nif:beginIndex, nif:endIndex`). One can also provide the text at this level (`nif:anchorOf`), though this is redundant because `referenceContext/isString` is mandatory and contains the full text.

3.2 Text Links

Every NIF string (`Paragraph, Sentence, Phrase, Word` etc) must point to the enclosing context (`nif:referenceContext`). NIF has property `nif:subString` (and inverse `nif:superString`) that can be used to point uniformly from higher level texts to lower level texts (eg from Paragraph to Sentence to Phrase to Word). However it is not often used. There is also a specialized property `nif:word` (inverse `nif:sentence`) that points from a sentence down to its words; but it is not declared as specialization of `nif:subString`. One can also make chains of sentences (`nif:previousSentence, nif:nextSentence`) and words (`nif:previousWord, nif:nextWord`), and point to the first/last word of a sentence.

In contrast, FN has non-uniform treatment of links: to navigate from `Sentence` to its strings (`Label`), one has to follow the property path `entenceInDocument/annoForSentence/hasLayer/hasLabel`.

3.3 Text Nodes

FN doesn't recommend any convention for the URLs of text nodes, but you can see a pattern in sec 2.5. Eg `iran_missile_fullTextAnnotation_sentence_52_:annotationSet_6_` is the URL of label 0 in layer 2 in set 6 of sentence_52 (which is actually sentence 3 of paragraph 10 of the fullTextAnnotation corpus. Note: labels, layers and sets use only even numbers in this representation). This label represents the phrase *surface - to - surface missile* (from offset 282 to 253) representing `fe:Use.gizmo` of `frame:Gizmo`. This convention makes labels **relative** to annotation sets (frame instances), and indeed this is borne out by the fntbox class diagram (sec 2.2).

In contrast, NIF strongly recommends to adopt a URL scheme that is based on character offsets and is thus **global** within the document (`nif:Context`). The class `nif:RFC5147String` provides such a scheme. If the base is set to the Context URL, the above phrase would be addressed like this, where `<>` is the context.

```
<#char=282,253> a nif:Phrase; nif:referenceContext <>.
```

The reason is to ensure interoperability between different NLP tools that all output NIF format over the same text. Using a uniform node addressing scheme ensures that the triples produced by the different tools will "mesh" together.

This is perhaps the most significant difference between FN and NIF:

- FN defines Labels "as needed" by linguistic annotation, and locally. Several Label nodes can point to the same piece of text (offsets in the document). Labels are not shared between different annotations (NLP features).
- NIF typically defines Strings for every word and sentence of the document, globally. Each piece of text is represented by one node (but of course, Words overlap their containing Phrases and Phrases overlap their containing Sentences). Several NLP features can be attached to this node:
  - `nif:oliaLink` for syntactic individual
  - `nif:oliaCategory` for syntactic class
  - `its:taIdentRef` for Named Entity individual
  - `its:taClassRef` for Named Entity class (typically NERD is used for this purpose, eg nerd:Organization); etc

One could use the "NIF Stanbol" profile to associate several annotations with the same String. But:

- This complicates the representation
- It uses completely different properties, eg `fise:entity-reference` instead of `its:taIdentRef` and `fise:entity-type` instead of `its:taClassRef` (I have raised an issue against the NIF ontology about this)
- The MS project has standardized on using the **NIF Simple** profile

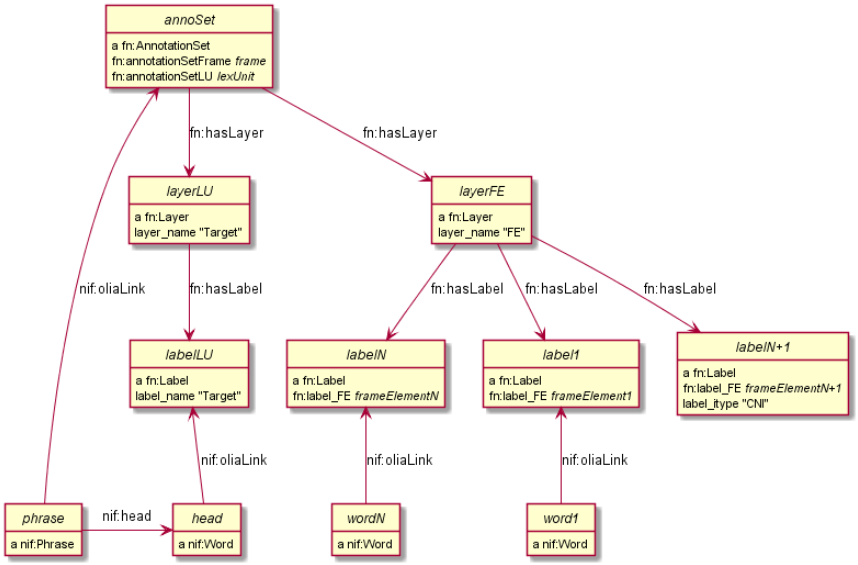
So it is preferable to continue to use the **NIF Simple** profile, and associate several annotations with a single word/phrase by using several `nif:oliaLink` properties.

4 Integrating FN in NIF

As we have seen in the previous section, the FN and NIF models for representing annotated text are totally different. Therefore I propose to represent the minimum possible FN nodes, and point to them from `nif:String` using `nif:oliaLink`.

The proposed representation to integrate FN in NIF is as follows. Let *phrase* have head-word *head* that corresponds to some *lexUnit*, which invokes *frame*. That frame has elements *frameElement1..N*, corresponding to

word1..N (these can be words or phrases, but for simplicity I assume words). Just for illustration, assume the frame has a lexically omitted FE *frameElementN+1* of type "CNI".



Notes:

- The easiest way to understand the representation is to think of `fn:AnnotationSet` as **frame instance** and think of `fn:Label` as **FE instance**.
- There are links between *frame*, *lexUnit*, and *frameElementN* that I don't show for simplicity. They are part of the frame definition, not frame instance
- I don't use `fe:label_start` and `fe:label_end` because those would duplicate `nif:beginIndex` and `nif:endIndex` unnecessarily
- The same word could participate in several frames (as LU or FE), in which case it will have several `nif:oliaLink`
- The lexically omitted FE (of type "CNI") has no corresponding NIF node. Nevertheless, it is a full participant in the frame
- *word1..N* are of course connected to *phrase*. I could show this with `nif:superString` but that is not often used: `nif:dependency` or specific dependency parsing properties are used. Eg in MS, UPF generates deep dependency parsing properties `upf-deep:deepDependency` (TODO ref)

Unfortunately the connection from *head* to the corresponding *lexUnit* is very indirect and goes through 3 intermediate nodes. The nodes *labelLU* and *layerLU* carry no information except the fixed string "Target". But to be faithful to the fntbox ontology (sec 2.2), we have to represent it this way.

4.1 A note on inverses

As shown in sec 2.2, fntbox has an inverse for each property. However, the designers of the PROV ontology have concluded that inverses actually harm interoperability by exerting a higher cost to achieve it:

> *When all inverses are defined for all properties, modelers may choose from two logically equivalent properties when making each assertion. Although the two options may be logically equivalent, developers consuming the assertions may need to exert extra effort to handle both (e.g., by either adding an OWL reasoner or writing code and queries to handle both cases). This extra effort can be reduced by preferring one inverse over another.*

I agree with them and therefore recommend to use exactly the FN properties shown above, and **not** their inverses.

4.2 Querying FN NIF

FN in NIF represents a fairly complex graph structure. In this section I show a few queries to extract data from that graph. I use SPARQL property paths (including inverses) liberally and indicate the input parameter of a query with `$`. I don't bother to check the types of intermediate nodes, relying that the specific FN properties will occur only on appropriate nodes.

Find all frames of a document (nif:Context) together with the corresponding `fn:AnnotationSet`

```
select * {
  $context ^nif:referenceContext/nif:oliaLink ?annoSet.
  ?annoSet fn:annotationSetFrame ?frame}
```

Find the LU corresponding to a head-word (if indeed it is the head-word of a frame-annotated phrase)

```
select * {
  $head nif:oliaLink [fn:label_name "Target"; ^fn:hasLabel/^fn:hasLayer/fn:annotationSe
```

Find all frames of a sentence together with the corresponding `fn:AnnotationSet`. As mentioned above, `nif:subString` is not often used to point out the phrases of a sentence. More often, `nif:word` is used to point out the words of a sentence (that is the practice in MS anyway). So we cannot find the `fn:AnnotationSet` of a phrase directly: we have to go a through one of the words. Here we use `filter exists` over all words, another option would be to look only for the head-word (`fn:label_name` "Target").

```
select * {
  filter exists {$sentence nif:word/nif:oliaLink/^fn:hasLabel/^fn:hasLayer ?annoSet}
  ?annoSet fn:annotationSetFrame ?frame}
```

4.3 Representing the Sample Sentence in FN NIF

In this section I represent the sample sentence from sec 1.1 as NIF, adding FN annotations. `./fe-nif.ttl` represents all SEMAFOR candidate frames, and below I reproduce only the biggest frame `Statement`. This example is largely due to Gerard Casamayor (UPF)

5 Acknowledgements

This work is part of the MultiSensor project that has received funding from the European Union under grant agreement FP7 610411. Gerard Casamayor (UPF) has driven the FN annotation in MS, provided the motivation for this paper, and discussed alternative representations using custom properties.

Class diagrams are made with PlantUML.

6 References

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