Parsing techniques for graph analysis

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Language-constrained paths filtering

- $\mathbb{G} = (\Sigma, N, P)$ — context-free grammar
- $G = (V, E, L)$ — directed graph, $E \subseteq V \times L \times V$, $L \subseteq \Sigma$
- $p = (v_0, l_0, v_1), \cdots, (v_{n-1}, l_{n-1}, v_n)$ — path in G
- $\omega(p) = \omega((v_0, l_0, v_1), \cdots, (v_{n-1}, l_{n-1}, v_n)) = l_0 l_1 \cdots l_{n-1}$
- $R = \{p | \exists N_i \in N(\omega(p) \in L(\mathbb{G}, N_i))\}$
- Other possible variants

Language-constrained paths filtering: more formal

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Applications

- Graph analysis
  - Graph database querying
  - Network graph analysis
  - ▶
- Code analysis
  - Static analysis CFL(linear conjunctive) reachability: alias analysis, points-to analysis, etc
  - Dynamically generated strings analysis
  - Multiple input parsing
- ...

Open Problems etc

- Effective algorithm creation
- Result representation for debugging, futer processing
- GPGPU utilization

Bar-Hillel theorem

- Context-free languages are closed under intersection with regular languages
- Parsing algorithms are constructive proof of Bar-Hille theorem for one simple case ...
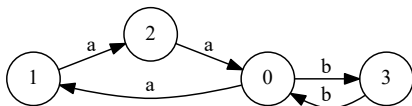- ....so, it can be generalized for arbitrary regular language processing

Example

Figure: An example: the map of School (input graph M)

$$
\begin{aligned}
0 : \quad & S \rightarrow a\ S\ b \\
1 : \quad & S \rightarrow Middle \\
2 : \quad & Middle \rightarrow a\ b
\end{aligned}
$$

Figure: An example: grammar G_1 for language $L = \{a^n b^n; n \geq 1\}$ with additional marker for the middle of a path
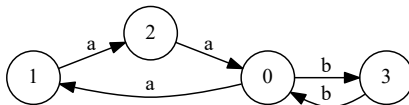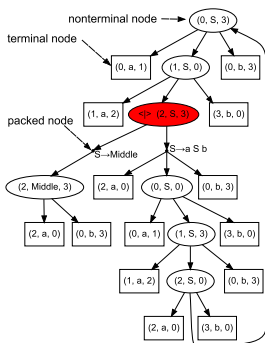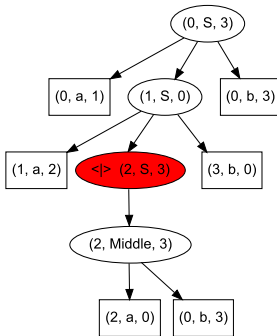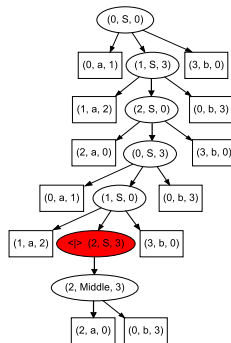
Example

Figure: An example: the map of School (input graph M)

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Our solutions

- Relaxed parsing of dynamically generated SQL-queries.
  - ▶ Based on RNGLR parsing algorithm (Izmailova, Afroozeh)
- Context-free path querying with structural representation of result.
  - ▶ Based on GLL parsing algorithm (Izmailova, Afroozeh)
- Combinators for context-free path querying
  - ▶ Based on Meerkat (Izmailova, Afroozeh)
- Context-free path querying by matrix multiplication
  - ▶ Inspired by Valiant and Okhotin

Future work

- Other grammars and language classes intersection
  - Context-free grammars intersection
    - ⋆ Mark-Jan Nederhof, "The language intersection problem for non-recursive context-free grammars"
  - Approximated intersection of regular and conjunctive/boolean languages
  - ...
- Mechanization in Coq
  - Bar-Hillel theorem
  - GLL-based algorithms
  - ...
- New areas for application

Information

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