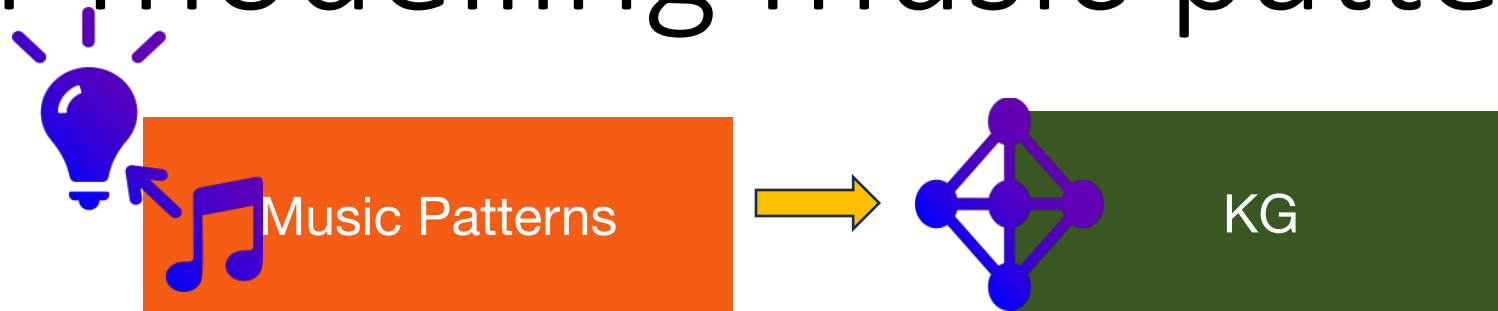
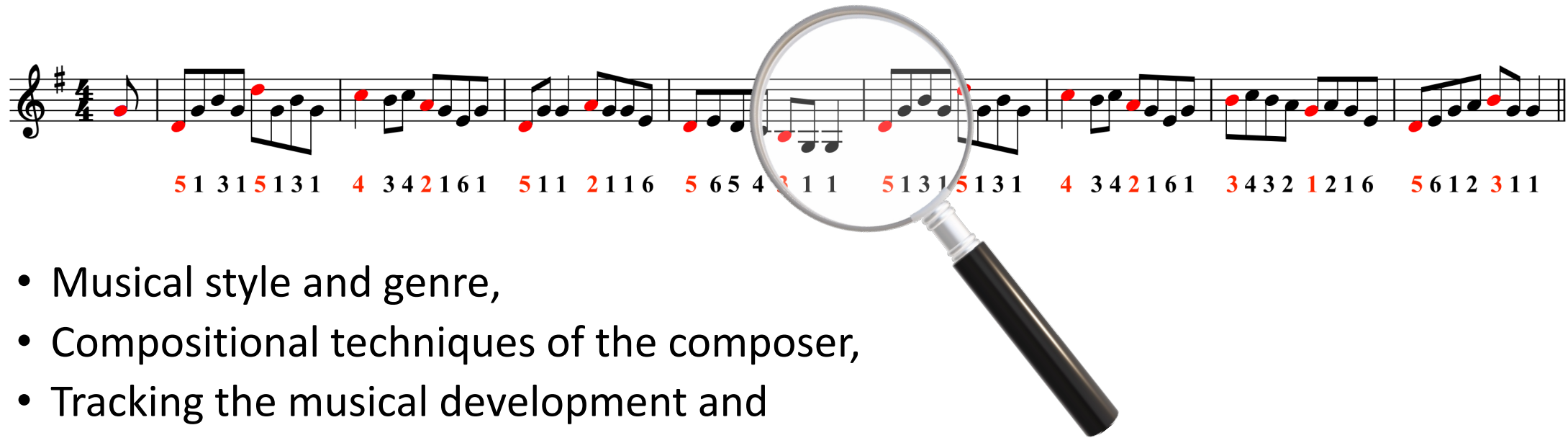


# Patterns2KG: JAMS pipeline for modelling music patterns



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# Music Analysis



A musical score in 4/4 time, G major, featuring a single melodic line on a treble clef staff. The notes are marked with red dots. Below the staff is a line of guitar tablature with numbers 1-5, where some numbers are red. A magnifying glass is positioned over the middle of the staff, highlighting a specific section of the music.

5 1 3 1 5 1 3 1 4 3 4 2 1 6 1 5 1 1 2 1 1 6 5 6 5 4 3 1 1 5 1 3 1 5 1 3 1 4 3 4 2 1 6 1 3 4 3 2 1 2 1 6 5 6 1 2 3 1 1

- Musical style and genre,
- Compositional techniques of the composer,
- Tracking the musical development and
- Evolution of different styles and genres over time,
- Classifying music
- Generating music

# Oral traditions

- In folk traditions,
  - it is the melody that is central.
  - A melody is simply a sequence of notes, with durations and rests.
- Thus, analysis of the patterns in this data could help us to understand and relate tunes.



# What is a pattern?



- Pattern is a central concept in many fields.
  - Mathematics has been called “the science of patterns” [1];
  - Schenker [2] claimed that repetition “is the basis of music as an art”
  - Bent [3] proposed that “the central act” in all forms of music analysis
- So, the more patterns we detect, the more internally coherent our analysis would be.

1. L. A. Steen, “The science of patterns,” *Science*, vol. 240, no. 4852, pp. 611–616, 1988.

2. H. Schenker, *Harmony*. University of Chicago Press, 1954, vol. 1.

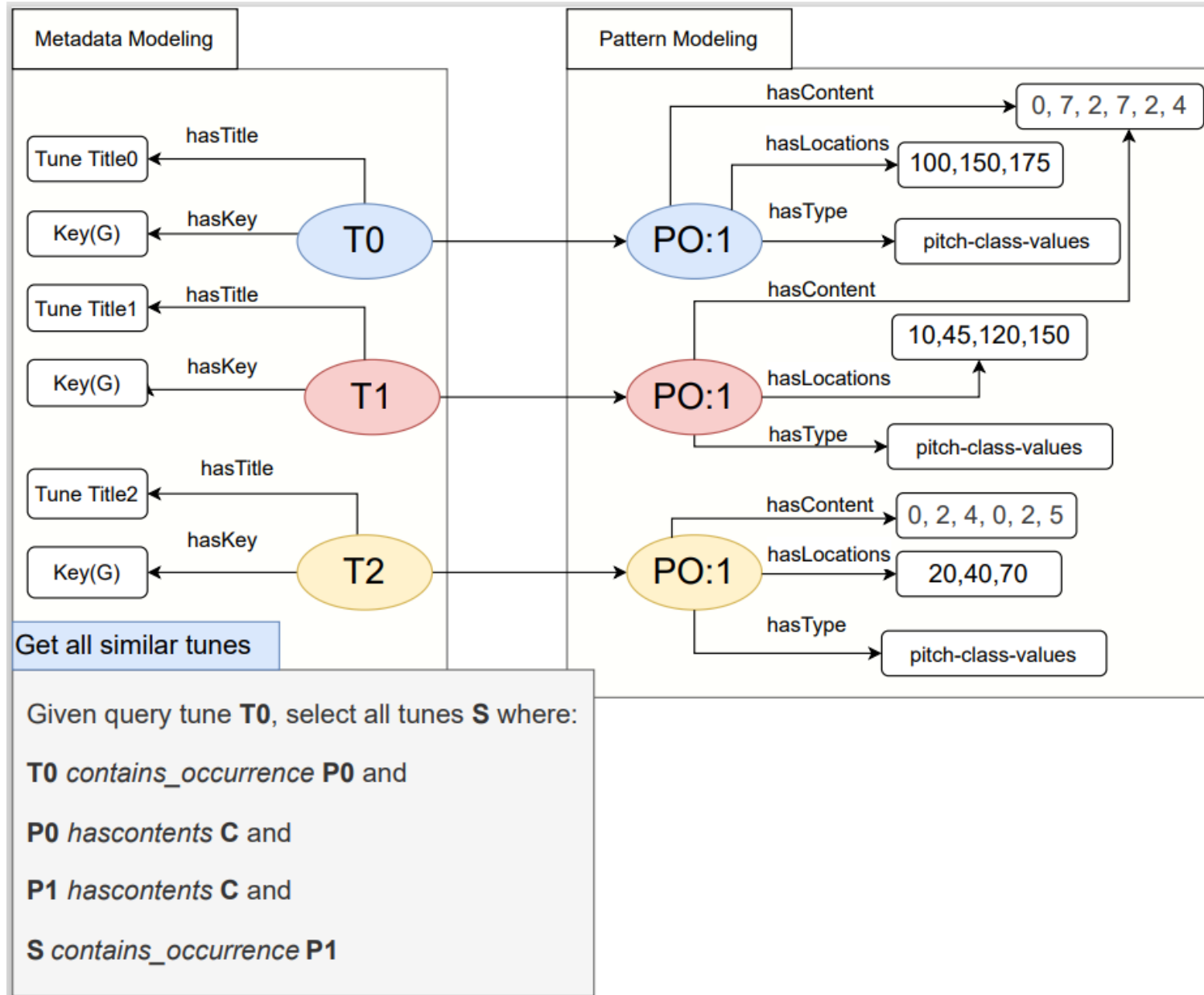
3. I. Bent and W. Drabkin, “The new grove handbooks in music analysis the macmillan press ltd,” UK, Houndmills, Basingstoke, Hampshire & London, 1987

# FoNN - FOlk N-gram aNalysis

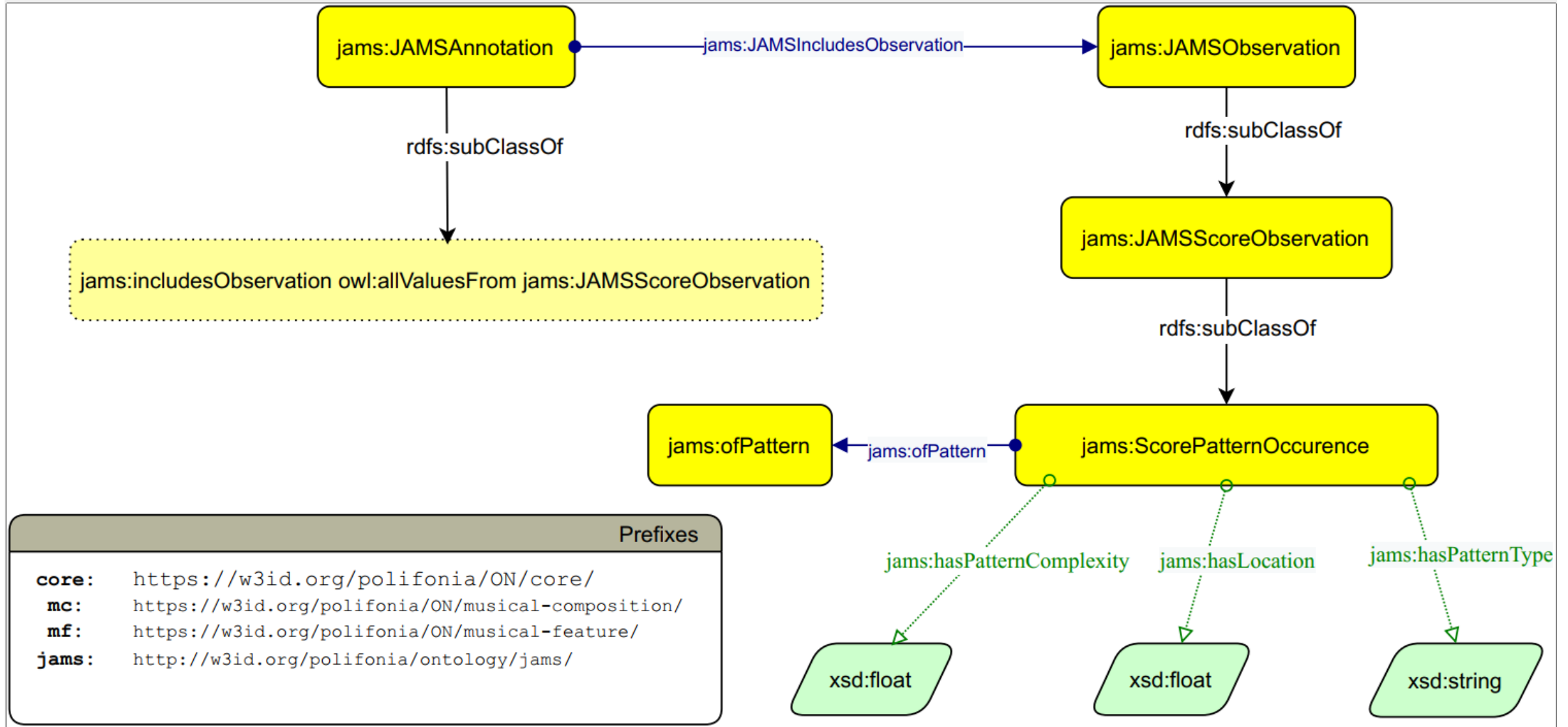
- We have a simple taxonomy of pattern.
- Based on  $n$ -grams of scale degree values.
- A pitch can be defined simply as an integer (e.g., in the range [0, 127])
- In our input corpus we count all  $n$ -grams of consecutive accented notes (represented as scale degree values) for  $n = 4 \dots 10$ .
- The focus of the current research is to present and preserve those extracted patterns.
- The solution is ontologies and knowledge graph.

```
KG_Data(  
  identifiers='3822',  
  feature='diatonic_scale_degree',  
  n_vals=(4, 5, 6),  
  duration=99,  
  pattern_locations={  
    (1, 3, 1, 5): [0, 16],  
    (3, 1, 5, 3): [1, 17],  
    (1, 5, 3, 3): [2, 18],  
    (2, 5, 3, 1): [7, 23, 39, 55],  
    (5, 3, 1, 6): [8, 24, 40, 56],  
    (3, 1, 6, 3): [9, 25, 41, 57, 73, 89],  
    (1, 6, 3, 3): [10, 26, 42, 58, 74, 90],  
    ....  
    ....
```

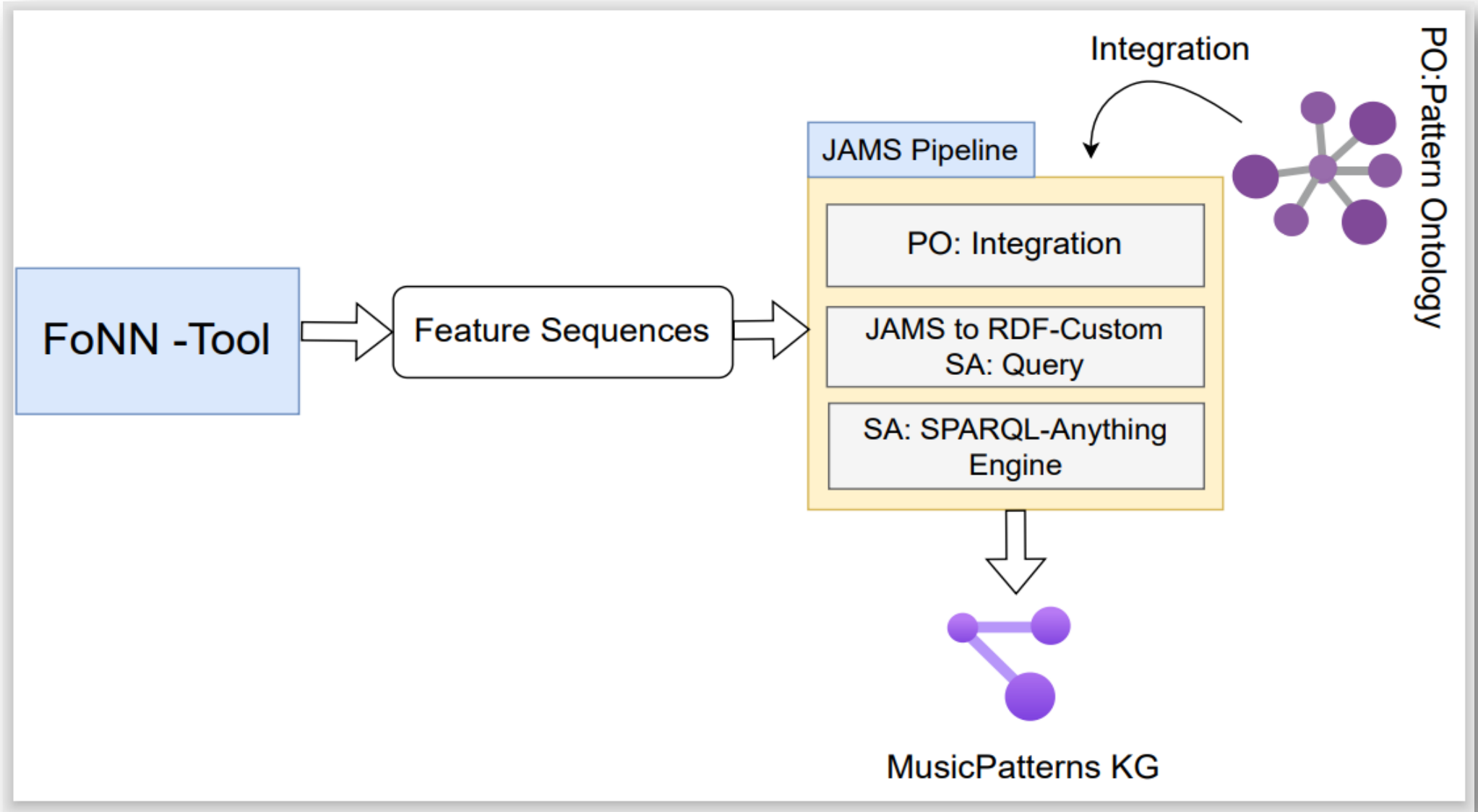
# Conceptual Model



# Snippet of the Pattern Ontology



# Patterns2KG

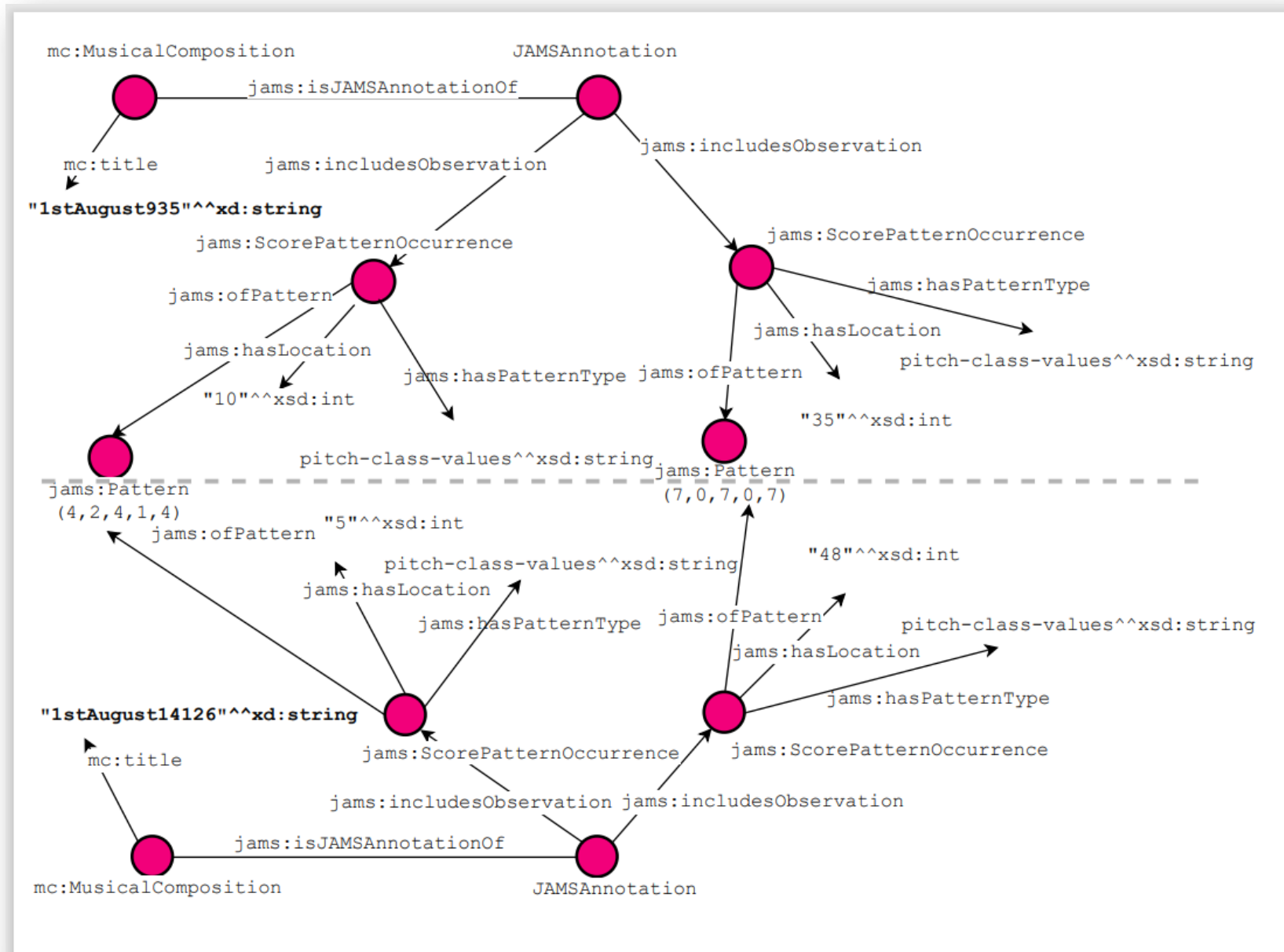




# Pikle2JAMS – features sequences to JAMS



# Knowledge Graph



# Under the hood

```
"time": 182.0,
"duration": 0.0,
"value": {
  "pattern_id": "1956:RainbowFlagThe",
  "pattern_content": "3, 7, 1, 2, 7, 5",
  "pattern_type": "pitch-class-values",
  "pattern_frequency": 2,
  "pattern_complexity": 0.83,
  "pattern_length": 6
},
"confidence": 1
},
"sandbox": {},
"time": 0,
"duration": null
},
"file_metadata": {
  "title": "Rainbow Flag, The",
  "artist": "",
  "release": "n-grams patterns-kg 1.0",
  "duration": 190.0,
  "identifiers": {
    "tune-corpus": "thesession",
    "url": "https://thesession.org/tunes/1956"
  },
  "jams_version": "0.3.4"
},
"sandbox": {
  "content": "G|:FDF GBG|AdB cAG|FDF GBA|GBd cAG|FDF GBG|AdB cAG|AdB cAG|1 FDD DAG:|2 A",
  "feature_data": "[7, 5, 7, 1, 3, 1, 2, 5, 3, 4, 2, 1, 7, 5, 7, 1, 3, 2, 1, 3, 5, 4, 2",
  "transcriber": "gian marco",
  "tunetype": "jig",
  "tunefamily": "",
```

```
<http://w3id.org/polifonia/resource/JAMSObservation/7d1dce7195d4dcla401935d4c597a
  jams:JAMSScoreObservation,
  jams:ScorePatternOccurrence ;
jams:hasPatternComplexity "0.83"^^xsd:float ;
jams:hasPatternLocation "182.0"^^xsd:float ;
jams:hasPatternType "pitch-class-values" ;
jams:ofPattern <http://w3id.org/polifonia/resource/pattern/3\_7\_1\_2\_7\_5> .

<http://w3id.org/polifonia/resource/MusicalComposition/f4b32fed20243d381a35ea999b
  rdfs:label "Rainbow Flag, The" ;
  jams:beatsDuration "190.0"^^xsd:float ;
  jams:key <http://w3id.org/polifonia/resource/key/Dmixolydian> ;
  jams:timeSignature <http://w3id.org/polifonia/resource/timesig/6\_8> ;
  jams:tuneContent "G|:FDF GBG|AdB cAG|FDF GBA|GBd cAG|FDF GBG|AdB cAG|AdB cAG|",
  jams:tuneFamily <http://w3id.org/polifonia/resource/tunefamily/> ;
  jams:tuneId "1956" ;
  jams:tuneType <http://w3id.org/polifonia/resource/tunetype/jiq> ;
  mc:title "Rainbow Flag, The" ;
  prov:wasDerivedFrom <http://w3id.org/polifonia/resource/JAMSFile/f4b32fed2024
```

# Dataset

- Large dataset of Irish folk music, **The Session**.
- All of the tunes from the 17th and 18th centuries are included in the dataset (<https://thesession.org/>).
- This dataset is crowd-sourced but is seen as quite a definitive resource by practitioners.
- The whole dataset has been processed through FoNN, and n-grams of size (for  $n = 4, 5,$  and  $6$ ) has been generated.
- The FoNN tool produces a pickle file, which is given to JAMS Pipeline, which creates JAMS files for each tune having relevant patterns.
- A total of 40,152 JAMS files have been created, which were processed to create KG.
- A total of around 45 million (4,979,281) statements were generated and deployed using Blazegraph.

Table 2: List of competency questions developed in conjunction with musicologist

No.	Question
CQ1	Metadata: Find tune metadata such as key signature and name of the transcriber.
CQ2	Pattern types: Identify the types of patterns present, e.g. a pattern might be composed of a list of notes, or of accented notes, pitch-class values, etc.
CQ3	Pattern search: Given a pattern, find a list of tunes it occurs in.
CQ4	Pattern search (2): Given instead with two patterns, find a list of tunes both occur in.
CQ5	Pattern frequency: Retrieve the patterns and their frequencies per tune.
CQ6	Pattern location: Given a pattern, retrieve its location in a tune (beginning, middle, or end).
CQ7	Similar tunes: Given a tune, find a ranked list of similar tunes (based on pattern similarity).
CQ8	Bridging patterns: Find patterns that play a bridging role between multiple musical traditions/datasets.
CQ9	Characteristic patterns: Given a tune, find other members of the same family based on patterns.
CQ10	Pattern Containment (subsume) – given a pattern, find all tunes when it or a pattern that contains a pattern occurs.

# Similar Tunes

```
SELECT distinct
  (concat(?givenTuneId,"-",?givenTuneTitle) as ?givenTuneInfo)
  (concat(?matchedTuneId,"-",?matchedTuneTitle) as ?matachedTuneInfo)
  ?sharedPattern ?patternComplexity
WHERE
{
  VALUES ?givenTune {'Bucks Of Oranmore, The'}
  ?tune mc:title ?givenTune.
  ?tuneFile jams:isJAMSAnnotationOf ?tune.
  ?tuneFile jams:includesObservation ?observation.
  ?observation jams:ofPattern ?sharedPattern.
  ?observation jams:hasPatternComplexity ?patternComplexity.
  ?anotherTuneFile jams:includesObservation ?anotherTuneObser.
  ?anotherTuneFile jams:isJAMSAnnotationOf ?anotherTune.
  ?anotherTuneObser jams:ofPattern ?sharedPattern.
  FILTER(?tuneFile != ?anotherTuneFile).
  ?tune mc:title ?givenTuneTitle.
  ?tune jams:tuneId ?givenTuneId.
  ?anotherTune mc:title ?matchedTuneTitle.
  ?anotherTune jams:tuneId ?matchedTuneId.
}
LIMIT 5
```

givenTuneInfo	matchedTuneInfo	matchedPattern	patternComplexity
12344-Bucks Of Oranmore, The	16002-For The Sake Of Old Decency	2_5_2_5_2_5	"0.33"^^xsd:float
12344-Bucks Of Oranmore, The	18429-Tom Keane's	2_5_2_5_2_5	"0.33"^^xsd:float
12344-Bucks Of Oranmore, The	19712-Hedgehog, The	2_5_2_5_2_5	"0.33"^^xsd:float
12344-Bucks Of Oranmore, The	20073-Furze In Bloom, The	2_5_2_5_2_5	"0.33"^^xsd:float
12344-Bucks Of Oranmore, The	22236-Lady Madelina Sinclair	2_5_2_5_2_5	"0.33"^^xsd:float

Listing 9: Similar tunes: Given a tune, find a ranked list of similar tunes (based on pattern similarity).

# Search a pattern

```
SELECT distinct (concat(?tuneId, "-" ,?tuneTitle) as ?tuneInfo)
?tuneType ?tuneSignature
WHERE
{
VALUES ?Pattern
{<5_1_6_2_4_1>}
?observation jams:ofPattern ?pattern.
?tuneFile jams:includesObservation ?observation.
?tuneFile jams:isJAMSAnnotationOf ?tune.
?tune mc:title ?tuneTitle.
?tune jams:tuneId ?tuneId.
?tune jams:tuneType ?tuneType.
?tune jams:timeSignature ?tuneSignature.
}

LIMIT 5
```

TuneInfo	TuneType	TuneSignature
10963-A Day In Sligo	jig	6_8
11909-A Jig For Bernie	jig	6_8
12265-All Alive	jig	6_8
13055-Apples In Winter	jig	6_8
30574-A Trip To The Cottage	jig	6_8

Listing 5: List of the tunes where a given pattern was found

# Metadata

```
SELECT distinct ?title ?tuneType ?key ?signature ?transcriber
WHERE
{ VALUES ?givenTuneTitle {'Bucks Of Oranmore, The'}
?tuneFile jams:isJAMSAnnotationOf ?tune.
?tune mc:title ?title.
FILTER (?title = ?givenTuneTitle) .
?tune jams:tuneType ?tuneType.
?tune jams:key ?key.
?tune jams:timeSignature ?signature .
?tune jams:transcriber ?transcriber.
?tune jams:tuneContent ?tuneContent.
} limit 5
```

Tune	TuneType	Key	Signature	Transcriber
2-Bucks Of Oranmore, The	reel	Dmajor	4_4	Jeremy
29659-Bucks Of Oranmore, The	reel	Dmajor	4_4	JACKB
29662-Bucks Of Oranmore, The	reel	Dmajor	4_4	JACKB
22356-Bucks Of Oranmore, The	reel	Dmajor	4_4	JACKB
28224-Bucks Of Oranmore, The	reel	Dmajor	4_4	GaryAMartin

Listing 2: How can we find metadata-related information about a tune/corpus?  
Query and results



# Co-occurrence of patterns

```
SELECT * {
{
  SELECT ?TuneId (sample(?tuneName) as ?TuneTitle) (count(?Pattern1)
  AS ?Pattern1_Freq)
{
  VALUES ?Pattern1 {<5_1_3_1>}
?observation1 jams:ofPattern ?Pattern1 .
?tuneFile jams:includesObservation ?observation1.
?tuneFile jams:isJAMSAnnotationOf ?tune.
?tune mc:title ?tuneName.
?tune jams:tuneId ?TuneId.
  } GROUP BY (?TuneId)
}
{
  SELECT ?TuneId (count(?Pattern2) AS ?Pattern2_Freq)
{
  VALUES ?Pattern2 {<5_3_1_1_5_1>}
?observation2 jams:ofPattern ?Pattern2 .
?tuneFile jams:includesObservation ?observation2.
?tuneFile jams:isJAMSAnnotationOf ?musicalComposition.
?musicalComposition mc:title ?tuneName.
?musicalComposition jams:tuneId ?TuneId.
} GROUP BY (?TuneId )
} } ORDER BY DESC (?Pattern1_Freq)
LIMIT 5
```

TuneId	TuneTitle	Pattern1_Freq	Pattern2_Freq
32009	Twirl	"4"^^xsd:integer	"2"^^xsd:integer
27737	Mourne Mountains, The	"4"^^xsd:integer	"2"^^xsd:integer
20603	Eddie Dooley's	"4"^^xsd:integer	"1"^^xsd:integer
39054	Belharbour, The	"4"^^xsd:integer	"1"^^xsd:integer
39782	Blackbird, The	"3"^^xsd:integer	"1"^^xsd:integer

Listing 6: How can I find the list of tunes based on the co-occurrence of two patterns?

# Common patterns

```
SELECT ?pattern (count(?pattern) as ?patternFreq)
{
  VALUES ?givenCorpus {"The Session"}.
  ?tuneFile jams:isJAMSAnnotationOf ?tune.
  ?tuneFile jams:includesObservation ?observation.
  ?observation jams:ofPattern ?pattern.
  #?observation jams:ofPattern ?pattern.
  ?tune jams:tuneFamily ?tuneFamily.
  FILTER (str(?tuneFamily) =
    "http://w3id.org/polifonia/resource/tunefamily/Lord_McDonald's").
  ?tune prov:wasDerivedFrom ?corpus.
  ?corpus prov:wasDerivedFrom ?givenCorpus.
}
GROUP BY ?pattern
HAVING (?patternFreq >= 3)
ORDER BY DESC (?patternFreq)
LIMIT 5
```

Pattern	PatternFreq
5_2_5_2	"29"^^xsd:integer
2_5_2_5	"21"^^xsd:integer
5_2_5_2_5	"14"^^xsd:integer
2_5_2_5_2	"13"^^xsd:integer
5_3_5_2	"13"^^xsd:integer

Listing 11: Given a national corpus, what patterns are characteristic of that corpus?

# Conclusion

- Pattern ontology based on Musical Annotation Patterns
- JAMS pipeline to populate a Knowledge graph of the music patterns (n-gram pitch-class-values).
- Evaluated using competency questions
- This evaluation suggest the current modeling provides a solid foundations, further modeling is necessary to enhance its utility.
- In future,
  - datasets such as Meertens tune collections (Dutch dataset), which may lead to discover interesting links between various music traditions.
  - User interface which uses our KG as a back-end, allowing non-technical musicologists to ask and answer research questions based on our KG.
  - Finally, we would like to engage a wider community to ensure we can answer more complex types of user queries.

# Thanks to Polifonia & Questions?

[https://github.com/polifonia-project/folk\\_ngram\\_analysis](https://github.com/polifonia-project/folk_ngram_analysis)

<https://github.com/polifonia-project/patterns-knowledge-graph>