Formal Language Driven Data Analysis Research Group Report

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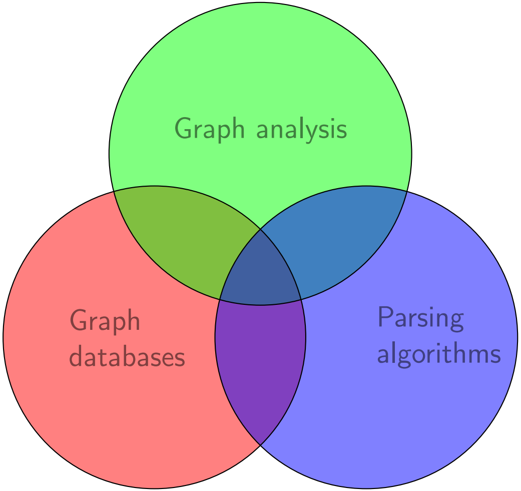
Saint Petersburg State University

September 14, 2022

Research Area

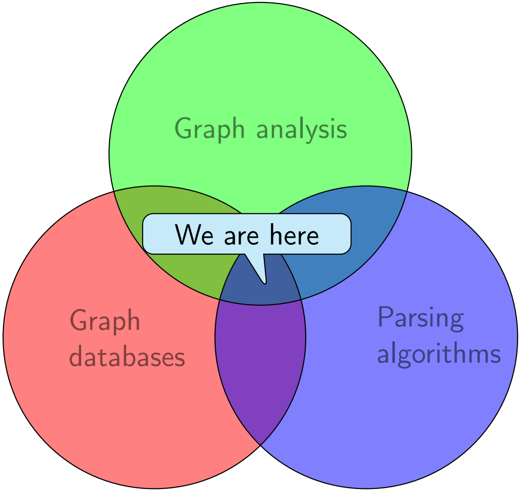


Graph analysis

Graph databases

Parsing algorithms

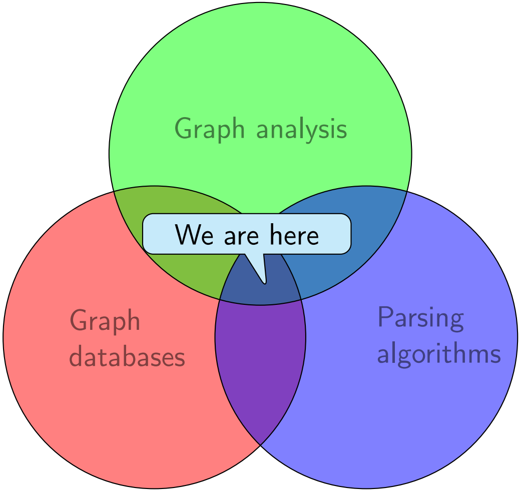
Research Area



Research Area

Applications

- Code analysis
- Code querying
- Code parsing



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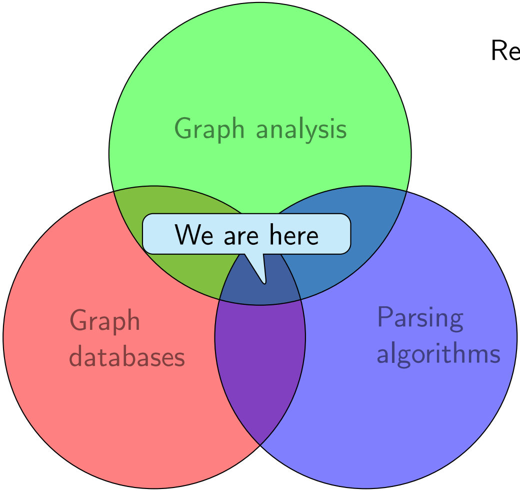

Research directions

- Graph algorithms
  - Dynamic graphs
  - Linear algebra
  - Path querying
- Formal languages
  - Languages classes and properties
  - Parsing algorithms
  - Formal language constrained path querying

Code Analysis and Querying

Huge software projects

- Millions LOC
- Complex structure
- Dynamic (IDE-level analysis)

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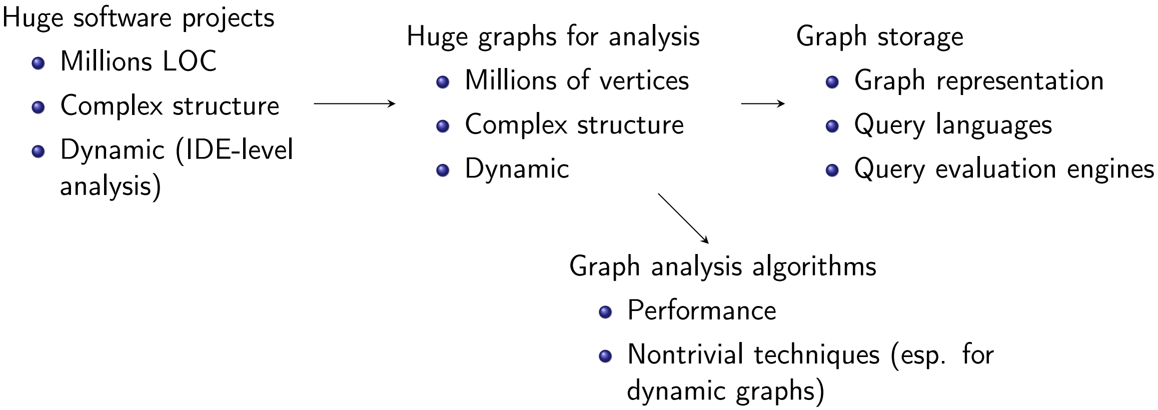
Graph storage

- Graph representation
- Query languages
- Query evaluation engines

Code Analysis and Querying



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Graph analysis algorithms

- Performance
- Nontrivial techniques (esp. for dynamic graphs)

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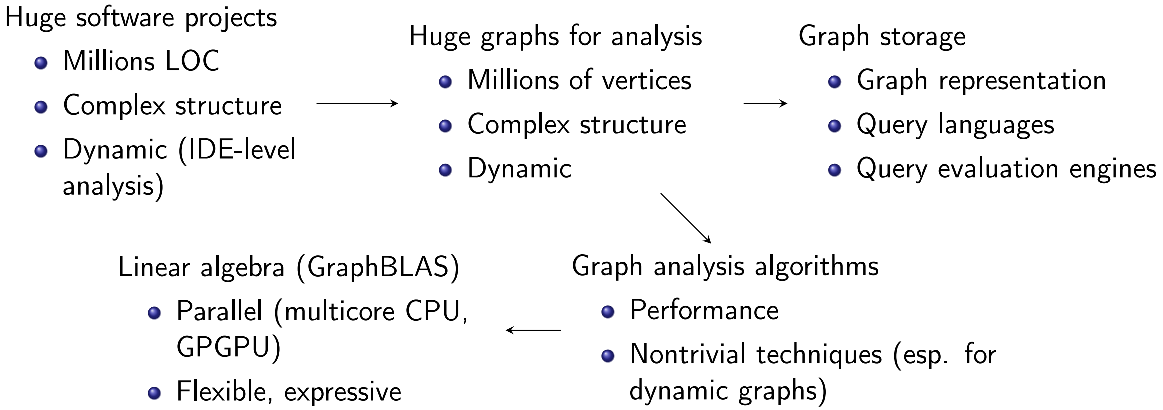

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Linear algebra (GraphBLAS)

- Parallel (multicore CPU, GPGPU)
- Flexible, expressive

Code parsing (for IDE)

Parsing for IDE

- Frequent code updates
- Partially correct code
- Multiple languages support
- Performance-critical

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Parsing technique

- Error recovery
- Reparsing
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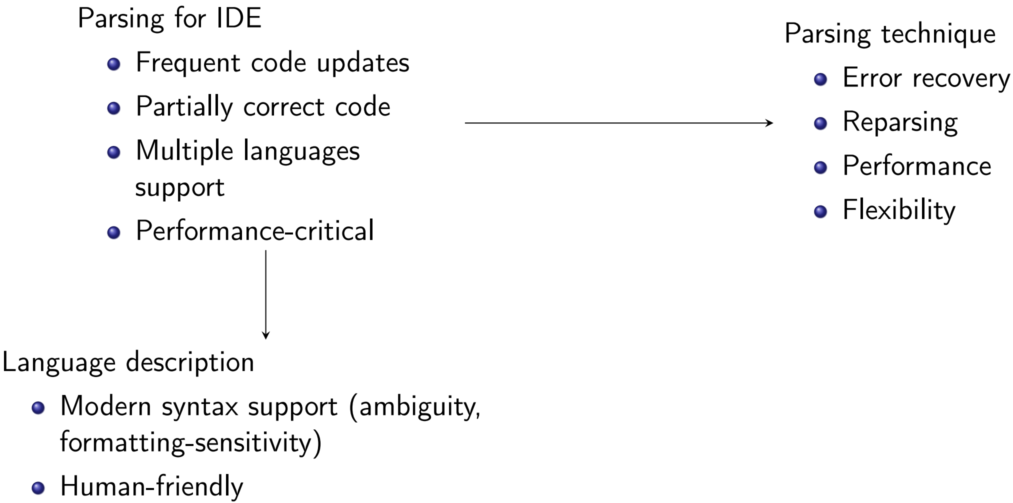

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Language description

- Modern syntax support (ambiguity, formatting-sensitivity)
- Human-friendly

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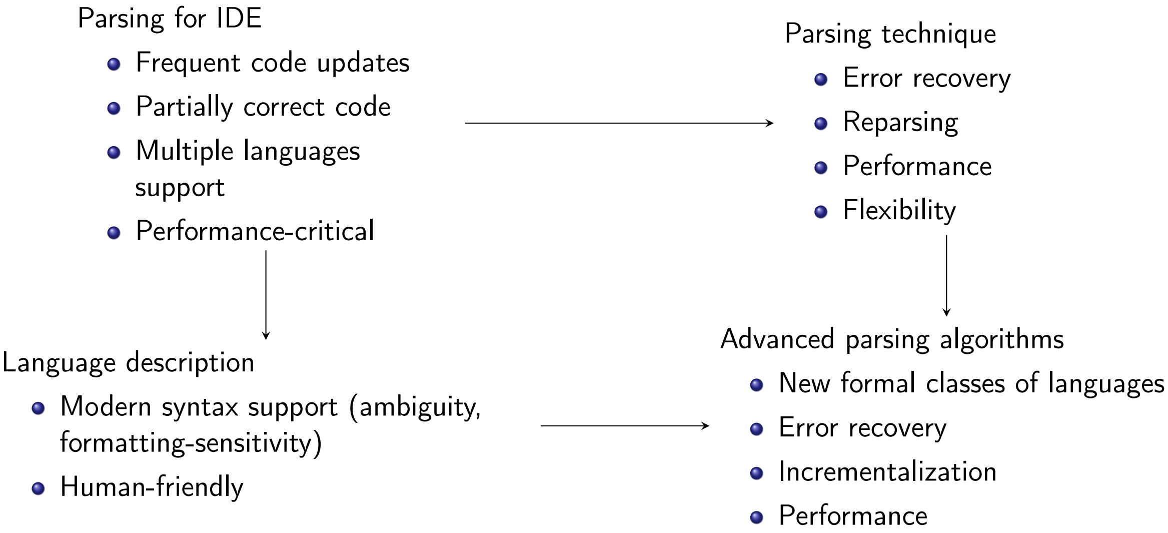

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Language description

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Advanced parsing algorithms

- New formal classes of languages
- Error recovery
- Incrementalization
- Performance

Results

Graph analysis for symbolic execution engine	Research prototype	• Graph extraction and update mechanism • Constrained shortest paths for dynamic graph

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Graph querying algorithms	Research prototype	• New algorithms • Complexity analysis • Performance analysis

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Graph analysis for symbolic execution engine	Research prototype	• Graph extraction and update mechanism • Constrained shortest paths for dynamic graph
Graph querying algorithms	Research prototype	• New algorithms • Complexity analysis • Performance analysis
Sparse linear algebra library on GPGPU	Research prototype	• Operations implementation • Optimizations • Performance analysis

Rustam Azimov (Graph analysis and querying)

- ✓ Linear algebra based graph analysis algorithms research and development
  - Regular path querying
  - Context-free path querying
  - Multiple context-free path querying
- ✓ Graph analysis algorithms evaluation
  - Formal language constrained path querying
  - Static code analysis cases
  - Linear algebra based algorithms

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- ⌛ Code analysis specific dataset for graph analysis algorithms evaluation and comparison
  - New graphs
  - New scenarios
  - New quey types
- ⌛ Graph analysis algorithms evaluation and comparison
  - New cases
  - New graphs
  - New algorithms

Ekaterina Shemetova (Graph analysis and querying)

- ✓ Linear algebra based graph analysis algorithms research and development
  - Complexity analysis
  - Specific cases of graphs and language classes
- ✓ Graph analysis algorithms evaluation
  - Formal language constrained path querying
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  - GLL-based algorithms

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- ⌛ Dynamic graph analysis
    - Specific algorithms for symbolic execution engine and code analysis
    - Theoretical analysis
    - Performance analysis
- ⌛ Parsing algorithms development end evaluation
    - Dynamic reparsing
    - Error recovery

Vladimir Kutuev (Graph analysis and querying)

- ✓ Graph analysis algorithms development and evaluation
  - Linear algebra based algorithm
  - Static code analysis cases
- ✓ Graph querying algorithm fo Neo4j development and evaluation
  - Static code analysis cases
  - GLL-based algorithms

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- **Scholarship will be paused**

Denis Porsev (Graph analysis and querying)

- ✓ New linear algebra based algorithm for multiple source regular path querying
  - Development
  - Implementation
  - Evaluation

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✓ New linear algebra based algorithm for multiple source regular path querying

- Development
- Implementation
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⌛ The algorithm improvements

- Performance analysis and improvements
- Evaluation and comparison
- Flexibility improvements

Vlada Pogozhelskaya (Graph analysis and querying)

- ✓ Neo4j-based graph analysis algorithm evaluation
  - General cases
  - Static code analysis cases

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Ilya Epelbaum (Graph analysis and querying)

✓ Multiple Context-Free Language constrained path querying algorithm in terms of linear algebra

- Development
- Implementation
- Evaluation

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  - Development
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- **Collaboration stopped**

Egor Orachyov (Linear algebra for GPGU)

- ✓ GPGPU-based sparse linear algebra library design and implementation
  - High-level design and architecture of portable extensible library
  - Project infrastructure
  - High-level concepts implementation

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- ⌛ Basic low-level primitives implementation
  - Data structures
  - Operations
- ⌛ Basic graph algorithms implementation and evaluation
  - BFS
  - TC
- ⌛ Out-of-GPGPU-memory graphs handling

Dmitriy Panfilenok (Linear algebra for GPGU)

✓ Kernel fusion optimization for element-wise matrix-matrix operations

- Development
- Implementation
- Evaluation

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  - Development
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Kirill Garbar (Linear algebra for GPGU)

- ✓ Well-typed element-wise matrix-matrix operations: generic generalized kernels for GPPGU
    - Development
    - Implementation
    - Evaluation

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✓ Well-typed element-wise matrix-matrix operations: generic generalized kernels for GPPGU

- Development
- Implementation
- Evaluation

⌛ Applied linear algebra based graph analysis algorithms

- BFS
- TC
- Supplementary matrix-vector operations
- Implementation and evaluation

Artem Chernikov (Linear algebra for GPGU)

- ✓ GPGPU-based operations on vectors and matrices
    - Collections sort
    - Matrix transpose

Artem Chernikov (Linear algebra for GPGU)

✓ GPGPU-based operations on vectors and matrices

- Collections sort
- Matrix transpose

⌛ Generic well-typed matrix-matrix multiplication

- Sparse matrices
- Evaluation and comparison

Alexandra Istomina (Graph analysis and querying)

- Collaboration research in previous academic year but was paused for summer
- Research topic: graph analysis algorithms for special types of graphs and languages

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⌛ Graph analysis algorithms for special types of graphs and languages

- Code analysis specific cases

The Plan

Code querying for declarative code analysis

- Code querying and graph querying languages
  - CodeQL
  - Datalog
  - GQL
  - ...
- Query evaluation engines
  - Performance
  - Flexibility
- Graph analysis algorithms
  - Performance
  - Scalability
  - Incrementalization

The Plan

Code querying for declarative code analysis

- Code querying and graph querying languages
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Parsing techniques and algorithms

- Language specification formalisms
- Error recovery techniques
- Reparsing techniques

Scholarships request (2022–2023 academic year, 9 months)

- Egor Orachyov
- Alexandra Istomina
- Kirill Garbar
- Denis Porsev
- 2-3 new students