

Parser-Combinators for Context-Free Path Querying*

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ABSTRACT

[illegible]

CCS CONCEPTS

- **Information systems** → **Graph-based database models;**
- Query languages for non-relational engines;**
- **Theory of computation** → *Grammars and context-free languages;*

KEYWORDS

Graph data bases, Language-constrained path problem, Context-Free path querying, Parser Combinators, Generalized LL, GLL, Neo4J, Scala

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1 INTRODUCTION

Graph as data model, Graph data bases.

Navigation queries. Path querying and context-free path querying. Same generation query is not a regular. Static code analysis.

Integration with general purpose programming languages is a problem. String-embedded DSLs. Special DSL vs Combinators (LINQ [4, 11], etc) [9]

We propose !!! and we make the following contributions in this paper.

- (1) Combinators for CF path querying with structural representation of result
- (2) Implementation in Scala. Generalization of linear parsing. Integration with Neo4J graph data base. Available on [github:https://github.com/YaccConstructor/Meerkat](https://github.com/YaccConstructor/Meerkat)
- (3) Evaluation on realistic data, which shows that it is applicable. Comparison with other tools for CF path querying.

2 RELATED WORK

Language-constrained path querying, Yannakakis [18]. Hellings [6, 7], RDF [19], etc [2, 3, 12, 15, 17]

Special graph query languages. SPARQL, cypher

Language integration problem: special DSLs for SQL, ORM, Linq
Parser-combinators is one of classical approach for parsing!!!

Scala combinators for graph [9] – one of attempt to adopt combinators technique for graph processing. But language class is not discussed.

- Classical combinators has restrictions: left-recursive grammars.
- GLL [16] can handle arbitrary context-free grammars, SPPF [13]
- Parser combinators library based on GLL – Meerkat ¹ [8].
- etc

3 PARSER-COMBITATORS FOR PATH QUERING

In this section we present our implementation of and describe some details.

Our implementation is based on Meerkat library. We need only some steps for generalization.

As far as linear input is a one of case of graph, it is possible to provide input abstraction which make possible to generalize combinators.

¹<https://github.com/meerkat-parser/Meerkat>

$$\begin{aligned}
S &\rightarrow \text{subClassOf}^{-1} S \text{ subClassOf} \\
S &\rightarrow \text{type}^{-1} S \text{ type} \\
S &\rightarrow \text{subClassOf}^{-1} \text{subClassOf} \\
S &\rightarrow \text{type}^{-1} \text{type}
\end{aligned}$$
Figure 1: Query 1 grammar

$$\begin{aligned}
S &\rightarrow B \text{ subClassOf} \\
B &\rightarrow \text{subClassOf}^{-1} B \text{ subClassOf} \\
B &\rightarrow \text{subClassOf}^{-1} \text{subClassOf}
\end{aligned}$$
Figure 2: Query 2 grammar

SPPF may be an arbitrary graph in opposite of linear input parsing.

Let we introduce an example. Graph. Grammar. In terms of combinators.

- Interface for Neo4J bata base
- Extensible solution
- An architecture of the solution.

4 EVALUATION

Some experiments on real data and comarison with existing solutions

4.1 Ontology querying

One of well-known graph querying problems is a queries for ontologies [1]. We use Meerkat to evaluate it on some popular ontologies presented as RDF files from paper [19]. We convert RDF files to a labeled directed graph like the following: for every RDF triple (*subject*, *predicate*, *object*) we create two edges (*subject*, *predicate*, *object*) and (*object*, *predicate*⁻¹, *subject*). On those graphs we apply two queries from the paper [5] which grammars are on Fig. 1, and Fig. 2 in two ways.

- Convert RDF files to a graph input for meerkat and then directly parse on query 1 and query 2
- Convert RDF files to a Neo4j database and then parse this database on given queries

Table 1 shows experimental results of those two aproaches over the testing RDF files where *number of results* is a number of triples of type (*nonterminal*, *start vertex*, *end vertex*) The performance is about 2 times slower than in [5] and shows the same results. If compare the performance of in memory graph querying and database querying, the second one is slower in about 2 – 4 times.

Integration with Neo4J

4.2 Static code analysis

Alias analysis is one of the fundamental static analysis problems[10]. Alias analysis checks may-alias relations between code expressions and can be formulated as a Context-Free language (CFL) reachability problem[14]. In that case program represeted as Program

$$\begin{aligned}
M &\rightarrow \bar{D} V D \\
V &\rightarrow (M? A)^* M? (A M?)^*
\end{aligned}$$
Figure 3: Context-Free grammar for the may-alias problem in syntax

Program	Code Size (KLOC)	Count of aliases		Time (ms)
		M aliases	V aliases	
wc-5.0	0.5K	0	174	350
pr-5.0	1.7K	13	1131	532
ls-5.0	2.8K	52	5682	436
bzip2-1.0.6	5.8K	9	813	834
gzip-1.8	31K	120	4567	1585

Table 2: Running may-alias queries on Meerkat on some C open-source projects

Expression Graph (PEG)[20]. Verticies in PEG are program expressions and edges are relations between them. In a case of analysing C source code there is two kind of edges **D**-edge and **A**-edge.

- Pointer dereference edge (**D**-edge). For each pointer deference $*e$ there is a directed D-edge from e to $*e$.
- Pointer assignment edge (**A**-edge). For each assignment $*e_1 = e_2$ there is a directed A-edge from e_2 to $*e_1$

Also, for the sake of simplicity, there are edges labeled by \bar{D} and \bar{A} which corresponds to reversed D-edge and A-edge, respectively.

The grammar for may-alias problem from [20] presented on Fig. 3. It consists of two nonterminals **M** and **V**. It allows us to make two kind of queries for each of nonterminals **M** and **V**.

- **M** production shows that two l-value expression are memory aliases i.e. may stands for the same memory location.
- **V** shows that two expression are value aliases i.e. may evaluate to the same pointer value.

We made **M** and **V** queries on the code some open-source C projects. The results are presented on the Table 2

Comparison with GLL

Comparison with [9]

5 CONCLUSION

We propose a native way to integrate language for language-constrained path querying into general purpose programming language. We implement it and show that our implementation can be applied for real problems.

Code is available on GitHub:

Future work is

SPPF processing for debugging and results processing

Attributed grammars processing to provide mechanim for semantics calcaultion

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Ontology	Number of tripples	Query 1			Query 1		
		Number of results	In memory graph query time (ms)	DB query time (ms)	Number of results	In memory graph query time (ms)	DB query time (ms)
atom-primitive	425	15454	174	236	122	49	56
biomedical-mesure-primitive	459	15156	328	398	2871	36	52
foaf	631	4118	23	42	10	1	2
funding	1086	17634	151	175	1158	18	23
generations	273	2164	9	27	0	0	0
people_pets	640	9472	68	87	37	2	3
pizza	1980	56195	711	792	1262	44	56
skos	252	810	4	29	1	0	1
travel	277	2499	23	93	63	2	2
univ-bench	293	2540	19	74	81	2	3
wine	1839	66572	578	736	133	5	7

Table 1: Evaluation results for In Memory Graph and Graph DB

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