Sentiment Analysis meets Linguistic Linked Data

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Hello!

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1.
Introduction

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2. Background
3. Why: Use cases
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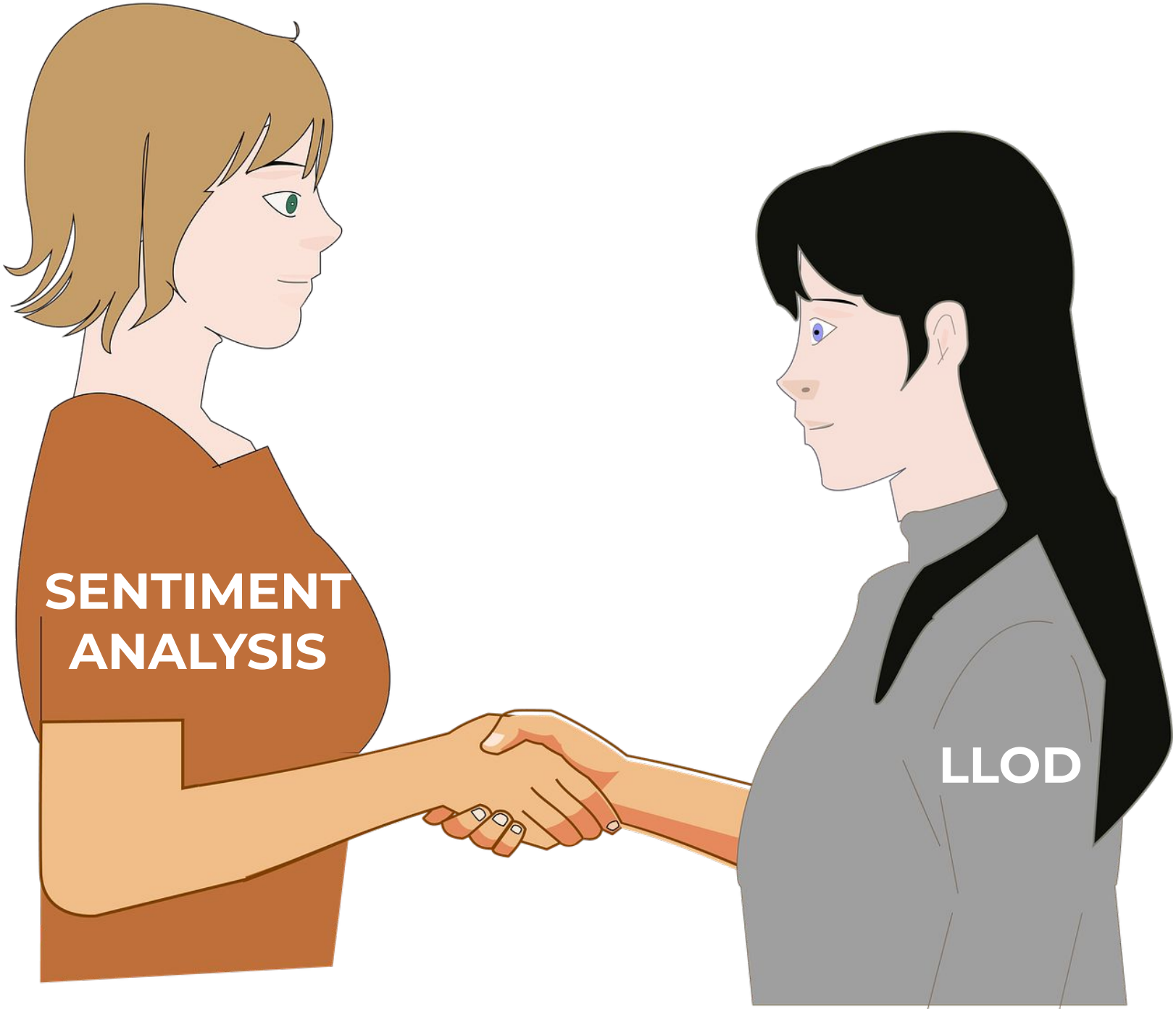
SENTIMENT ANALYSIS
LLOD

Areas of Affect Computing

- Multimodal emotion detection
  - facial expression
  - body gesture analysis
  - speech analysis
  - physiological monitoring
- **Sentiment and Emotion recognition** in texts
- Simulating Emotions

Source: https://recfaces.com/articles/emotion-recognition

Case study: TripAdvisor Review

Taberna 1941 Claimed

1,223 reviews | #7 of 1,463 Restaurants in Zaragoza | ££ - £££, Seafood, Mediterranean, Spanish

Calle Martires 2 Calle Martires Nº 2, 50003 Zaragoza Spain | +34 876 28 51 39 | Website | Menu | **Open now:** 08:30

COVID-19 update: See the added health and safety measures this property is taking.

Reserve a table — thefork

2 | Sun, 8/29 | 20:00

18:00	18:30	19:00
19:30	20:00	20:30
21:00	21:30	22:00

Esra E
Tripoli, Libya
7 6

Reviewed 16 May 2021 via mobile

Best restaurant in Zaragoza

Best restaurant in Zaragoza, Such an amazing food and hospitality, the chef Fatema was great cooker , the food so tasty we had ordered tuna salad with tomatoes and another one with a Anchovies they were amazing, starter dish was octopus with paprika it was so nice, last and amazing main dish which i really recommended to every one is grilled Monk fish, un forgettable dish so nice and amazing i was feeling full and eat becouse it was tasty, my kids had great time and food felt full..
We asked the waiters to thanks the chef, and it was very nice from the chef Fatema she came to our dining table and thanking us.

Show less

Date of visit: May 2021

Ask Esra E about Taberna 1941

Thank Esra E

CASE STUDY

Sentiment Analysis

Taberna 1941 Claimed

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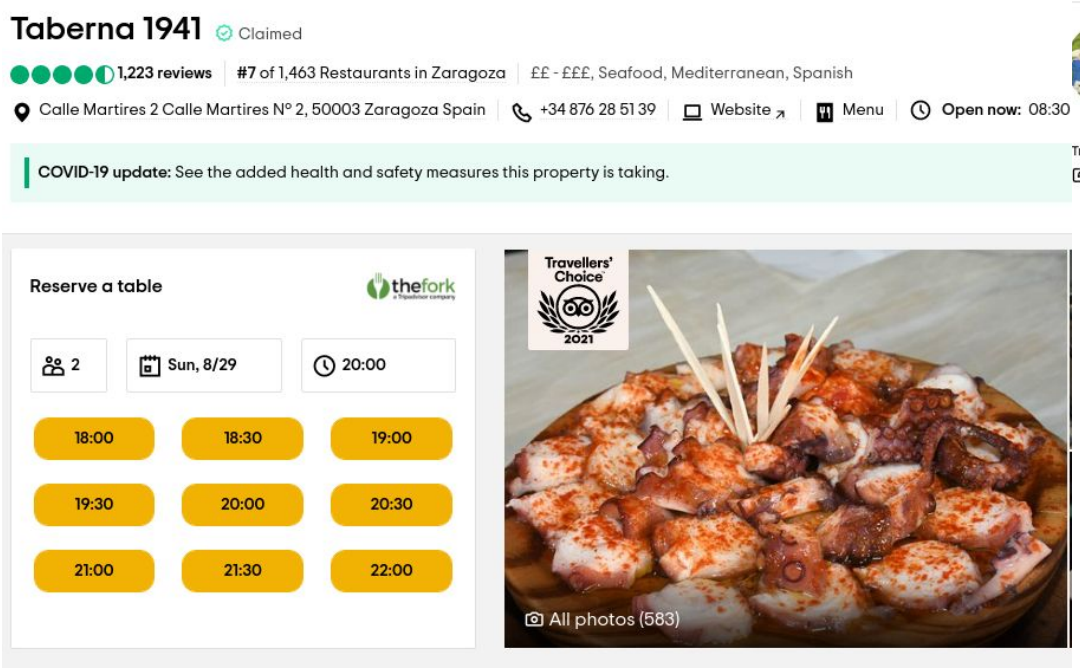
Ask Esra E about Taberna 1941

Thank Esra E

🙂 or ☹️ ?

Aspect-based Sentiment Analysis



Service ✓

Food ✓ ✓ ✓

🙂 or ☹️ ?

Emotion Analysis

Taberna 1941 Claimed

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Ask Esra E about Taberna 1941

Thank Esra E

Sentiment Language resources

WORDNET

SentiWordNet

WordNet-Affect

ANEW

SenticNet

LIWC

SemEval

Sentiment Services

Sentiment140

VADER

GATE general architecture for text engineering

meaning cloud

expert.ai

kopernica

Toloka

Komprehend

IBM Watson

sas

Microsoft Cognitive Services

Google Cloud

Linguistic Linked Open Data (LLOD)

- Freely accessible interoperable and interlinked language resources
- LLOD cloud [Bosque-Gil et al, 2018; Khan et al. 2021]:
  - **Corpora (and Linguistic Annotations)**
    - NLP Interchange Format (NIF) [Hellmann et al., 2013]
    - Web Annotation
  - **Lexicons and Dictionaries**
    - OntoLex-Lemon Model[Cimiano et al. 2016, McCrae, 2017]
  - **Terminologies, Thesauri and Knowledge Bases**
    - SKOS
  - **Linguistic Resource Metadata**
    - Ontolex-Lemon lime
  - **Linguistic Data Categories**
  - **Typological Database**

Motivation: Sentiment-LLOD

- Plethora of opinionated data
  - Mostly short text, prone to **ambiguity**
- Popularity of sentiment analysis
  - **Heterogeneous ad-hoc formats**
    - for services and language resources
  - Diversity of emotion models: interoperability
- Multimedia
  - **Fusion**
  - Heterogeneous **formats** and **models**

Challenges for Sentiment & Emotion

[Denis et al., 2013]

- **Interoperability**
  - Language resources (lexica and corpora)
  - Services
  - Polarity values
  - Emotion models
- Provenance
- **Domain** dependence
  - Machine learning algorithm dependence
  - Prior polarity dependence
  - Emotion model dependence
- Multi-modal **fusion**

Prior vs contextual polarity

[Wilson et al. 2009]

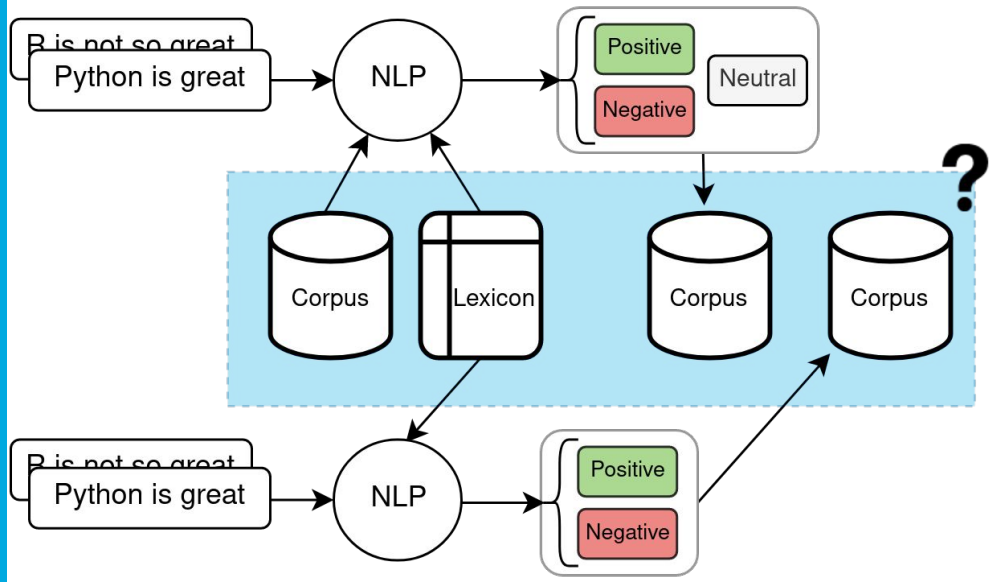
- Most Sentiment analysis lexical resources provide only prior polarity:
  "cold beer" or "cold pizza"

ID	PosScore	NegScore	# SentiWordNet
01251128	**0**	**0.75**	**cold#1**

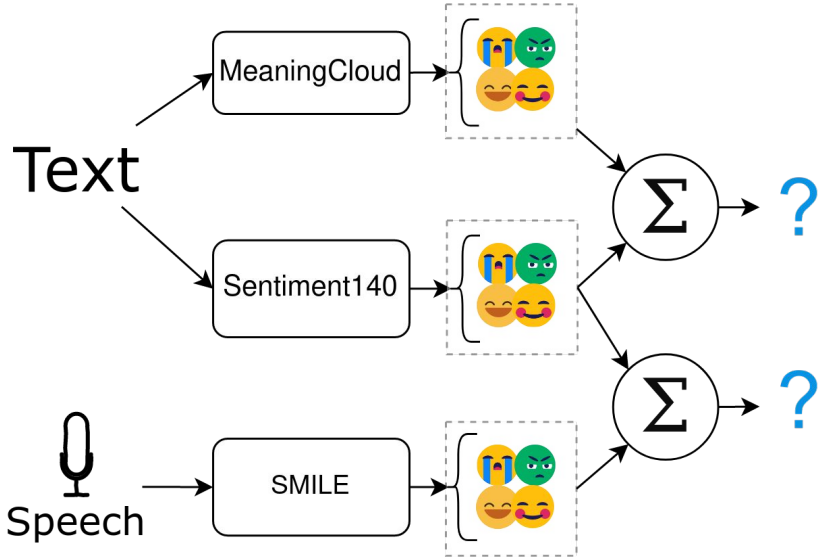
having a low or inadequate temperature or feeling a sensation of coldness or having been made cold by e.g. ice or refrigeration; "a cold climate"; "a cold room"; "a cold beer", ...

- Context can influence the polarity. E.g.
  - Domain, Target (Entity)
  - Negation: it is not good (valence shifter)
  - Multiple opinions (The hotel is good but the room is small), multiple holders, ...

Goal



Common format for
language resources



Common format for
sentiment and emotion **services**

2. Background

1. Introduction
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   - **2.1. LLOD**
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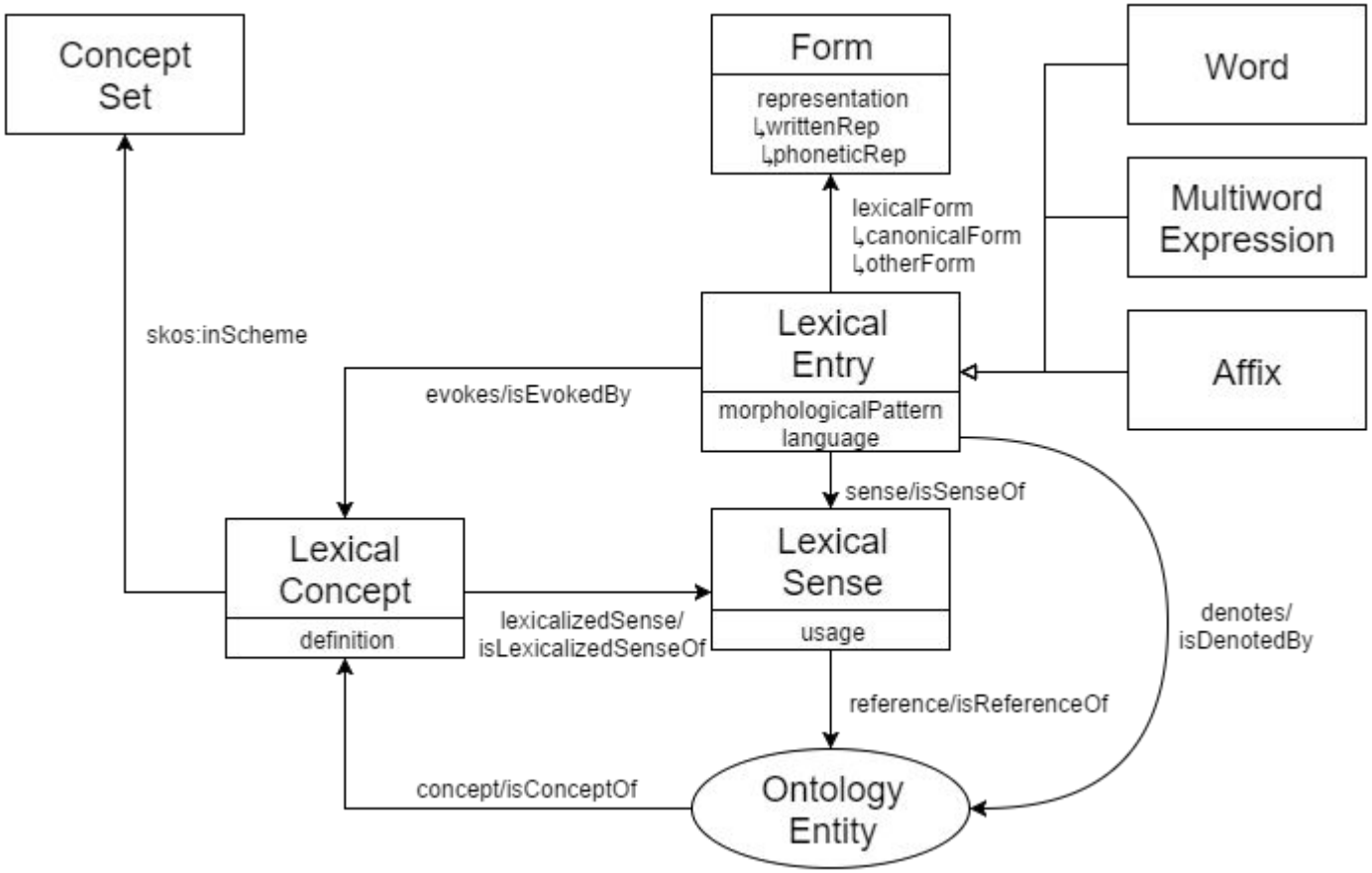
Lemon OntoLex Core [Cimiano et al. 2016]



Lemon Ontolex Modules

- Syntax and Semantics (**symsem**)
  - Mapping syntactic frames into ontology constructs
- Decomposition (**decomp**)
  - Define components of multiword lexical entries (LE)
- Variation & Translation (**vartrans**)
  - Relations (variation & translation) between LEs
- Metadata (**lime**): number of entries, senses, ...
- Lexicography (**lexicog**): building dictionaries
- New modules
  - Etymology; Morphology; Frequency, Attribution and Corpus Information (FrAC), ...
- Tools: Web
  - Web App - **LexO** [Bellandi, 2021]

NIF [Hellmann et al., 2013]

- **URI Schemas** to identify parts of text
  - Avoid ambiguity
  - Enable **fusion**
- Two parts
  - Annotations
  - REST **API** for services

Guidelines for developing NIF-based NLP services

Final Community Group Report 22 December 2015

Example [Hellmann et al., 2013]

"My favourite actress is Natalie Portman."

Tokenizer

```
<#char=3,12>
 a nif:String, nif:RFC5147String, nif:Word;
 nif:anchorOf              "favourite";
 nif:referenceContext      <#char=0,>;
 nif:beginIndex            "3";
 nif:endIndex              "12".
```

Snowball Stemmer

```
<#char=3,12>
 nif:stem          "favourit".
```

Stanford Core NLP

```
<#char=3,12>
 nif:oliaLink        <http://purl.org/olia/penn.owl#JJ>;
 nif:oliaCategory    <http://purl.org/olia/olia.owl#Adjective>;
 nif:lemma           "favorite". [sic]
```

DBpedia Spotlight

```
<#char=3,12>
 itsrdf:taIdentRef <http://dbpedia.org/resource/Favourite>;
 itsrdf:taConfidence "0.10"^^xsd:decimal.
```

Integration through merged RDF

```
<#char=3,12>
 a nif:RFC5147String, nif:String;
 a nif:Word;
 nif:anchorOf          "favourite";
 nif:referenceContext  <#char=0,>;
 nif:beginIndex        "3";
 nif:endIndex          "6";
 nif:stem              "favourit";
 nif:oliaLink          <http://purl.org/olia/penn.owl#JJ>;
 nif:oliaCategory      <http://purl.org/olia/olia.owl#Adjective>;
 nif:lemma             "favorite";
 itsrdf:taIdentRef <http://dbpedia.org/resource/Favourite>;
 itsrdf:taConfidence "0.10"^^xsd:decimal.
```

@base <http://example.org/prefix>

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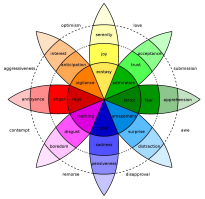
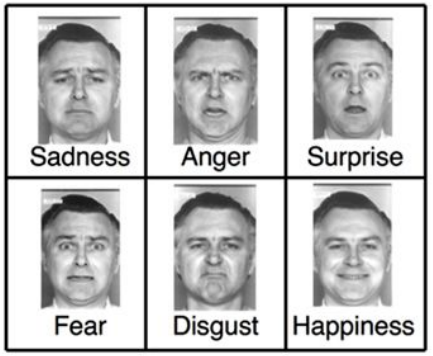
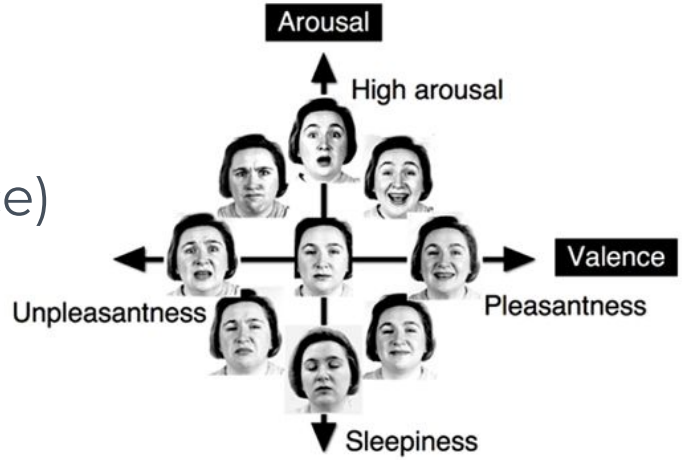


Interoperability: emotion models

- **Categorical**
  - *Ekman's* big 6 [Ekman, 1972]
  - Plutchik's wheel [Plutchik & Conte, 1997]



- **Dimensional**
  - VAD (Valence-Arousal-Dominance) [Russell and Mehrabian, 1977]
  - FSRE [Fontaine et al., 2007]



3.
Why: use cases

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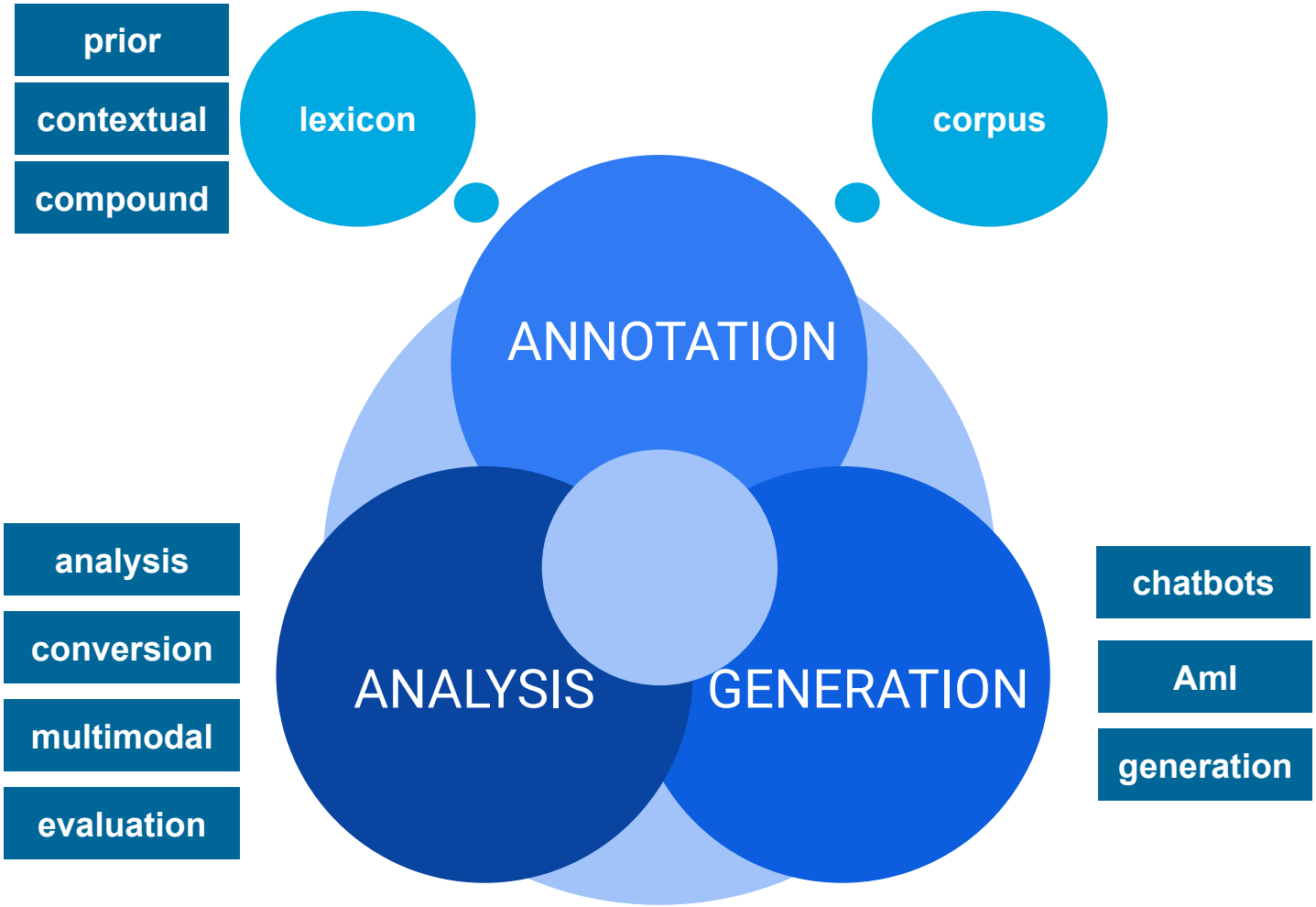
Main use cases



4.

How? Main approaches

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Emotion Representation formats

- EmotionML [Burkhardt et al., 2013]
- WordNet-Affect [Strapparava & Valitutti, 2004]
- Semantic approaches
  - W3C CG LD Models for Sentiment & Emotion Analysis
    - Marl [Westerski et al., 2011]
    - Onyx [Sánchez-Rada et al., 2009]
  - HEO [Grassi, 2009]
  - Semantic (SKOS) versions of LIWC, WN-Affect
  - OntoEmotions [Francisco et al. 2007]
  - ArsEmotica [Patti et al. 2015]
  - SenticNet [Cambria, 2020, Dragoni et al., 2018]
  - Chinese Emotion Ontology [Yan et al., 2008]
  - Japanese Emotion Objects' ontology [Ptaszynski, et al., 2012]

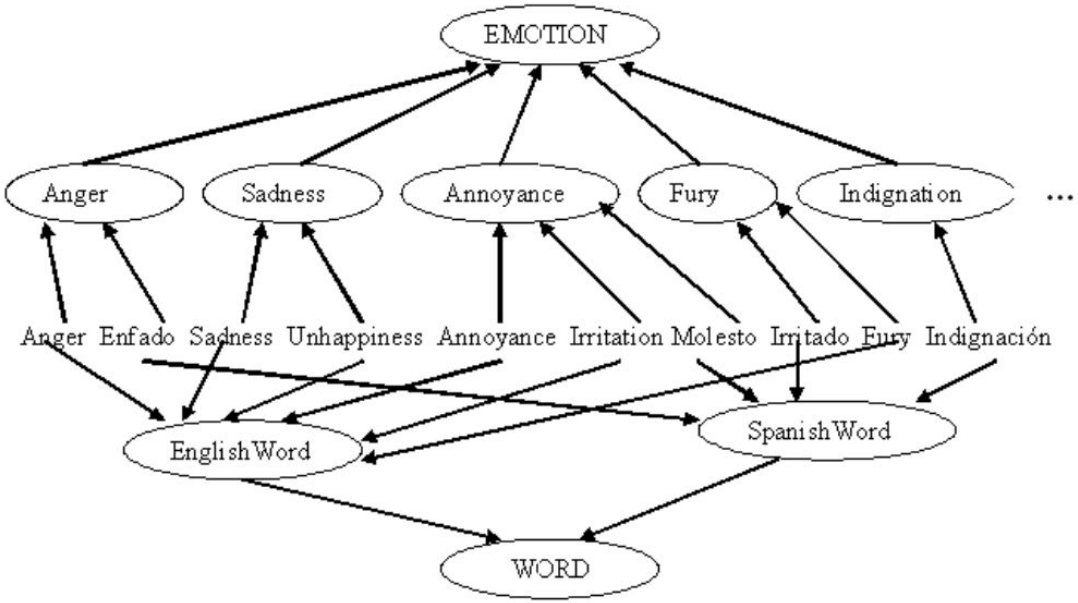
EmotionML [Burkhardt, F. et al. 2014]

- W3C recommendation for
  - Manual **annotation** of emotions of contents
  - Automatic **recognition** of emotions
  - **Generation** of emotion-related responses
  - **Annotation** of emotions and related states
- Metamodel
- Vocabularies for emotion theories
  - 14 defined in https://www.w3.org/TR/emotion-voc/

```
<emotion>
        <category name="Disgust" value="0.82"/>
        ‘Come, there’s no use in crying like that!’
</emotion>
```

OntoEmotions & EmoTag

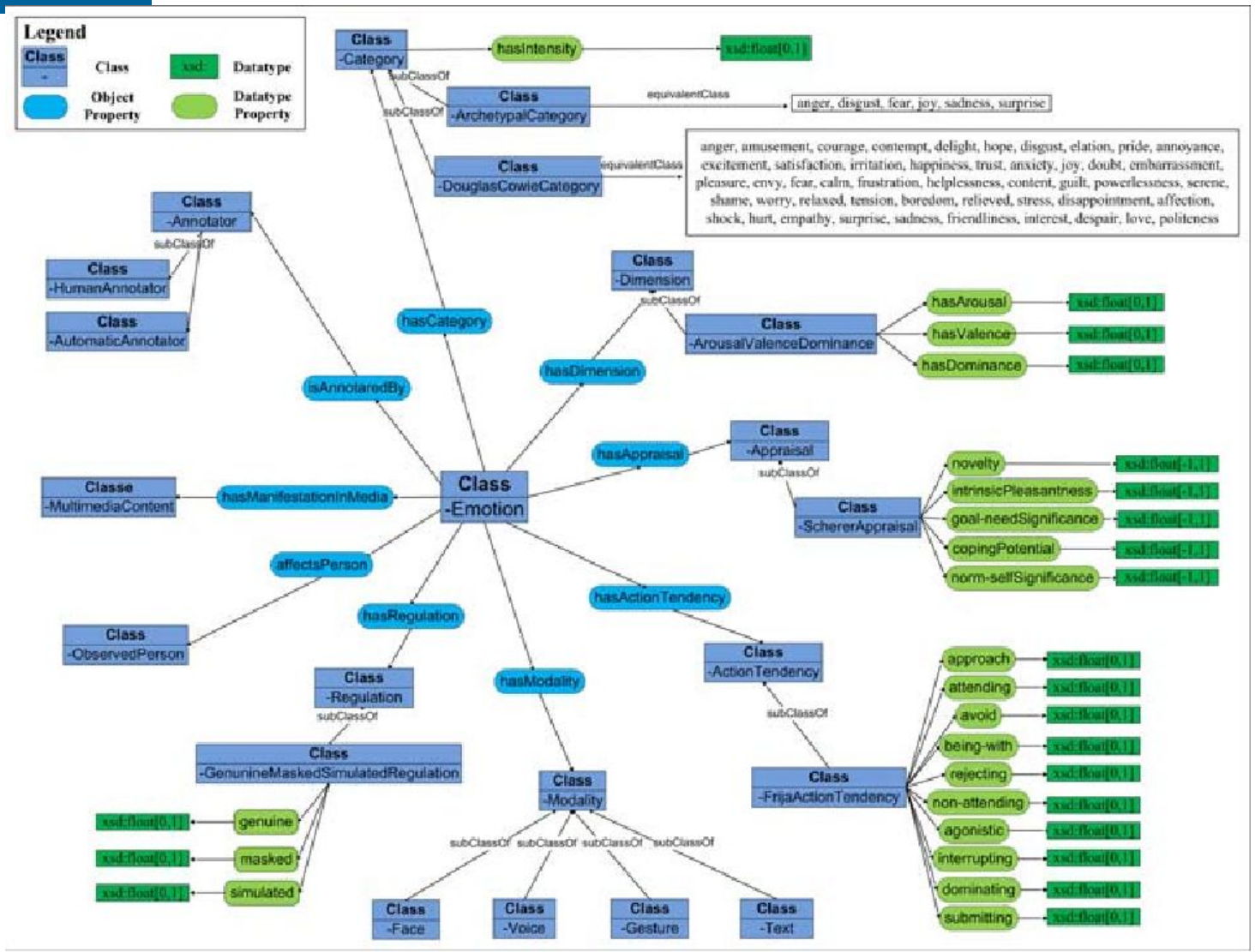
[Francisco et al. 2007]



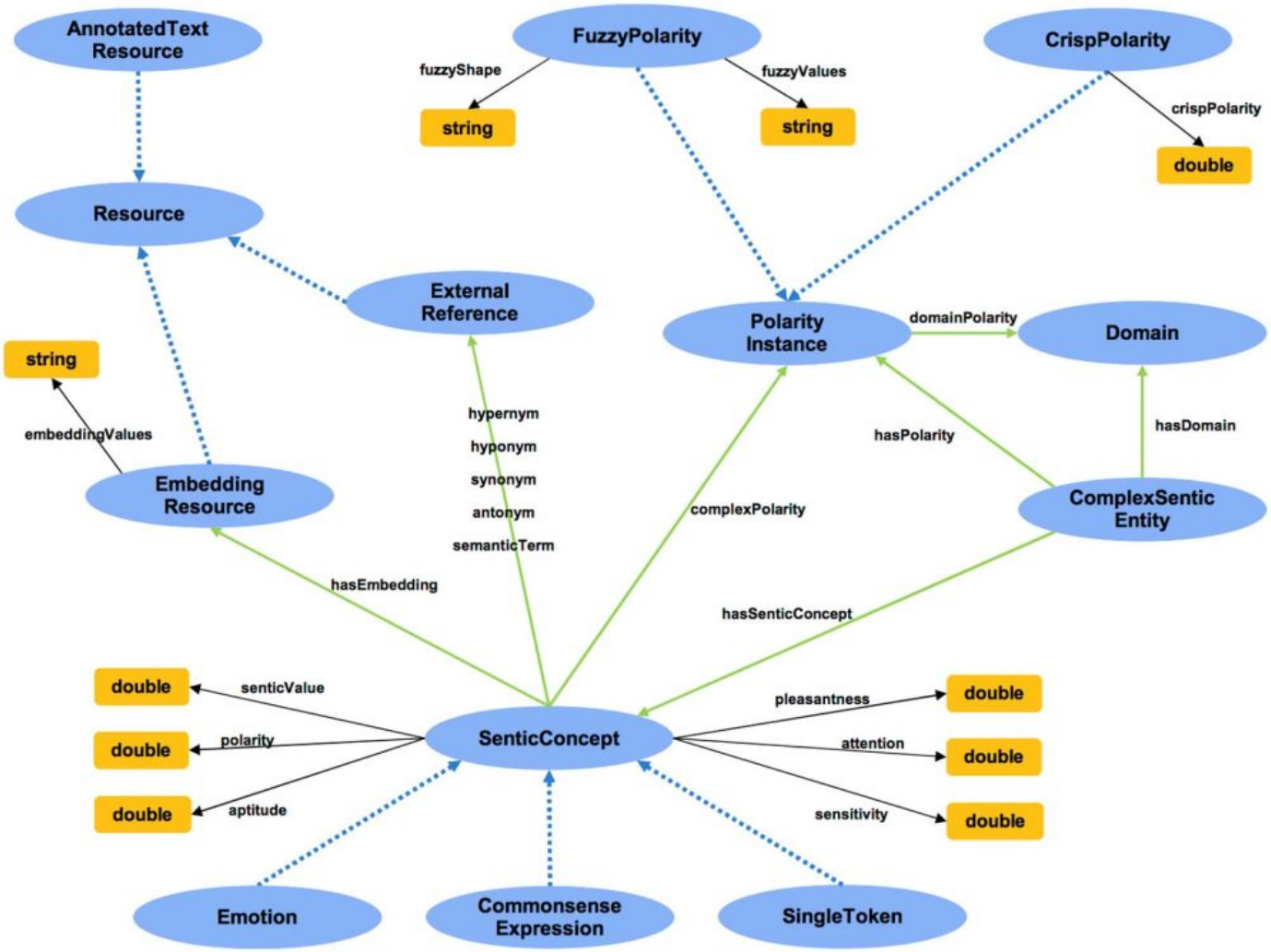
<anxiety>The knight faced the lioness. </anxiety>
<neutral>He fought she. </neutral>
<neutral>The knight threw the spear.</neutral>
...
<delight>She returned to the strong castle. </delight>
<happy>The knight and the princess lived happy ever afterward. </happy>

<emo val=4.52 act=5.03 cont=5.08>In exchange for your cheese I will give you a piece of advice for the future: </emo>

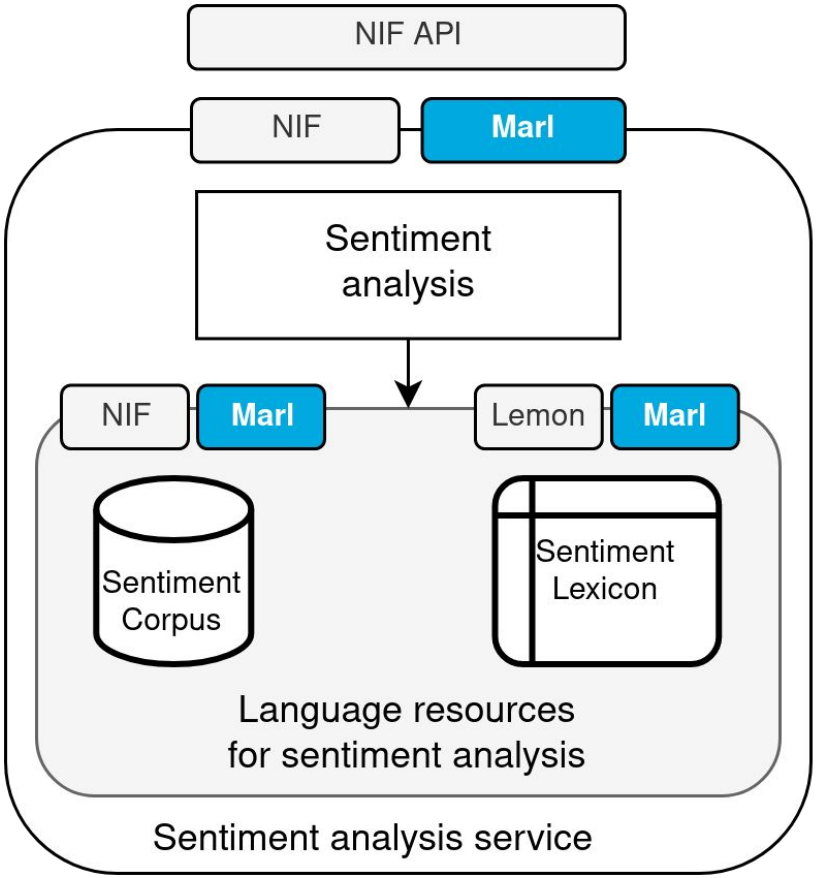
HEO ontology [Grassi, 2009]

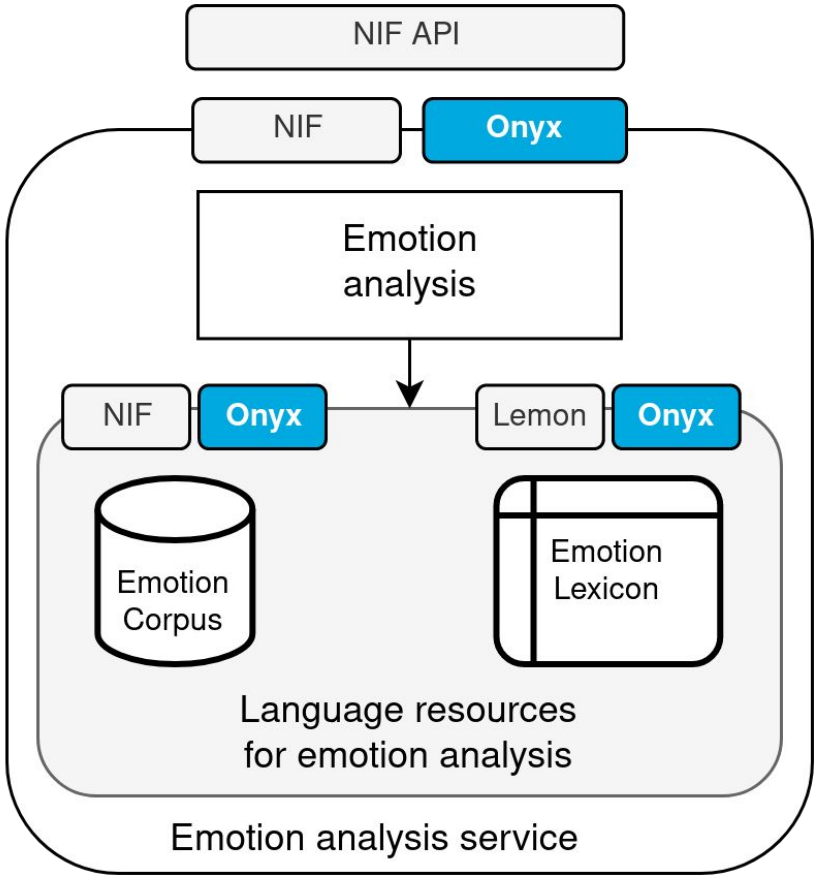


OntoSenticNet [Dragoni et al., 2018]



W3C CG - Marl & Onyx [W3CLD, 2020]

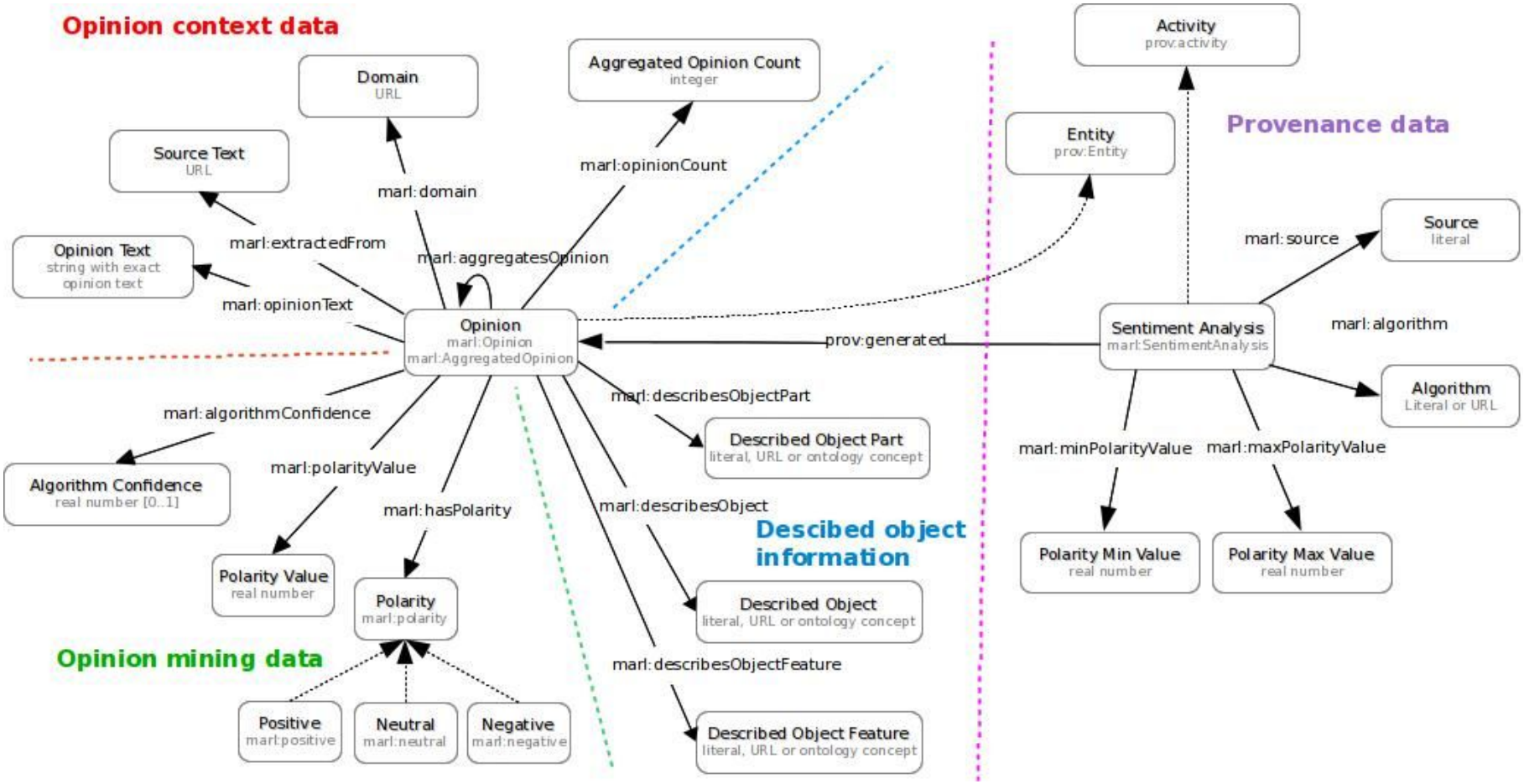




Marl [Westerski et al., 2011]

- Vocabulary for **annotating sentiments**
- Used for both lexical inputs and service outputs
- Aligned with **PROV-O** and published in LOV
- Adopted by various EU projects
- Adopted as vocabulary by **NIF**
- Adopted as recommendation **W3C WG**

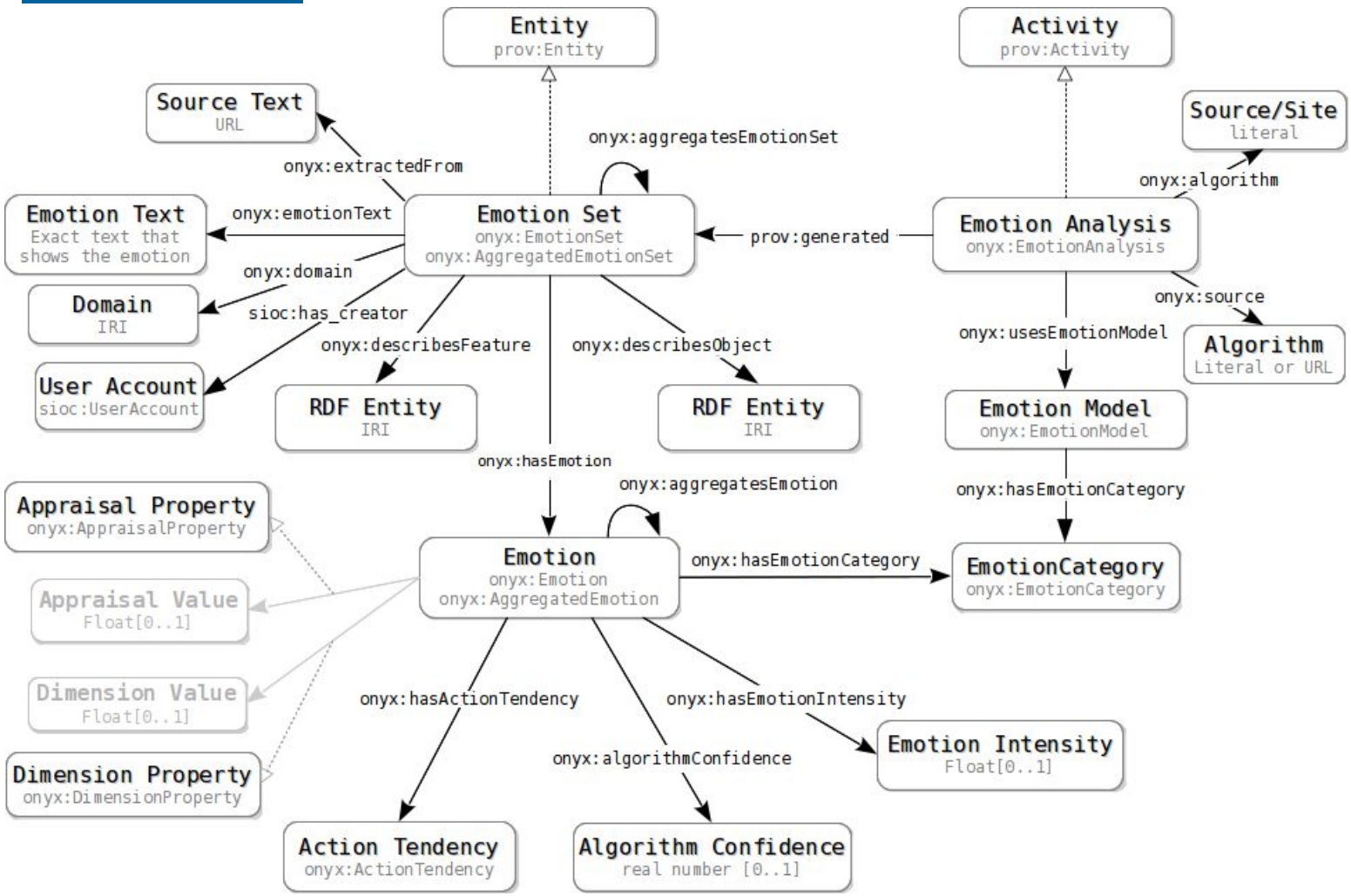
Marl


Opinion context data
Domain
URL
Aggregated Opinion Count
integer
Source Text
URL
marl:domain
marl:opinionCount
Opinion Text
string with exact opinion text
marl:extractedFrom
marl:aggregatesOpinion
marl:opinionText
Opinion
marl:Opinion
marl:AggregatedOpinion
prov:generated
marl:algorithmConfidence
Algorithm Confidence
real number [0..1]
marl:polarityValue
marl:hasPolarity
Polarity Value
real number
Polarity
marl:polarity
Opinion mining data
Positive
marl:positive
Neutral
marl:neutral
Negative
marl:negative
marl:describesObjectPart
Described Object Part
literal, URL or ontology concept
marl:describesObject
Descibed object information
Described Object
literal, URL or ontology concept
marl:describesObjectFeature
Described Object Feature
literal, URL or ontology concept
Activity
prov:activity
Entity
prov:Entity
Provenance data
marl:source
Source
literal
Sentiment Analysis
marl:SentimentAnalysis
marl:algorithm
Algorithm
Literal or URL
marl:minPolarityValue
marl:maxPolarityValue
Polarity Min Value
real number
Polarity Max Value
real number

Onyx [Sánchez-Rada et al., 2016]

- Generic **meta-model** for emotions
  - Emotions
  - Emotion models
  - Emotion Analysis (with **PROV-O**)
  - Emotion conversion
- Compatible with **W3C EmotionML**
- Extensible through external vocabularies
- Adopted as recommendation **W3C WG**
- Adopted by several EU projects

Overview of Onyx



Onyx vocabularies

- Emotion category vocabularies
  - **Ekman's "big six" basic emotions**
  - Everyday emotion vocabulary
  - OCC categories
  - FSRE categories
  - Frijda's categories
- Emotion dimension vocabularies
  - Mehrabian's PAD dimensions
  - FSRE dimensions
  - The intensity dimension
- Appraisal vocabularies
  - OCC appraisals
  - Scherer's appraisals
  - **EMA appraisals**
- Action tendency vocabularies
  - Frijda's action tendencies

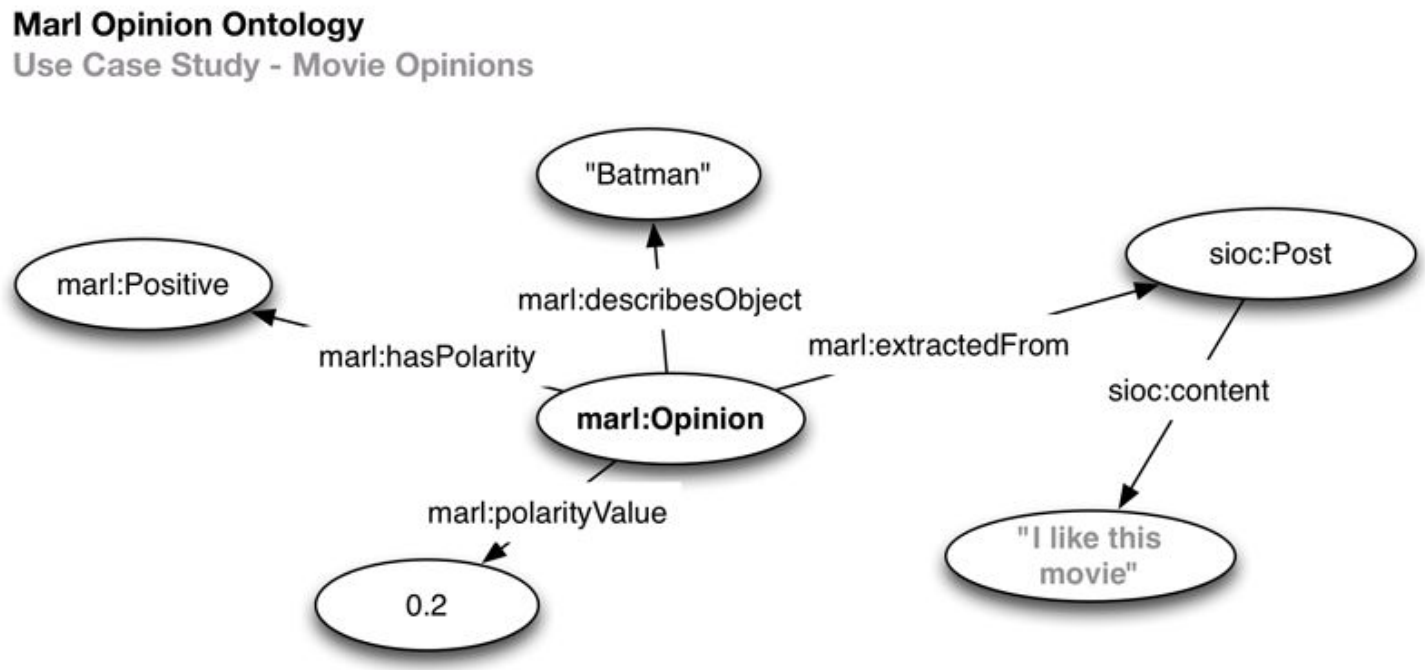
```
:big6 a onyx:EmotionModel ;
      onyx:hasEmotionCategory
        :big6_anger,
        :big6_disgust,
        :big6_fear,
        :big6_happiness,
        :big6_sadness,
        :big6_surprise .

:ema-appraisals a onyx:EmotionModel ;
    onyx:hasAppraisalProperty
        :ema-appraisals_agency ...
```

http://gsi.upm.es/ontologies/onyx/vocabularies/emotionml/ns

Case study

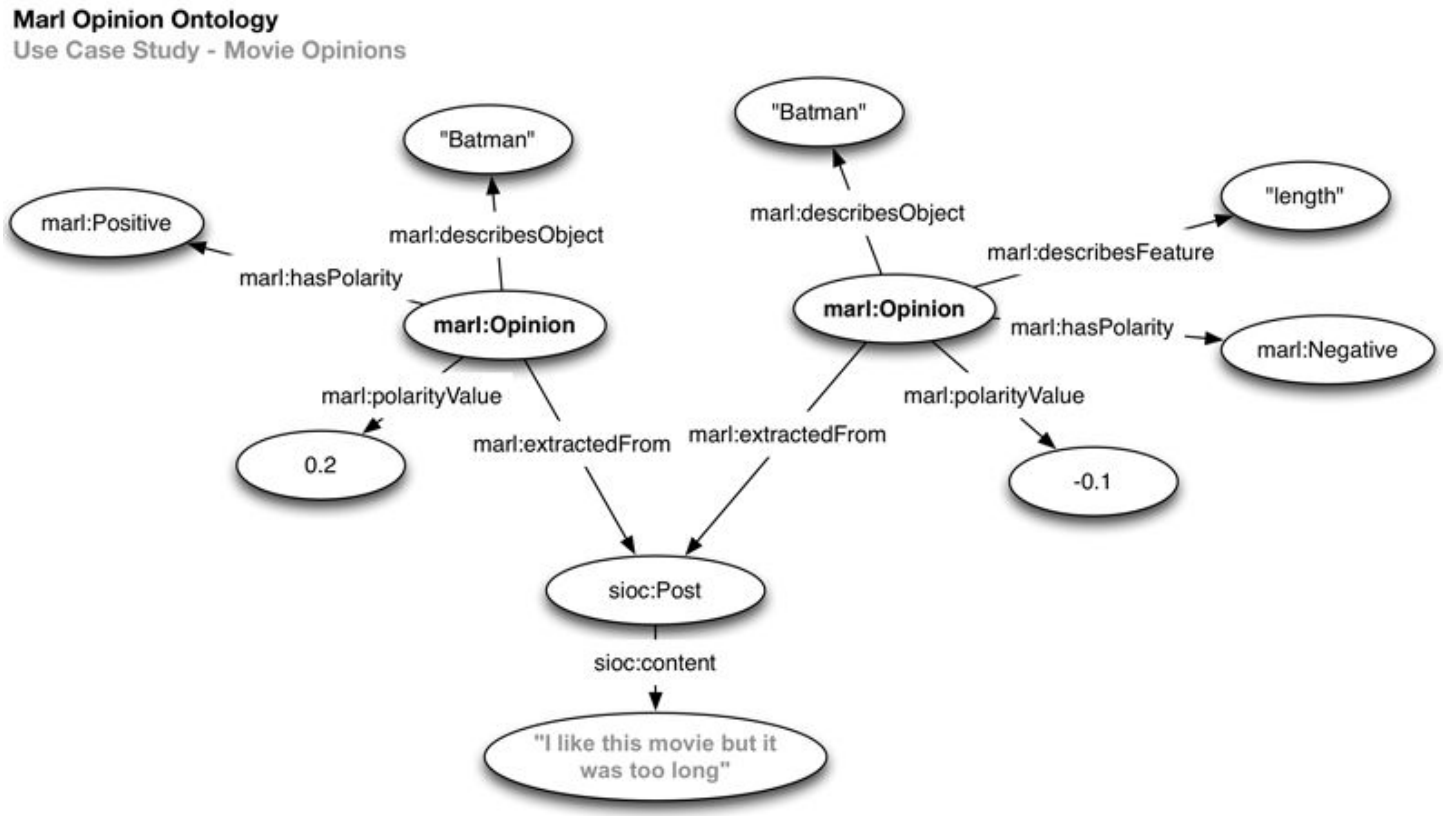
Tell me the opinions about the film Avatar

I like this movie




```
marl:extractedFrom http://gi2mo.org/.../comment/054321/rdf;
marl:describesObject "Batman";
marl:polarityValue "0.2";
marl:hasPolarity http://purl.org/marl/ns#Positive;
rdf:type http://purl.org/marl/ns#Opinion.
```

I like this movie but it was too long



I like this movie but it was too long

```
#Opinion #1: gi2mo.org/.../comment/054321/opinion/1/rdf
    marl:extractedFrom
    http://gi2mo.org/.../comment/054321/rdf ;
    marl:describesObject "Batman" ;
    marl:polarityValue "0.2" ;
    marl:hasPolarity http://purl.org/marl/ns#Positive ;
    rdf:type: http://purl.org/marl/ns#Opinion .

#Opinion #2: gi2mo.org/.../comment/054321/opinion/2/rdf
    marl:extractedFrom
    http://gi2mo.org/.../comment/054321/rdf ;
    marl:describesObject "Batman" ;
    marl:describesFeature "length" ;
    marl:polarityValue "-0.1" ;
    marl:hasPolarity http://purl.org/marl/ns#Negative ;
    rdf:type http://purl.org/marl/ns#Opinion .
```

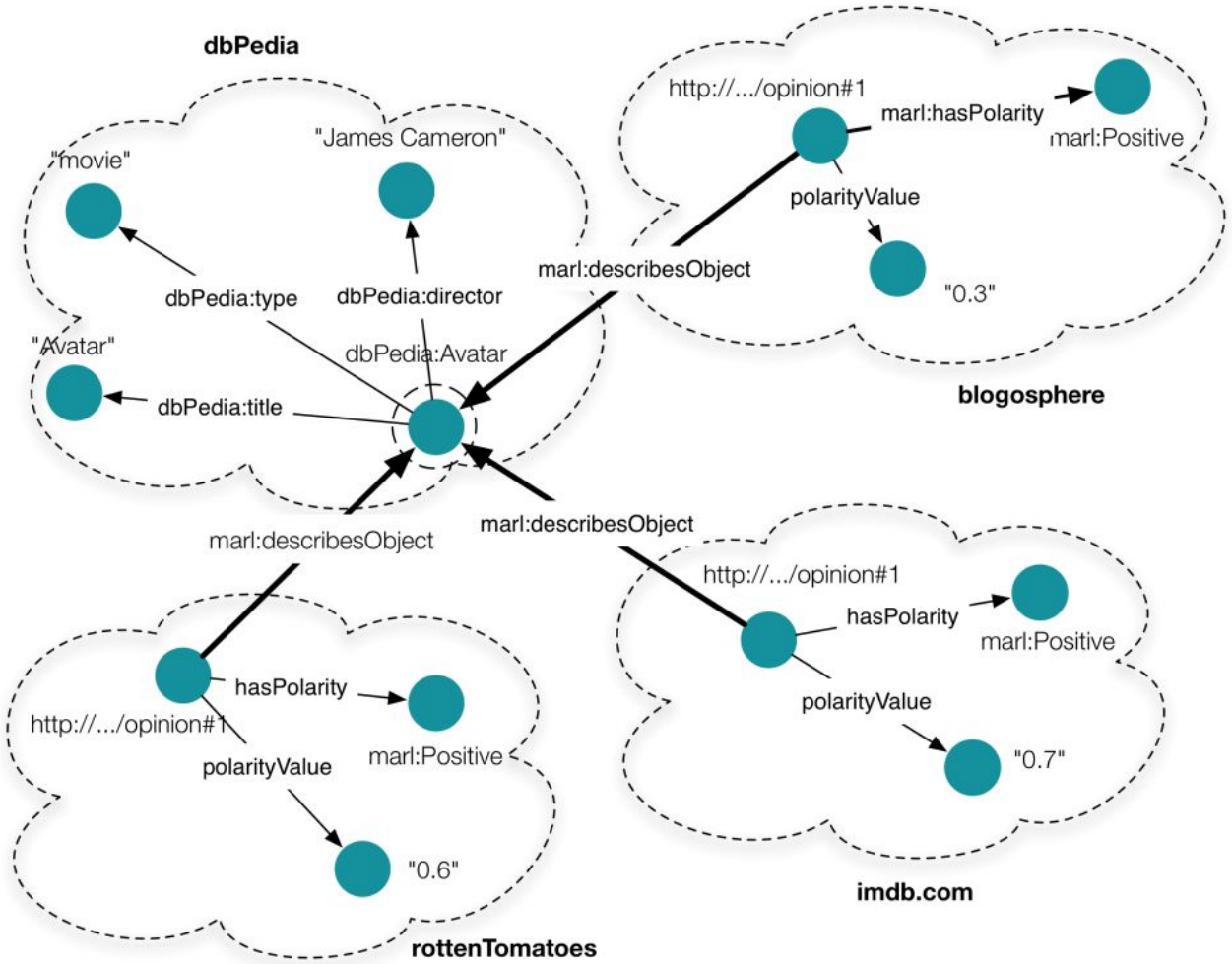
Show all the positive opinions about Avatar

```
PREFIX sioc: <http://rdfs.org/sioc/ns#> .
PREFIX marl: <http://purl.org/marl/ns#> .
SELECT ?opinion_full_text ?opinion_uri WHERE {
   ?comment_uri a sioc:Post .
   ?comment_uri sioc:content ?opinion_full_text .
   ?comment_uri marl:hasOpinion ?opinion_uri .
   ?opinion_uri marl:hasPolarity marl:Positive .
   ?opinion_uri marl:describesObject ?opinion_about .
   FILTER regex(?opinion_about, "Avatar") .
}
```

Show all the positive opinions about acting in Avatar

```
PREFIX sioc: <http://rdfs.org/sioc/ns#> .
PREFIX marl: <http://purl.org/marl/ns#> .
SELECT ?opinion_full_text ?opinion_uri WHERE {
   ?comment_uri a sioc:Post .
   ?comment_uri sioc:content ?opinion_full_text .
   ?comment_uri marl:hasOpinion ?opinion_uri .
   ?opinion_uri marl:hasPolarity marl:Positive .
   ?opinion_uri marl:describesObject ?opinion_about .
   ?opinion_uri marl:describesFeature ?opinion_about_feature .
   FILTER regex(?opinion_about, "Avatar") .
   FILTER regex(?opinion_about_feature, "acting") .
}
```

Marl


dbPedia
"movie"
"James Cameron"
dbPedia:type
dbPedia:director
"Avatar"
dbPedia:Avatar
dbPedia:title
marl:describesObject
http://.../opinion#1
marl:hasPolarity
marl:Positive
polarityValue
"0.3"
blogosphere
marl:describesObject
marl:describesObject
http://.../opinion#1
hasPolarity
marl:Positive
polarityValue
"0.7"
imdb.com
hasPolarity
http://.../opinion#1
marl:Positive
polarityValue
"0.6"
rottenTomatoes

Onyx results

```
x:CustomAnalysis
  a onyx:EmotionAnalysis;
  onyx:algorithm "SimpleAlgorithm";
  onyx:usesEmotionModel wna:WNAModel.
ex:Result1
  a onyx:EmotionSet;
  prov:wasGeneratedBy :customAnalysis;
  sioc:has_creator [ sioc:UserAccount
                          <http://twitter.com/JohnDoe>. ];
  onyx:hasEmotion [
    onyx:hasEmotionCategory wna:Hate;
    onyx:hasEmotionIntensity 0.5;
    onyx:algorithmConfidence 0.9; ];
  onyx:emotionText "I hate Mondays!" ;
  onyx:describesObject wn:Monday_1;
  dcterms:created "2013-05-16T19:20:30+01:00"^^dcterms:W3CDTF.
```

Service interoperability

[Sánchez-Rada et al., 2020]

- REST API extending NIF 2.0
- **Integration** & **Evaluation & Conversion**
- **Reference plugin-based architecture Senpy**
  - **Sentiment plugins**
    - Sentiment140, SenticNet, Vader
    - MeaningCloud, ES; Cogito-Exper.AI IT; Taiger, ES
  - **Emotion plugins**
    - WordNet-Affect, ANEW, DepecheMood
    - Emotion hashtags (NUIG, IE)
  - **Other media plugins**
    - Emotion in audio: Phonesia, CZ; U. Passau, DE
    - Emotion in video: Emotion-Research ES

NIF-based API

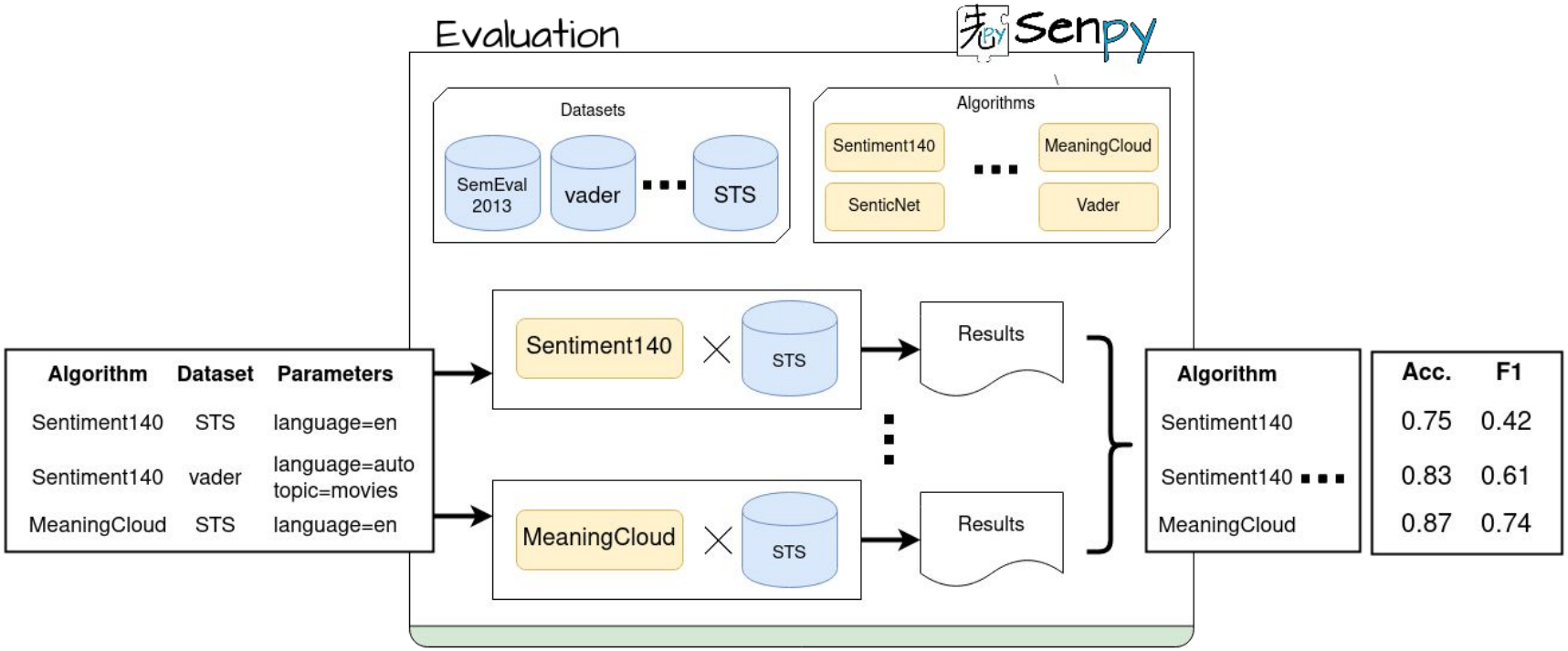
input (i)	serialized data (i.e. the text or other formats, depends on informat)
informat (f)	Input format: turtle, text (default) or json-ld
outformat (o)	output format: turtle (default), text, json-ld or CSV
prefix (p)	prefix for URIs

Basic NIF API

minpolarity (min)	minimum polarity value
maxpolarity (max)	maximum polarity value
language (l)	language (e.g, Spanish)
domain (d)	analysis domain (e.g. banking)
algorithm (algo)	analysis algorithm (plugin)
emotionModel	output emotion model(e.g., PAD)
conversionType	emotion conversion type
fields	fields included in the output

Sentiment & Emotion extension

Interoperability & Services



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Polarity of Compound Words in German and Bavarian dialects

[Declerck2016, Krieger2014, Declerck et al. 2014, Declerck et al. 2016]

```
:Rotsperre_lex
   rdf:type ontolex:MultiwordExpression ;
   lexinfo:partOfSpeech lexinfo:noun ;
   rdf:_1 :Rot_comp ;
   rdf:_2 :sperre_comp ;
   decomp:constituent :Rot_comp ;
   decomp:constituent :sperre_comp ;
   decomp:subterm :Sperre_lex ;
   decomp:subterm :rot_lex ;
   Ontolex:denotes <https://www.wikidata.org/wiki/Q1827> .
:Rot_comp
   rdf:type decomp:Component ;
   decomp:correspondsTo :rot_lex .
:sperre_comp
   rdf:type decomp:Component ;
   decomp:correspondsTo :Sperre_lex .
```

Sentiment of the compound

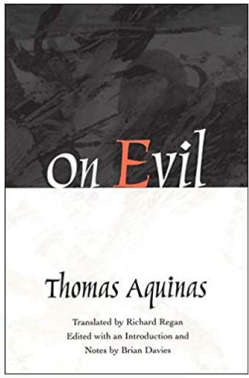
```
:rotsperre_sense
   rdf:type ontolex:LexicalSense ;
   op:assessedBy :SentiMerge ;
   op:hasPolarity op:Negative ;
   op:maxPolarityValue "1.0"^^xsd:double ;
   op:minPolarityValue "-1.0"^^xsd:double ;
   op:polarityValue "-0.628"^^xsd:double ;
   rdfs:label "Sense for the German word \"Rotsperre\""@en ;
   ontolex:isSenseOf :Rotsperre_lex ;
   ontolex:reference <http://de.dbpedia.org/resource/Wettkampfsperre> .
```

Annotate senses' sentiment

```
:sperre_sense1
  rdf:type ontolex:LexicalSense ;
  op:hasPolarity op:Neutral ;
  op:maxPolarityValue "1.0"^^xsd:double ;
  op:minPolarityValue "-1.0"^^xsd:double ;
  op:polarityValue "0.0"^^xsd:double ;
  rdfs:label "A sense for the German word \"Sperre\""@en
  ontolex:isSenseOf :Sperre_lex ;
  Ontolex:reference <http://de.dbpedia.org/resource/Lock> .
:sperre_sense2
  rdf:type ontolex:LexicalSense ;
  op:hasPolarity op:Negative ;
  op:maxPolarityValue "1.0"^^xsd:double ;
  op:minPolarityValue "-1.0"^^xsd:double ;
  op:polarityValue "-1.0"^^xsd:double ;
  rdfs:label "A sense for the German word \"Sperre\""@en
  ontolex:isSenseOf :Sperre_lex ;
  Ontolex:reference <http://de.dbpedia.org/resource/Wettkampfsperre> .
```


LINKUS
DATUS!!

Lila Latin: LatinAffectus [Sprugnoli et al. 2020]



malum (evil)

```
@prefix lemma: <http://lila-erc.eu/data/id/lemma/> .
@prefix rdfs:  <http://www.w3.org/2000/01/rdf-schema#> .
@prefix ontolex: <http://www.w3.org/ns/lemon/ontolex#> .
@prefix marl:  <http://www.gsi.dit.upm.es/ontologies/marl/ns#> .

<http://lila-erc.eu/data/lexicalResources/LatinAffectus/id/LexicalEntry/lemma_111418>
        a                       ontolex:LexicalEntry ;
        rdfs:label              "malus" ;
        ontolex:canonicalForm   lemma:111418 ;
        ontolex:sense           <http://lila-erc.eu/data/lexicalResources/LatinAffectus/
                                 id/LexicalSense/lemma_111418> .

<http://lila-erc.eu/data/lexicalResources/LatinAffectus/id/LexicalSense/lemma_111418>
        a                     ontolex:LexicalSense ;
        rdfs:label            "Prior sense of malus" ;
        marl:hasPolarity      marl:Negative ;
        marl:polarityValue    -1.0 .
```

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Domain specific lexicons

[Vulcu et al., 2004, Vulcu et al., 2014]

http://tripadvisor.com/myhotel.txt

Like many Paris hotels, the rooms are too small

```
<http://tripadvisor.com/myhotel#char=0,49>
        rdf:type nif:RDF5147String , nif:Context  ;
        nif:beginIndex “0” ;
        nif:endIndex “49” ;
        nif:sourceURL <http://tripadvisor.com/myhotel.txt>
        nif:isString “Like many Paris hotels, the rooms are too small”.
```

Name spaces convention

- Wordnet Domains (wd)
  - http://web/lexicon/wndomains
- Hotel Lexicon English (le)
  - http://web/lexicon/hotel/en
- Hotel Lexical Entry English (lee)
  - http://web/lexicalentry/hotel/en

Example sentiment domain lexicon

	excellent, first-class, fantabolous, splendid, gorgeous, ...	1
	fantastic, grand, howling, marvelous, marvellous, rattling, terrific, tremendous, wonderful, good, ...	0.75
	restful, reposeful, relaxing, large, big, ready, aired, airy, stylish, fashionable, mod, modern, renewed, ...	0.5
ROOM	deficient, interior, cockroach, roach, dated, unventilated, **small**, little, gluney, glutinous, pasty, ..	-0.5
	unpleasant, ...	-0.625
	artic, frigid, glacial, icy, polar, acceptable, cold, insulate, dirty, soil, begrime, grime, colly, bemire, ...	-0.75
	Disgusting, disgustful, distasteful, foul, loathly, loathsome, repellent, repellant,	-1

Example lexicon

```
le:hotel_en a lemon:Lexicon ;
        lemon:language “en” ;
        lemon:topic ed:hotel;
        lemon:entry lee:room, lee:Paris, lee:small.

lee:room a lemon:LexicalEntry ;
        lemon:canonicalForm [ lemon:writtenRep "room"@en ] ;
        lemon:sense [ lemon:reference wn:synset-room-noun-1;
                              lemon:reference dbp:Room ] ;
        lexinfo:partOfSpeech lexinfo:noun .

lee:Paris a lemon:LexicalEntry ;
        lemon:canonicalForm [ lemon:writtenRep "Paris"@en ] ;
        lemon:sense [ lemon:reference dbp:Paris;
                              lemon:reference wn:synset-room-noun-1 ] ;
        lexinfo:partOfSpeech lexinfo:noun .

lee:small a lemon:LexicalEntry ;
        lemon:canonicalForm [ lemon:writtenRep "small"@en ]  ;
        lemon:sense  lee:sense/small_1 ;
        lexinfo:partOfSpeech lexinfo:adjective  .
```

lee:small (room) - Hotel

```
lee:sense/small_1 a lemon:Sense ;
        lemon:reference "01391351" ;
        lexinfo:partOfSpeech lexinfo:adjective ;
        lemon:context  lee:sense/room_1 ;
        marl:polarityValue "-0.5"^^xsd:double ;
        marl:hasPolarity marl:negative .
```

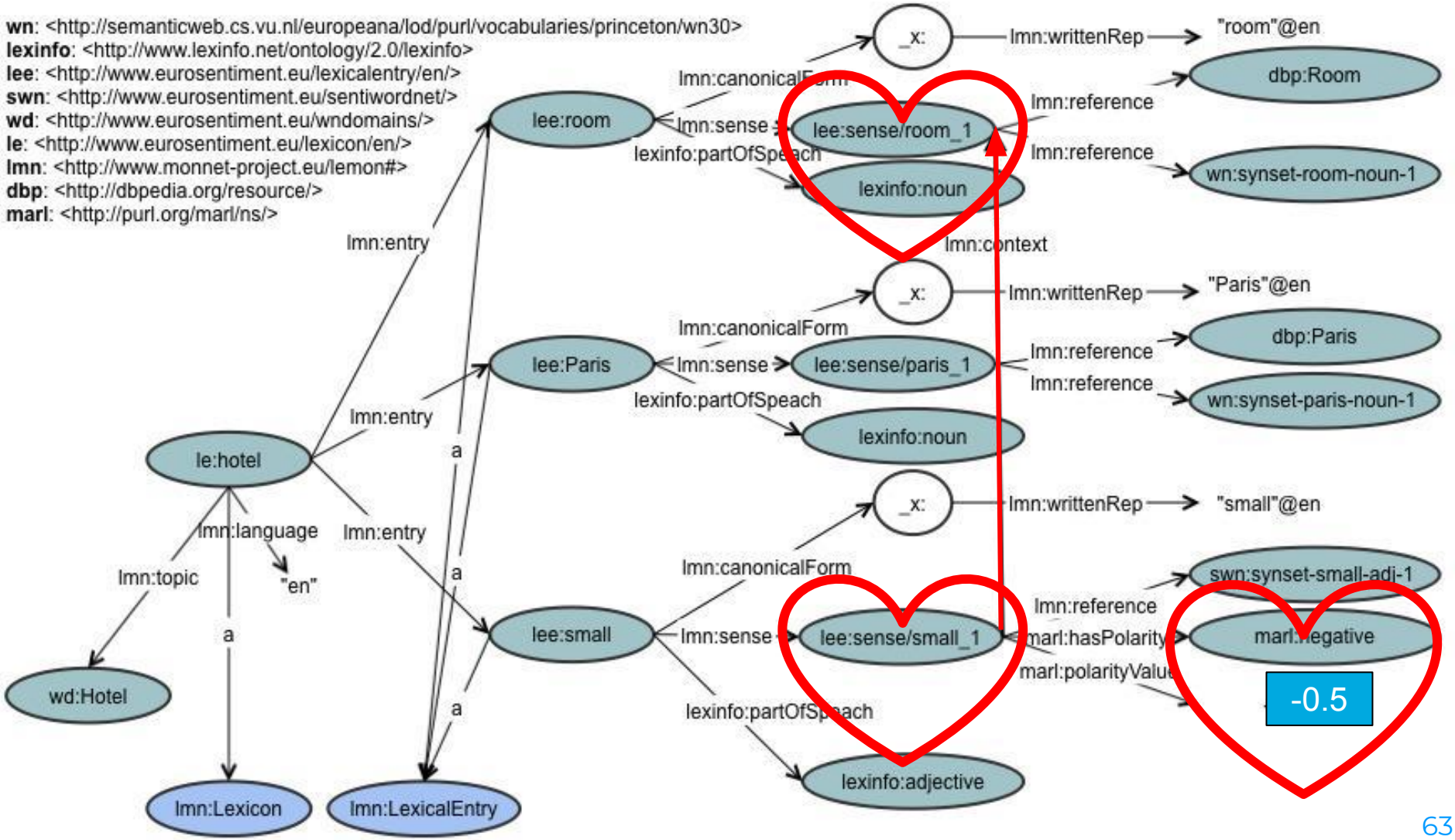
Sentiment Analysis

```
<http://tripadvisor.com/myhotel#char=0,49>
        rdf:type nif:RDF5147String , nif:Context  ;
        nif:beginIndex “0” ;
        nif:endIndex “49” ;
        nif:sourceURL <http://tripadvisor.com/myhotel.txt> ;
        nif:isString “Like many Paris hotels, the rooms are too small” ;
        marl:hasOpinion <http://tripadvisor.com/myhotel/opinion/1> .
```

```
<http://tripadvisor.com/myhotel/opinion/1>
       rdf:type marl:Opinion;
       marl:describesObject dbp:Hotel ;
       marl:describesObjectPart dbp:Room ;
        marl:describesFeature  “size” ;
        marl:polarityValue "-0.5" ;
        marl:hasPolarity: http://purl.org/marl/ns#Negative .
```

```
<http://eurosentiment.eu/analysis/1>
       rdf:type marl:SentimentAnalysis ;
        marl:maxPolarityValue "1" ;
        marl:minPolarityValue "-1" ;
        marl:algorithm “dictionary-based” ;
        prov:used le:hotel_en ;
        prov:wasAssociatedWith <http://dbpedia.org/resource/UPM>  .
```

Example Domain lexicon



Tourpedia [Gazzè, 2015]

- Annotate tourist data
  - FB, Foursquare, Booking, Google Places
- Annotation of tourist places
  - accommodations, restaurants, POIs and attractions
- Sentiment annotated with **Marl**

tp:Place
+ vcard:fn + dbpedia-owl:address + vcard:hasTelephone + vcard:hasPhoto + wgs84_pos:lat + wgs84_pos:long + dbpedia-owl:location + dbpedia-owl:wikiPageExternalLink + marl:hasOpinion
tp:Accommodation *extends* tp:Place
+ acco:feature + h:InternalFeature + **skos:related**
tp:Restaurant *extends* tp:Place
tp:POI *extends* tp:Place
tp:Attraction *extends* tp:Place
+ **owl:sameAs**
marl:AggregatedOpinion
+ marl:polarityValue

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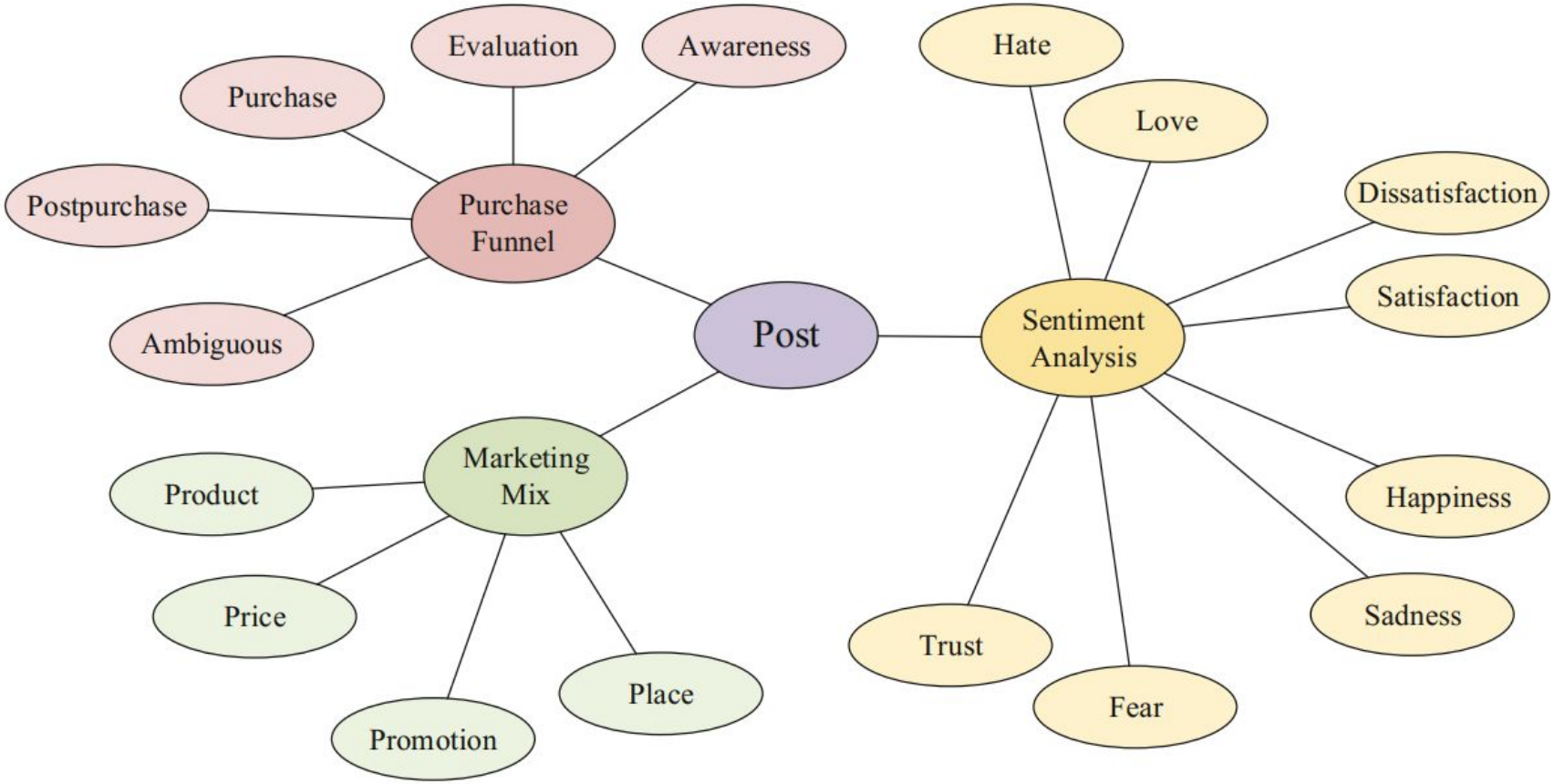
Sentiment Analysis towards Brands SAB Corpus [Navas-Loro et al. 2017]

- 4548 annotated tweets in Spanish
- Corpus annotated with Sentiments and Emotions towards Brands using **Marl** and **Onyx**

```
sabd:826812979421257730 a sioc:Post ;
  sioc:id "826812979421257730" ;
  sioc:content "Ya me quede sin credito?? Hace 3 dias tengo credito
                nomas... Movistar y la concha de tu hermana 😒"@es ;
  marl:describesObject sabd:Movistar ;
  sabd:isInPurchaseFunnel sabv:postPurchase;
  sabd:hasMarketingMix sabv:price;
  onyx:hasEmotion sabv:hate, sabv:dissatisfaccion ;
  marl:hasPolarity marl:negative ;
  marl:forDomain "TELCO" .
```

Marketing Analysis in Spanish MAS Corpus [Navas-Loro et al. 2018]

- Extends SAB corpus with new purchase funnel and marketing mix



Marketing Analysis in Spanish MAS Corpus [Navas-Loro et al. 2018]

```
mas:827146264517165056 a sioc:Post ;
  sioc:id "827146264517165056" ;
  sioc:content "Las camisetas nike 2002~2004 y las
     adidas 2006~2008 son el amor de mi vida"@es ;
  marl:describesObject mas:Nike ;
  sabd:isInPurchaseFunnel sabv:postPurchase;
  sabd:hasMarketingMix sabv:product;
  onyx:hasEmotion sabv:love, sabv:satisfaction,
                  sabv:happiness ;
  marl:hasPolarity marl:positive ;
  marl:forDomain "SPORT" .
```

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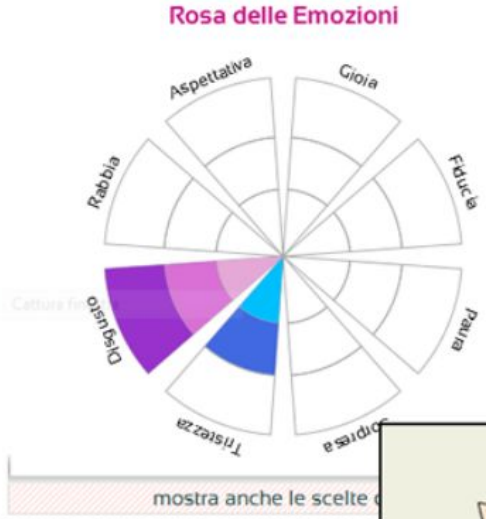
ArsEmotica [Patti et al, 2015]

- Emotional tagging of artworks
- Follows Plutchik model,
  - inspired by OntoEmotions
- Based on AEO
  - Linking emotions, artworks and people
- Interlinks with DBPedia, FOAF
- Emotion classes
  - BasicEmotion, ComplexEmotion
- Uses Lemon
  - lemon:LexicaEntry linked to WN-Affect synset using property lemon:sense
  - lemon:reference for linking emotional concepts to senses

ArsEmotica [Patti et al, 2015]



BiO

AUTORE/I

Filippo Valente

NOME

Dove la Raffinata Ragazza Bionda guarda il Grosso Toro Malmorto

DATA

2005-08-27

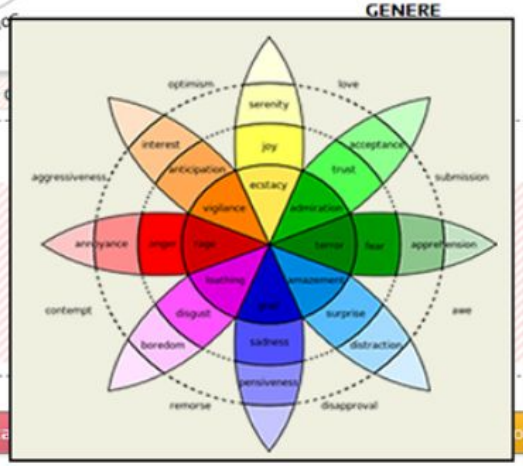
GENERE

mostra anche le scelte

Tag dell'opera

orrore Spagna sangue Toro infame bianco_e_nero la_bionda carne sconfiggere biondo trascinamento perversione Arena animale veicolo_animale morire preversione cattiveria fotografia inserviente corrida crudeltà barbarie tristezza

Altre opere d'arte affini:



Applica

otionML

Personalized Social Recommendation

[Díaz-Agudo et al. 2021]

- New museum experience
- Citizen curation of artworks
- Recommendation using Community detection
- User Generated Content annotated using **Marl** and **DBPedia**

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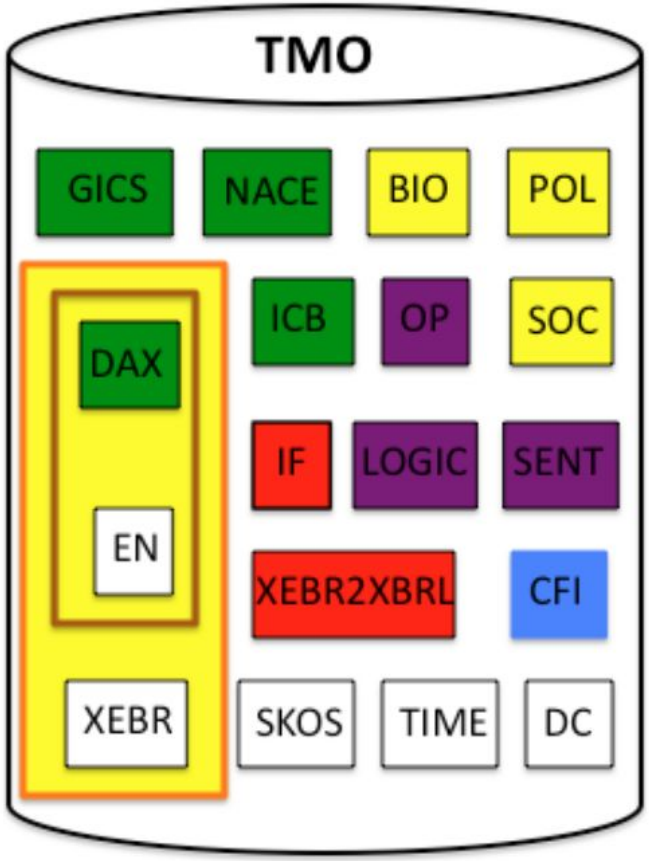
TMO - Finance & Politics Trends

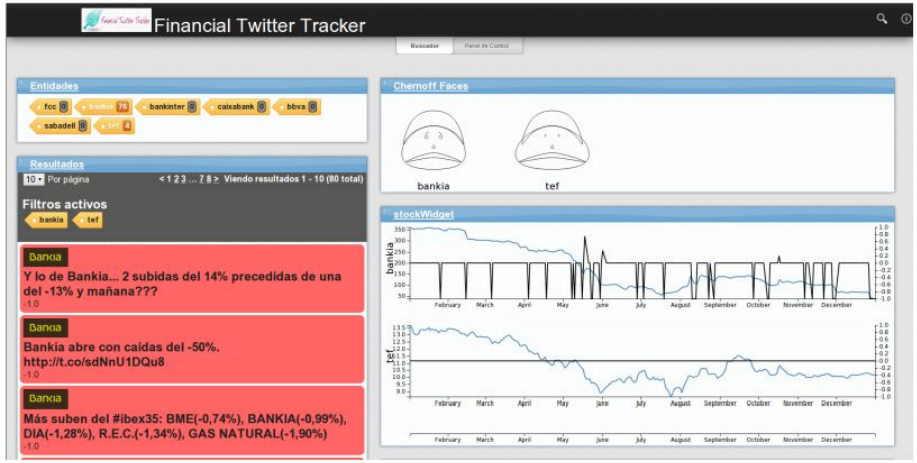
[Krieger & Declerck, 2014]

- TrendMiner: monitoring social streams
- Use cases
  - assisting financial investing decisions
  - EU-wide tracking of political views, trends and popularity
- OP ontology extends **Marl**
  - hasHolder, holdersTrust



Financial Twitter Tracker [Sánchez-Rada et al. 2014]

- Sentiment of financial tweets
- Combines Marl, Onyx and FIBO




```
ex : myOpinion a marl : Opinion ;
   marl : hasPolarityValue marl : Positive ;
   marl : describesObject ex : GSantander ;
   marl : extractedFrom ex : twit1 .
ex : twit1 a sioct : MicroblogPost ;
   sioc : content " I like testing Grupo Santander ".
ex : GSantander a fibo : IncorporatedCompany .
```

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Emotion & Automation for E-Learning

[Muñoz et al. 2020]

- Emotion sensing and regulation using rules
- Annotated with Onyx, EWE (Evented Web Automation) and HSO (Human Stress Ontology)
- Combines emotion sensing: gaze, face expression, and text analysis (forums, …)

```
:sad-emotion-detected a emo:EmotionDetected ;
    ewe:hasEmotion onyx:sadness .

:regulate-stress a ewe:Rule ;
    dcterms:title    "Stress regulation rule"^xsd:string ;
    ewe:triggeredByEvent    :sad-emotion-detected ;
    ewe:firesAction         :change-ambient-color-green .
```

Emotion & Automation for E-Learning

[Muñoz et al. 2020]

Question **2**
Answer saved
Marked out of 1.00
Flag question
Edit question

What symbol does a comment in Python begin with?

Answer: #

Question **3**
Answer saved
Marked out of 1.00
Flag question
Edit question

Which of the following is the correct way to print Hello World!?

Select one or more:

- [x] a.
```
print Hello+World!
```
- [ ] b.
```
print("Hello World!")
```
- [ ] c.
```
print('Hello World!')
```
- [ ] d.
```
print(Hello World!)
```

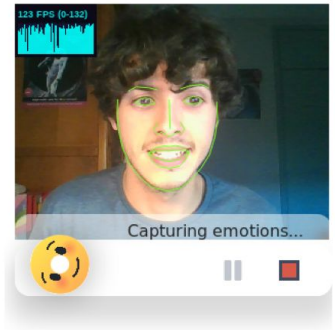
Question **4**
Answer saved
Marked out of 1.00
Flag question
Edit question

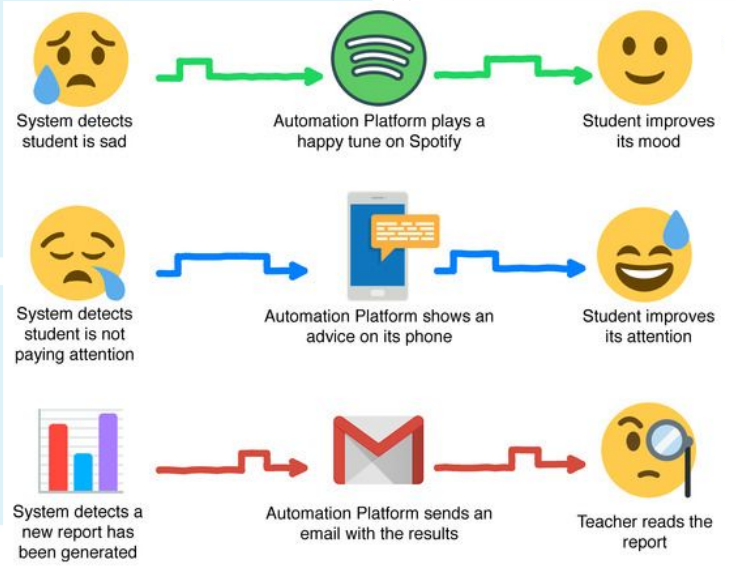
What is the likely cause of an EOL error?

Select one:

- (•) a. You forgot the closing parenthesis.
- ( ) b. You need to add exit() to the end of your program to exit.
- ( ) c. You forgot a closing quotation mark.

Emotion Test





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Annotating Patient Opinions

[Yang et al., 2020]

- **Decision support system** combining objective assessment and patient preferences based on similar patients
- Clinical Sentiment Ontology linking clinical diagnosis knowledge, clinical conditions and opinions
- Argumentation rules defines with **SWRL**
- Opinions about therapies are extracted from *'Patients like Me'* and annotated with **Marl**

Annotating Patient Opinions

[Yang et al., 2020]

TysabriSe...

AMBASSADOR

27146 37095

Frequent Features	Opinion Words
Stereotactic Biopsy	Radical
Left Breast	Pure
Mastectomy	Long
Torture	Large
Needle	Excruciating
Frequent Features	Unbearable
Core Biopsy	Not
Calcifications	Many
Mammogram	Small
MRI	Never
Stereotactic Core Needle Biopsy	No

Mar 27, 2010 03:28PM

In May 1999, I had a Stereotactic Biopsy of the left breast (a modified radical mastectomy resulted in August 1999.)

The procedure was pure torture. Four times, a long, large needle was plunged into center of my left breast - the pain was excruciating and unbearable. The core biopsy did not go well, and I bled all over the floor and the doctor had difficulty.

1) **I will not go through that torture again.**

2) As I understand there is a less than 10% chance that there is cancer in the areas many small calcifications. I will **not** get a Stereotactic Biopsy (**never again**.)

The result: **Not** another mammogram, **not** another MRI, **no** Stereotactic Core Needle Biopsy

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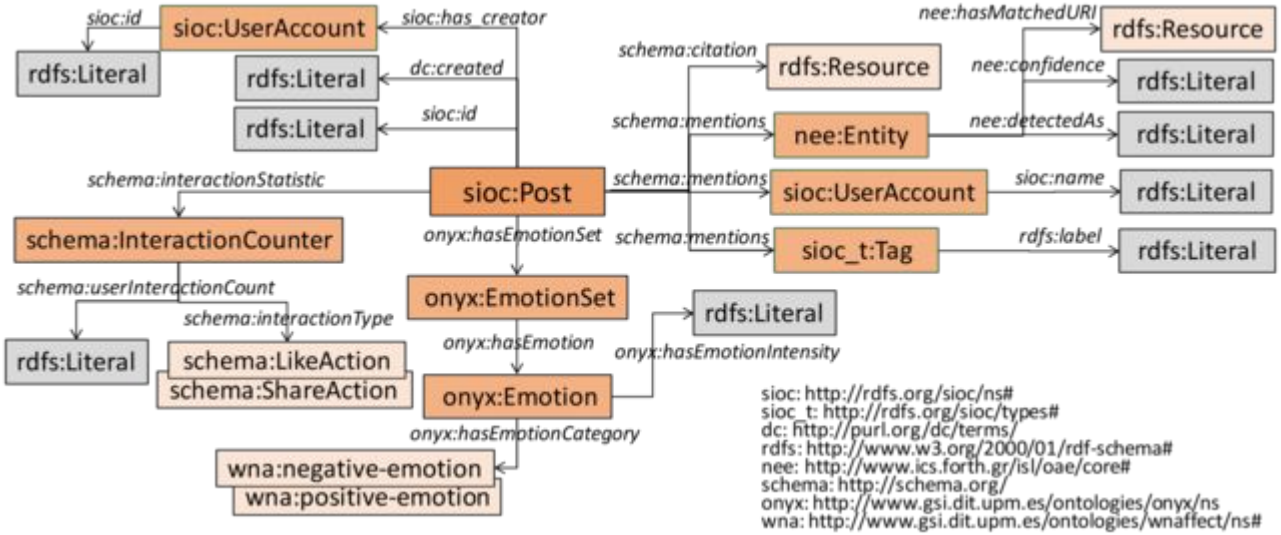
TweetsKB [Fafalios et al. 2018]

- Public RDF corpus of anonymized data for a large collection of annotated tweets
- 2B tweets, subset TweetsCOV19 (2019-2020)
- Annotated with Onyx, WNA



TweetsKB [Fafalios et al. 2018]

Retrieve popular tweets in 2016 mentioning German politicians with strong negative sentiment

```
SELECT DISTINCT ?tweetID ?sentNegScore ?retweetCount ?politician ?birthPlace WHERE {
  SERVICE <http://dbpedia.org/sparql> {
    ?politician dc:subject dbc:German_politicians ; dbo:birthPlace ?birthPlace }
  ?tweet a sioc:Post ; dc:created ?date ; sioc:id ?tweetID FILTER(year(?date) = 2016) .
  ?tweet schema:mentions ?entity . ?entity a nee:Entity ; nee:hasMatchedURI ?politician .
  ?tweet schema:interactionStatistic ?stat . ?stat schema:interactionType schema:ShareAction
  ?stat schema:userInteractionCount ?retweetCount FILTER(?retweetCount > 100) .
  ?tweet onyx:hasEmotionSet ?emotSet . ?emotSet onyx:hasEmotion ?emot .
  ?emot onyx:hasEmotionCategory wna:negative-emotion ;
        onyx:hasEmotionIntensity ?sentNegScore FILTER (?sentNegScore >= 0.75) }
```

MixedEmotions Toolbox

[Buitelaar et al., 2018]

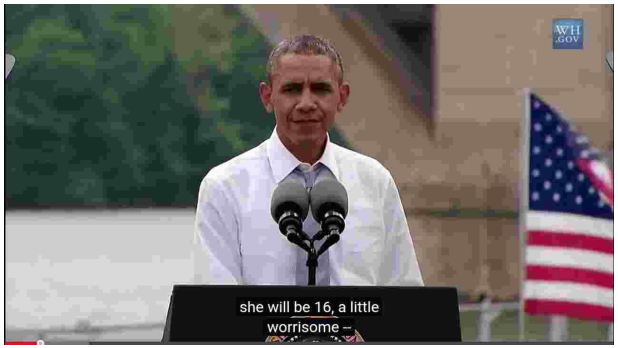
- Multimodal platform for sentiment analysis
- Use cases:
  - Emotion-driven Smart TV
  - Call center monitoring
  - Brand reputation analysis
- Component Senpy
- Annotation based on Lemon, NIF, Marl and Onyx
- Emotion model conversion

MixedEmotions

Multimodal Analysis [Sánchez-Rada et al., 2015]

- Analyze every modality
- Fusion of results
- Extending NIF for multimedia with Media Fragments URIs

Video analysis face expression



Text analysis captions

Text analysis comments

Caption Analysis [Sánchez-Rada et al., 2015]

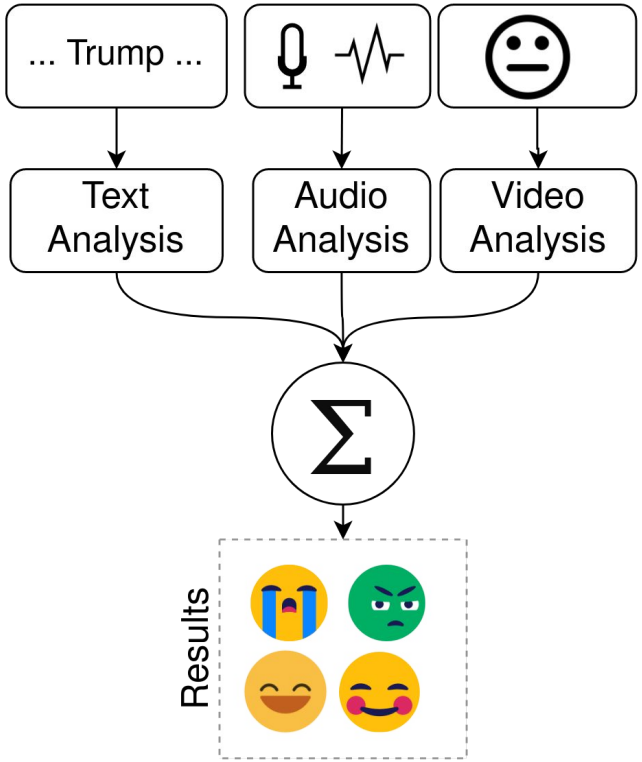
```
<http://youtu.be/W07PoKUD-Yk#t=108,110>
    rdf:type nifmedia:MediaFragmentString ;
    nif:anchorOf “Family budgets under pressure” ;
    marl:hasOpinion <http://www.gsi.upm.es/opinion/OpinionT01>.

<http://www.gsi.upm.es/opinion/OpinionT01>
    rdf:type marl:Opinion ;
    marl:hasPolarity  marl:Negative ;
    marl:polarityValue -0.3058 ;
    prov:generatedBy <http://www.gsi.upm.es/analysis/CaptionAnalysis> .

#Give me video fragments with negative opinions in text and cheerful tone

SELECT ?frag WHERE {
   ?frag a nifmedia:MediaFragmentsString;
            marl:hasOpinion ?opinion;
            onyx:hasEmotion ?emo.
   ?opinion prov:wasGeneratedBy _:TextAnalysis;
            marl:hasPolarity marl:Negative.
   ?emo prov:wasGeneratedBy _:AudioAnalysis;
            onyx:hasEmotionCategory wna:Cheerfulness.
}
```

Emotion model conversion

[Sánchez-Rada et al., 2017]

- Modeling emotion model conversion as PROV-O activity.
- Predefined strategies
  - Centroids
  - Aggregating to max emotion

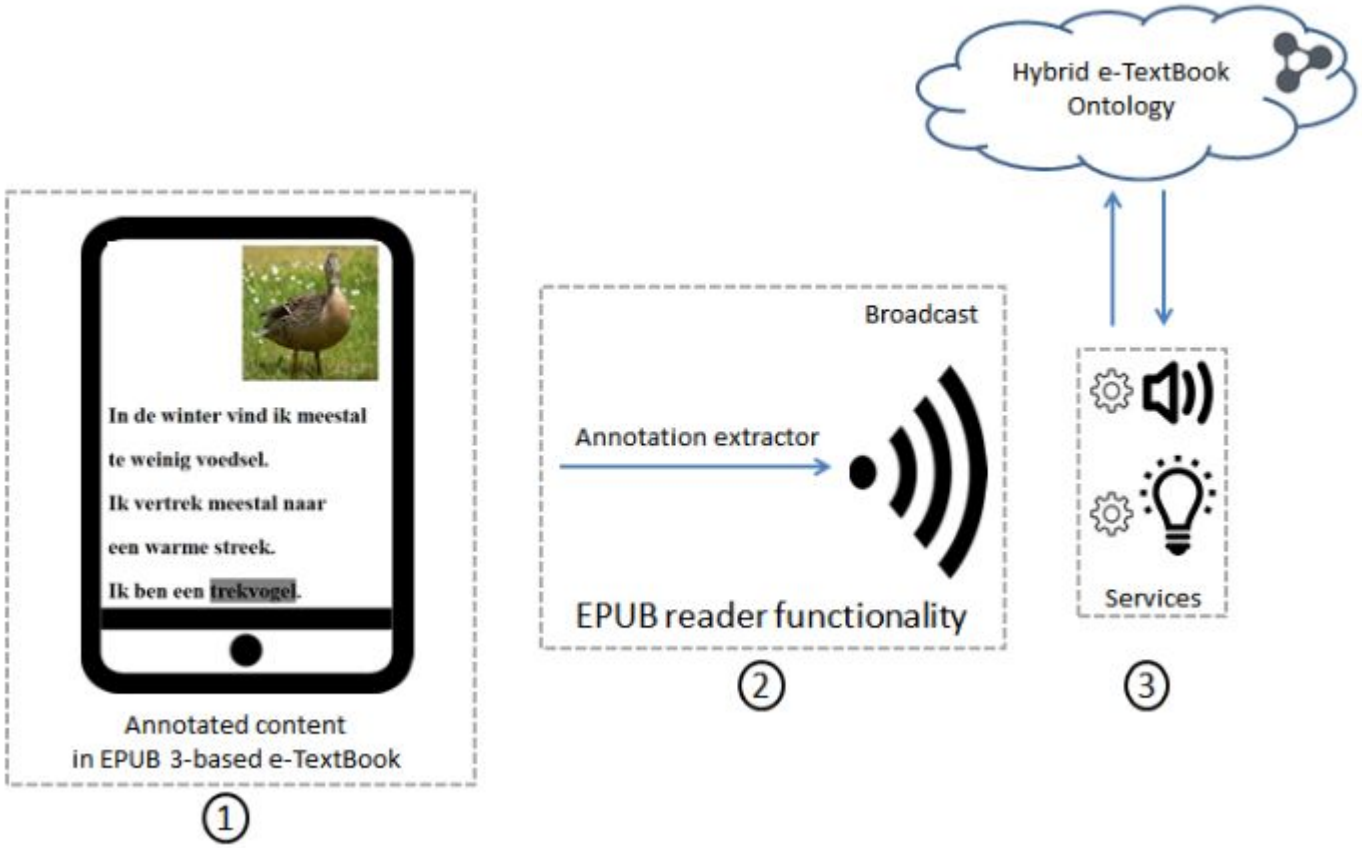
```
:Big6_to_PAD rdf:type onyx:EmotionConversion ;
    onyx:convertsFrom emoml:big6 ;
    onyx:convertsTo emoml:pad .
```



5. Applications

1. Introduction
2. Background
3. Why: Use cases
4. How: main approaches
5. **Applications**
   - 5.1. Digital Humanities
   - 5.2. Tourism
   - 5.3. Marketing
   - 5.4. Cultural Heritage
   - 5.5. Finance
   - 5.6. E-Learning
   - 5.7. E-Health
   - 5.8. Media
   - **5.9. Entertainment**
6. Datasets
7. Conclusions

Hybrid books [Sigarchian et al., 2015]



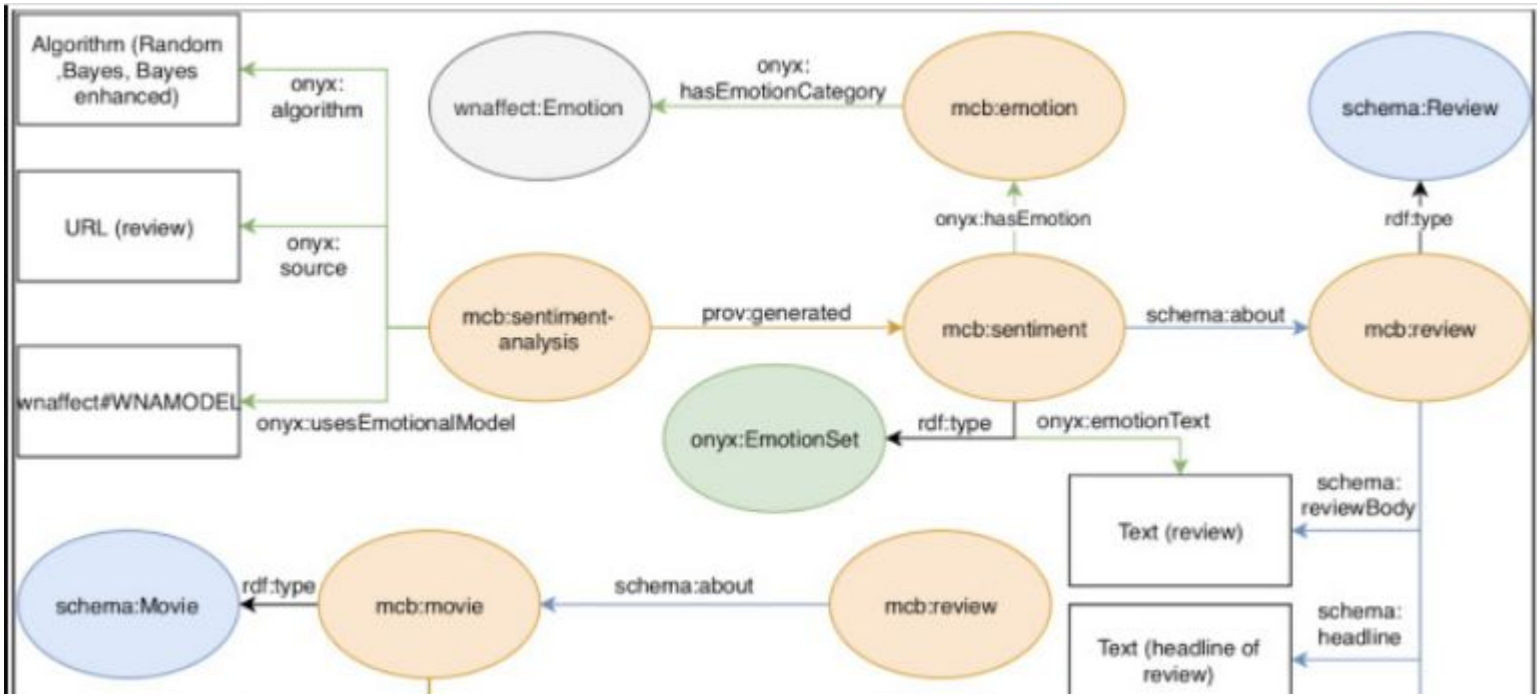
Hybrid books [Sigarchian et al., 2015]

- Broadcast ebook emotion annotations to smart devices
  - Emotion (e.g., afraid) → lights
  - Entity (e.g., wolf) → lights, sound player
  - Event (e.g., earthquake) → sound player
  - Temperature (e.g., cold) → thermostat
- eBooks annotated using aRDF and **Onyx**

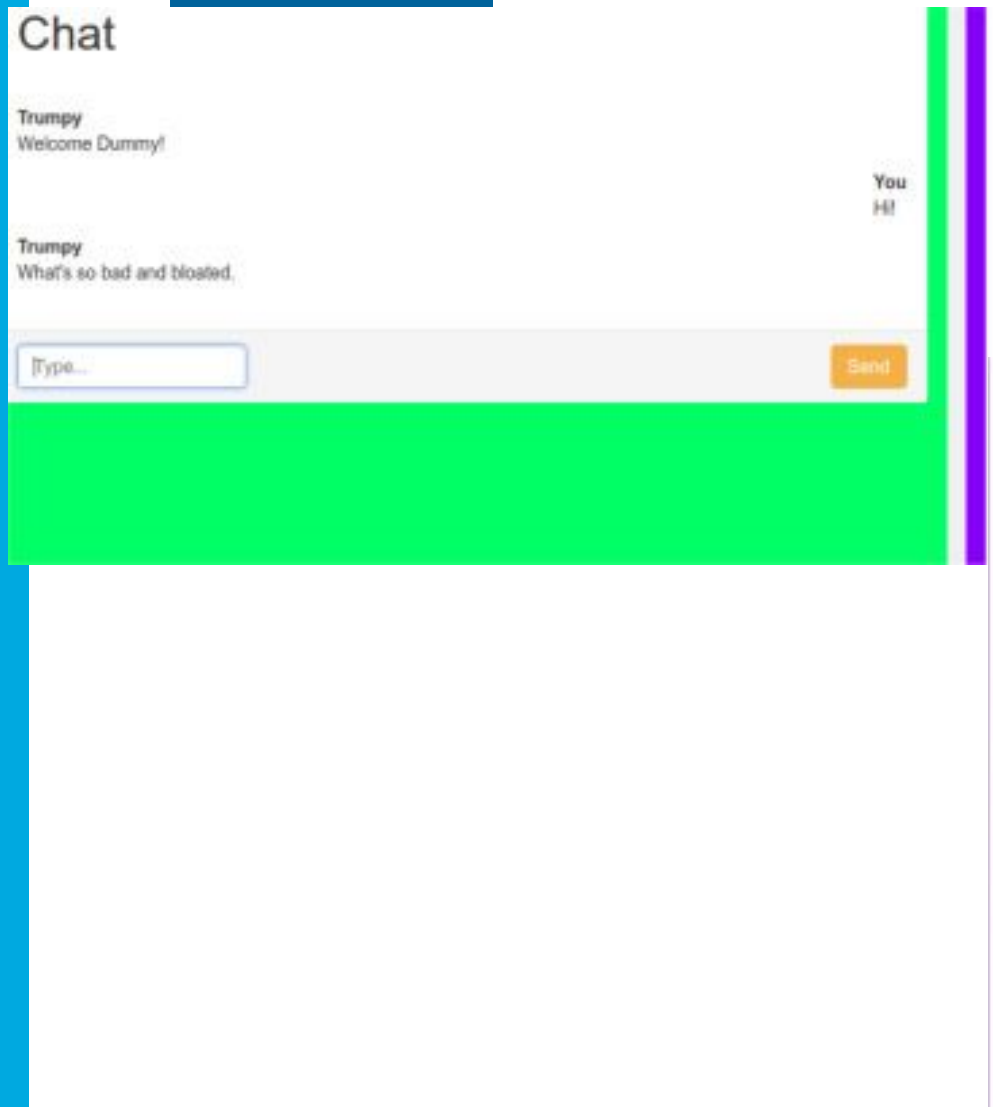
```
<span property=``animal:wolf; emotion:afraid’’>wolf</span>
```

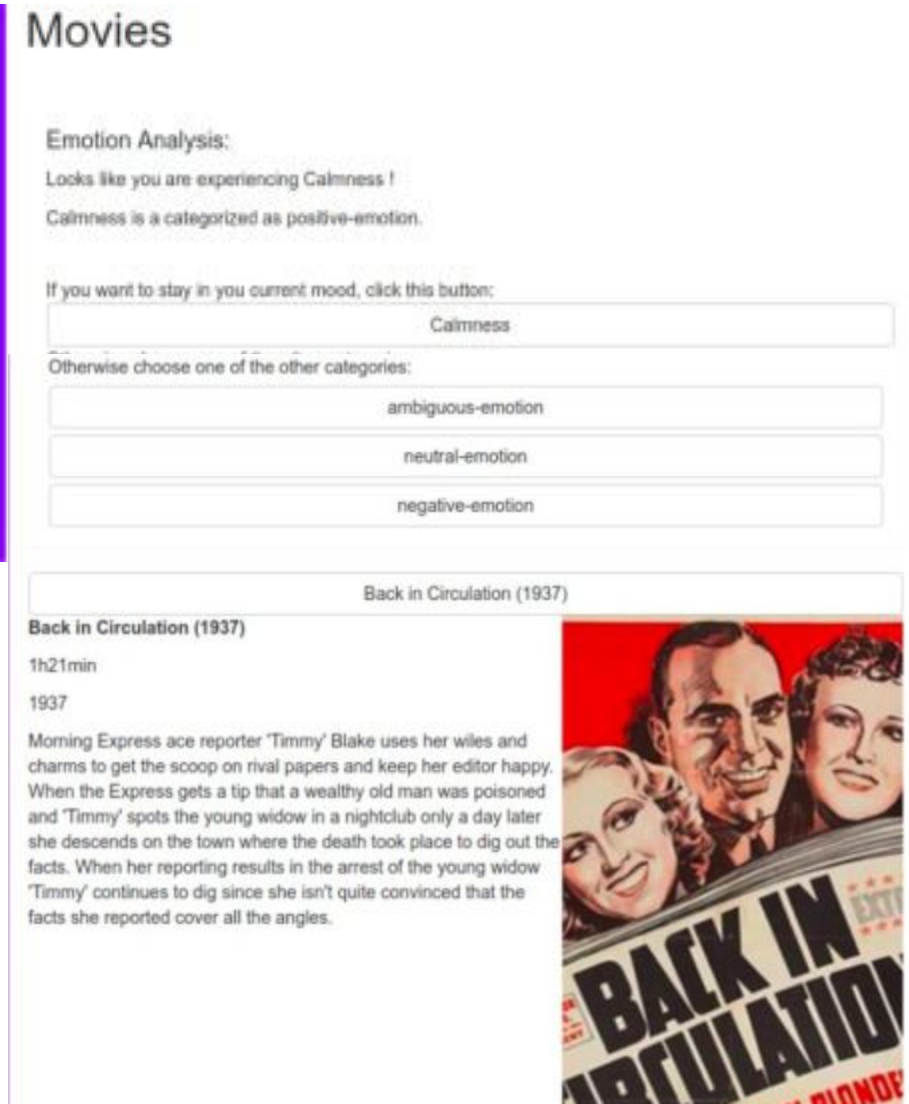
Representing Emotions in KGs for Movie Recommendation [Breitfuss, 2021]

- Chatbot that recommends movies based on user and movie emotions
- Emotions annotated with Onyx and WN-Affect
- 37,798,497 triples



Representing Emotions in KGs for Movie Recommendation [Breitfuss, 2021]





6.
Datasets

Datasets

Dataset	Description	Size	Vocabulary
KGMovies	KG Emotions in Movie Reviews	37M triples	Onyx, WN-Affect
TweetsKB	KG of tweets	2 B tweets	Marl
SABCorpus	Sentiment Toward Brands- tweets	4548 tweets	Marl, Onyx
MASCorpus	Marketing, tweets	3763 tweets	Marl, Onyx
LiLa dataset	Latin lexicon	134,228 lemma objects	Marl
SentiMerge	German lexicon	96918 lexical entries	Marl
Tourpedia	Tourist places	6M RDF triples	Marl
SenticNet	Knowledge base	200.000 common sense concepts	SenticNet

7.
Conclusions

1. Introduction
2. Background
3. Why: Use cases
4. How: main approaches
5. Applications
6. Datasets
7. **Conclusions**

Conclusions & Insights

- Sentiment technologies “meet” LLOD
- Mature proposals
  - W3C CG LD models for Sentiment & Emotion Analysis
- Works cover most use cases in many sectors
  - Focus on lexicons & corpora
  - Cases in AmI and chatbots, not yet in generation
- Available tools & datasets
- Need higher adoption
  - Identify new use cases
  - NLP community
  - Industry
  - Resources & tools

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Thanks!

Any questions?

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