An Empirical Investigation Into a Large-Scale Java Open Source Code Repository

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Motivation

- Getting insight into different aspects of source code artifacts
  - One trillion lines of code have been written
  - 35 billion lines of code added / year
- Getting empirical evidence of common patterns and facts of how programmers write code
- Typical usage
  - Provide guidance for commonly used techniques, patterns
  - Validate assumptions
  - Find matched subjects for empirical studies

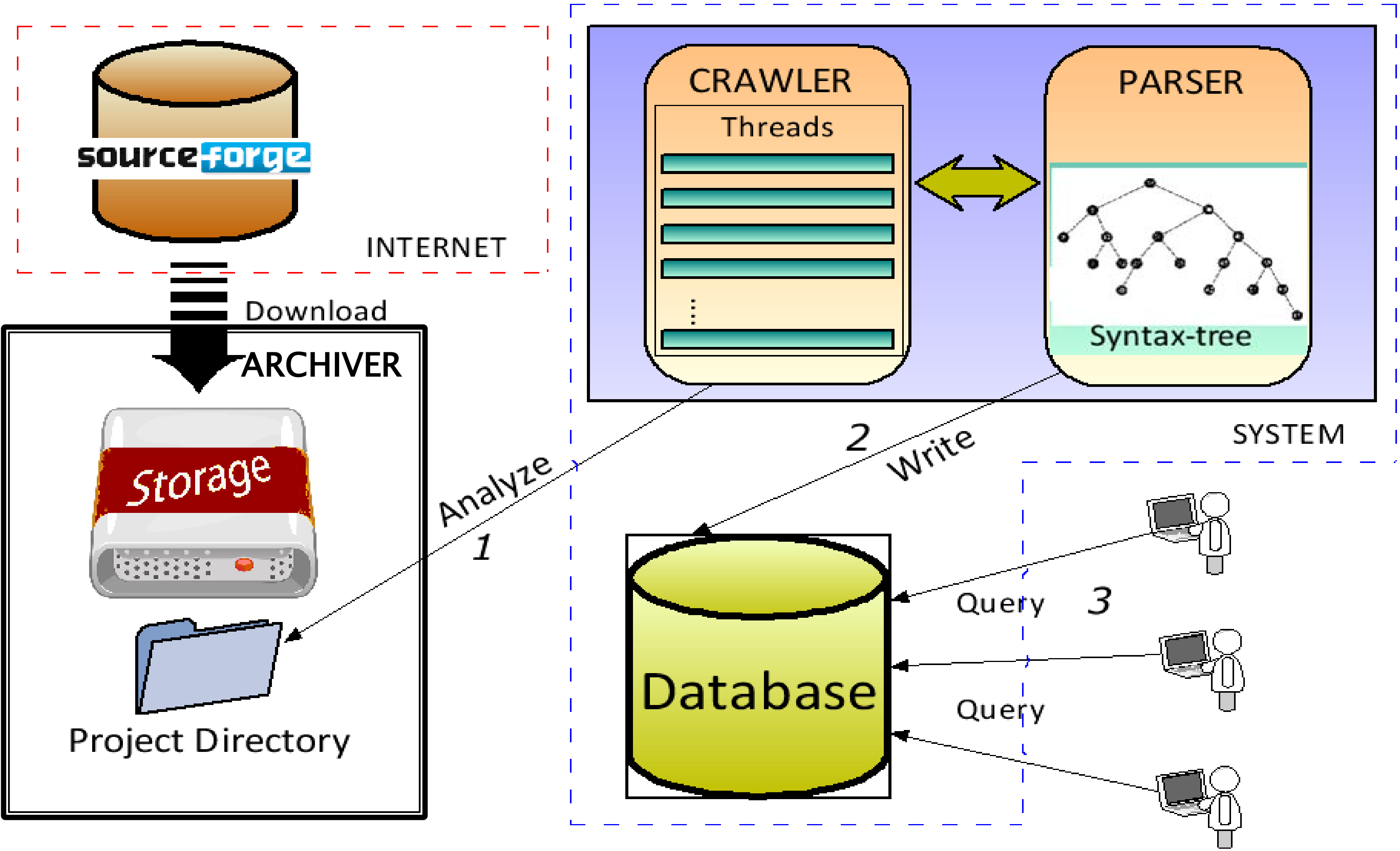
Challenges

- Source code files in large code repositories are treated as unstructured text by search engines and utilities
- Source code files are contained in compressed project files in the repositories
- Many repositories are polluted with poorly functioning projects
  - Fault tolerance mechanism
- Users should be able to form declarative queries
  - No low-level programs that traverse parse trees
  - SQL

Sourceforge

- Largest open-source software development website
  - Over 240,000 projects
  - Over 30,000 Java projects
- Widely used software
  - eMule – 539,287,695 downloads
  - 7-zip – 103,139,981 downloads
  - jEdit – 5,931,227 downloads

Infrastructure



Components

- Archiver
  - Crawl Sourceforge to retrieve Java projects
  - Populate project folders (250GB)
- Walker
  - Traverse project folders
  - Extract source files from zipped archive
  - Apply parser to the extracted source code
- Parser
  - Use JavaCompiler to Parse source code to build parse trees
  - Content of nodes are traversed and stored in databases
- Database
  - 71 tables and 278 attributes
  - Schema matches (non)terminals of the Java grammar
  - 9.2GB data (962MB compressed)
  - Publicly available at http://www.cs.wm.edu/semeru/treasure/

Query

- SQL query to state research questions

- Knowledge of
  - Database schema
  - Relations between schema and Java grammar
  - How to translate plain English to SQL

- Can be simple or complicated
  - SELECT c.name AS class, COUNT(m.id) AS number_methods FROM method m JOIN class c ON m.class = c.id GROUP BY c.id HAVING COUNT(m.id) >=100

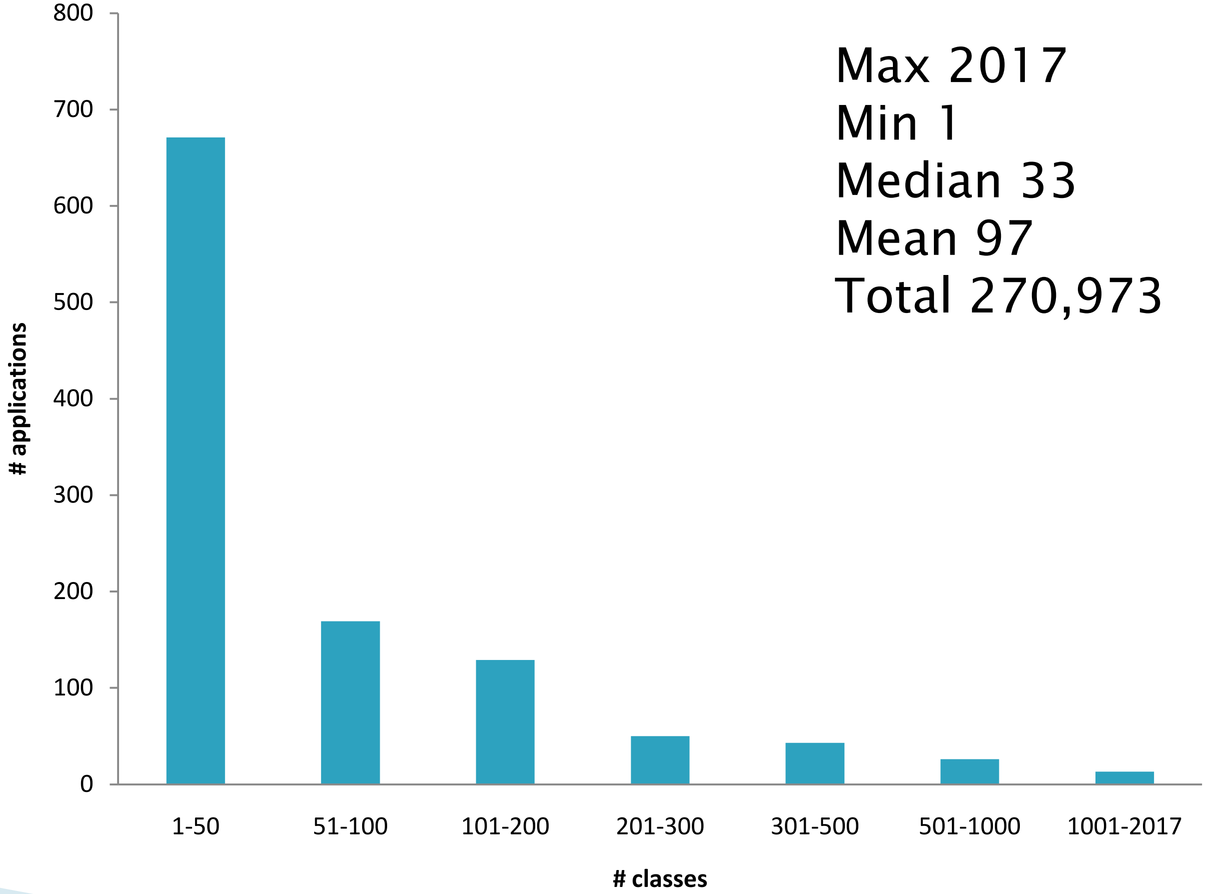
Empirical Evidence

- 2080 Java Applications
- 32 research questions
  - Classes and interfaces
  - Methods and constructors
  - Fields
  - Statements
  - Exceptions
  - Variables
  - Evolution and Maintenance

Classes and Interfaces

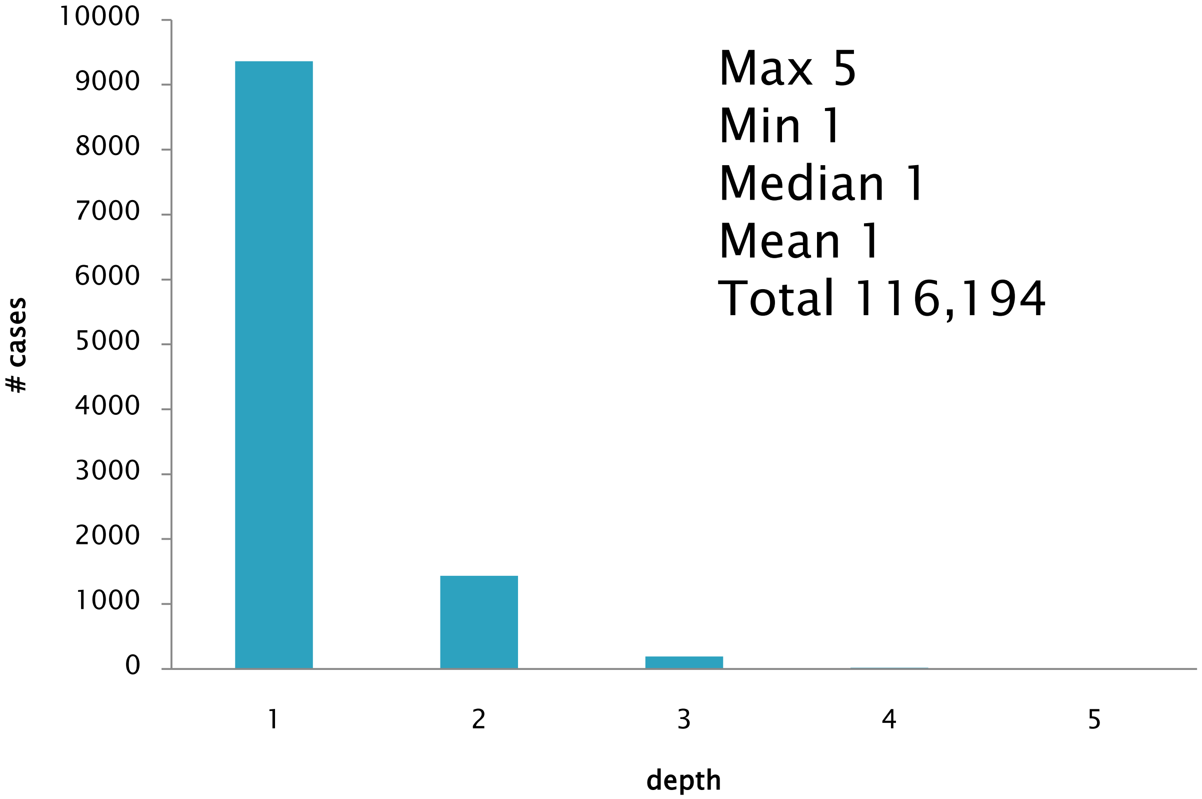
- 270,973 classes
  - 5827 declared as abstract
  - 7368 static classes
  - 29,237 anonymous classes
  - 14,270 nested classes
- 116,194 classes that are in some inheritance hierarchy
  - Maximum depth is 5
- 2026 interfaces extend hierarchies
  - Maximum depth is 4

Number of Classes per Application



Max 2017
Min 1
Median 33
Mean 97
Total 270,973

Inheritance Hierarchies Depth



Max 5
Min 1
Median 1
Mean 1
Total 116,194

AdminIPAccess->IPAccessControl->
LockssServlet->HttpServlet->GenericServelet

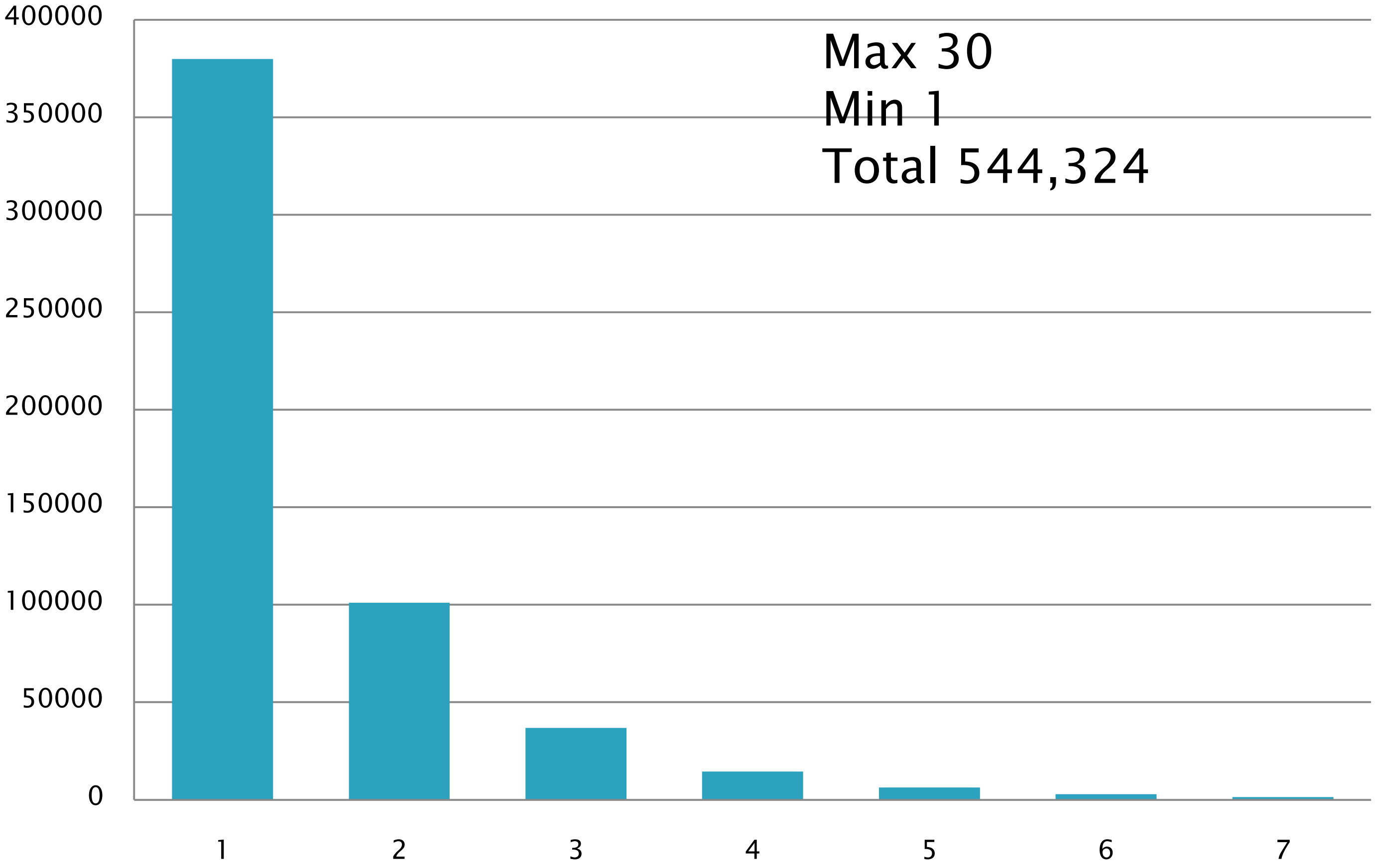
Methods and Constructors

- 938,779 methods in classes
  - 35,846 occurrences in recursive method calls
  - 231,647 static methods (excluding main)
  - 414,953 return void vs 523,826 return non-void
  - 840,937 use “this”
  - 544,324 have at least one argument

- 84,130 methods in interfaces

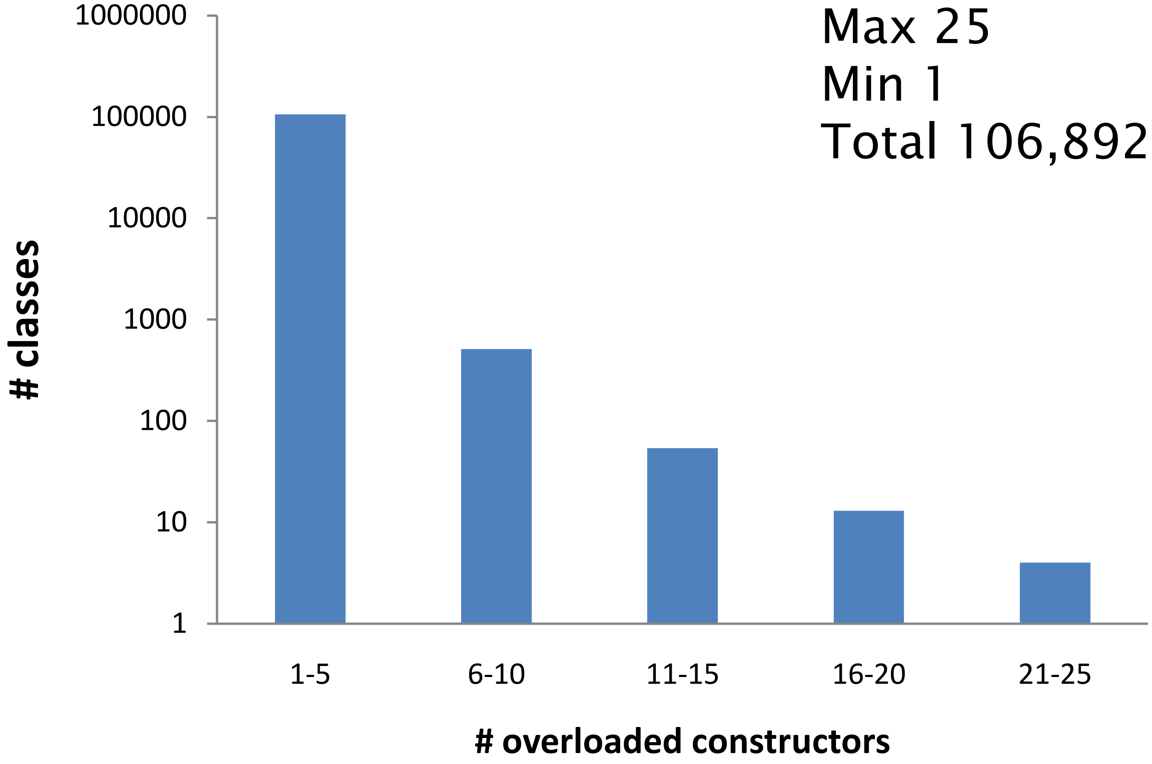
- 145,124 classes do not define constructors
- 106,892 classes have overloaded constructors

Number of Arguments per Method



Max 30
Min 1
Total 544,324

Number of Overloaded Constructors per Class

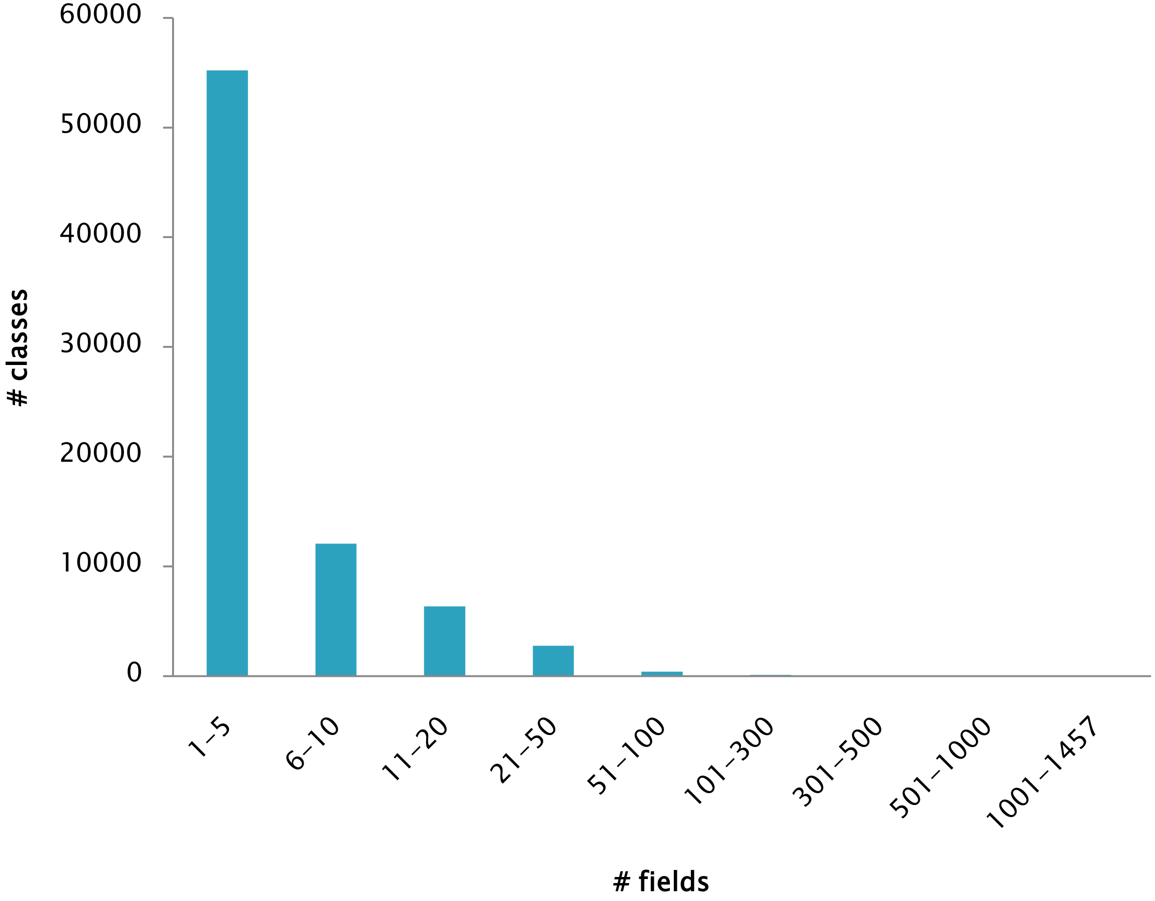


Max 25
Min 1
Total 106,892

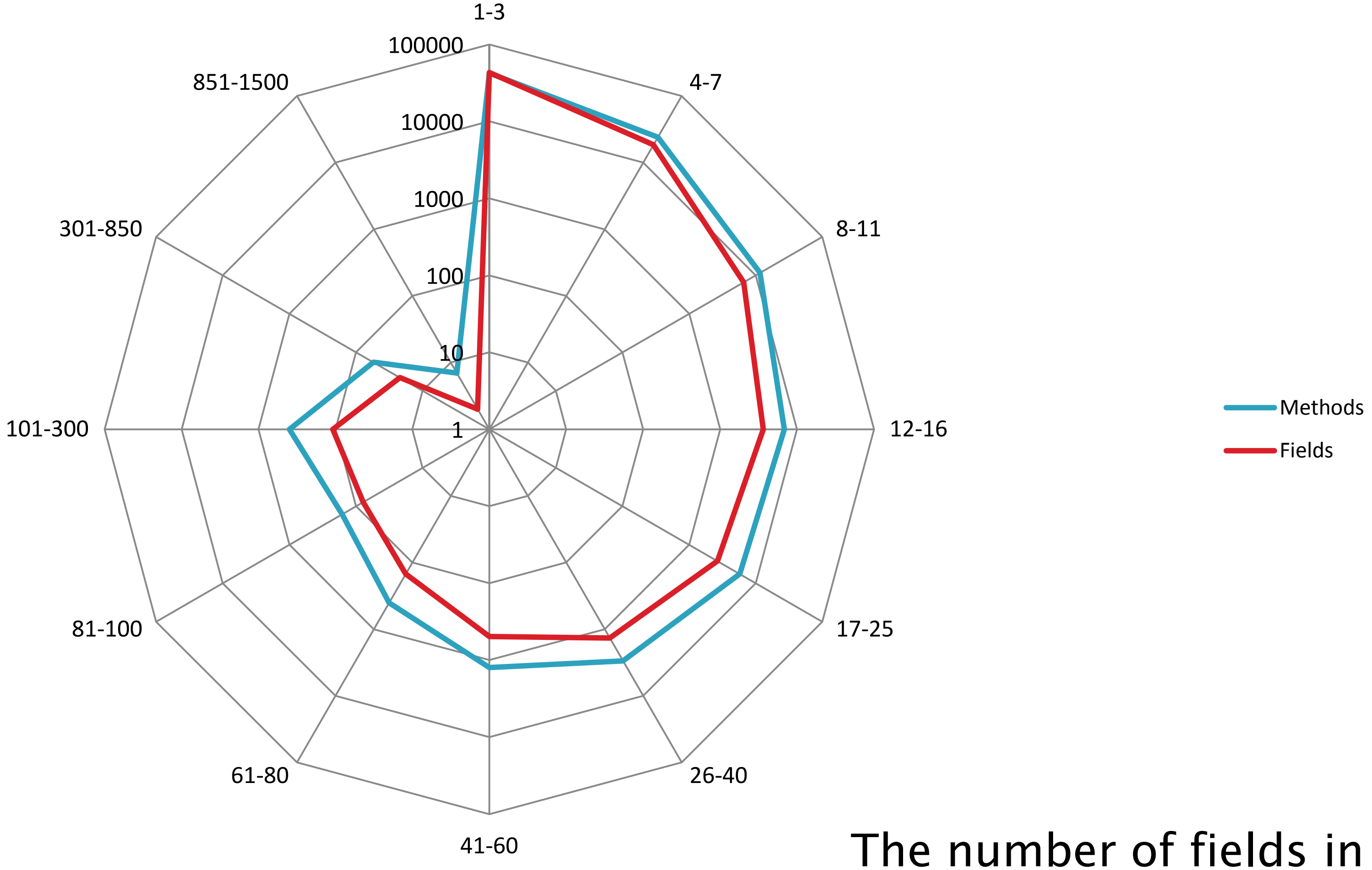
Fields

- 448,898 fields in classes
  - 492 volatile
  - 2,305 transient
  - 154,067 static
  - 231,647 of type String
- 831 out of 29,907 assignments to a static field is null
  - Signal garbage collection
- Correlation coefficient is 0.99 for number of methods and number of fields in classes

Number of Fields per Class



Methods/Fields Correlation per class

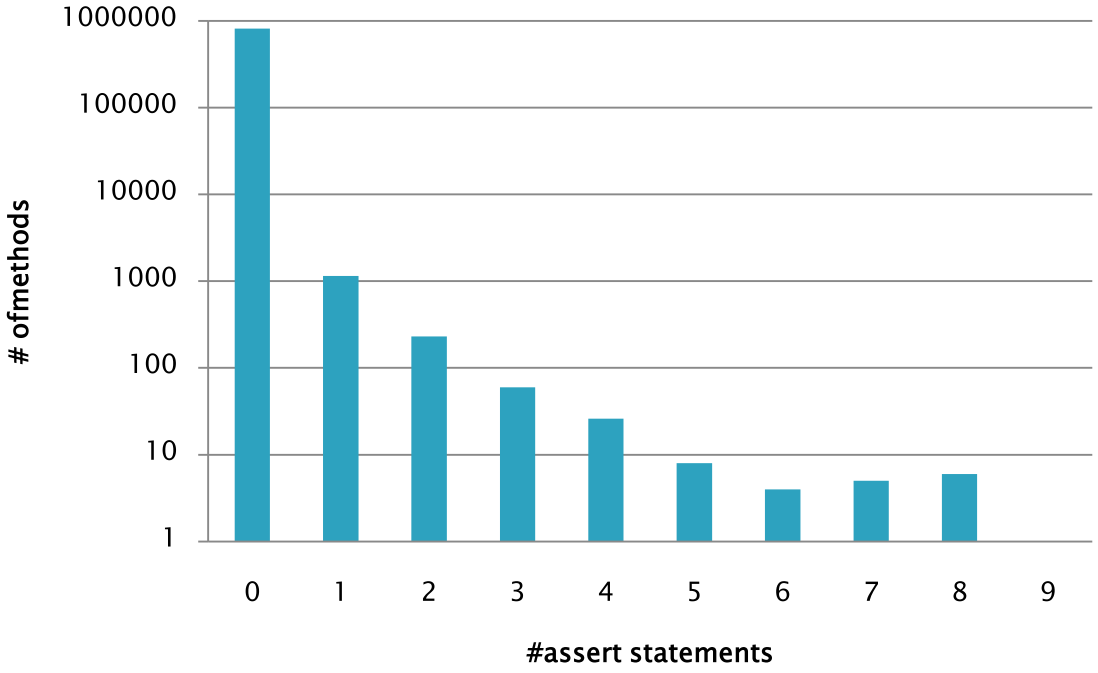


The number of fields in a class is strongly correlated with the number of methods in the same class

Statements

- 620,419 conditional statements
    - If-else/switch/for/while/do-while
    - 4,956 using simple boolean variables as conditions
    - 42% of switch statement do not contain default path
- 397,605 methods don’t have conditional statements
- 2,047 assert statements

Assert Statements per Method



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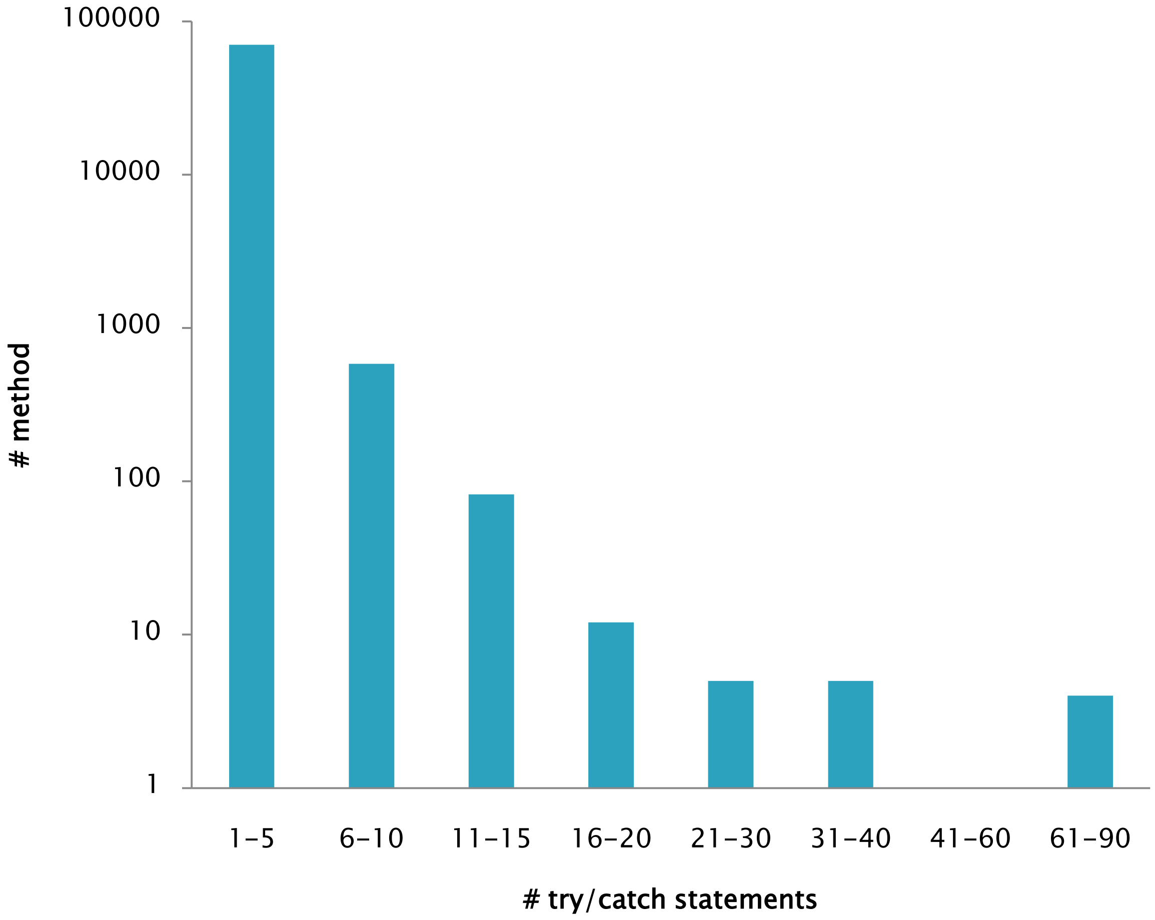
Exceptions

- 93,714 try/catch statements
  - Finally is used 6.8%
- 19,181 exceptions thrown using keyword throws
- 110,740 propagated exceptions

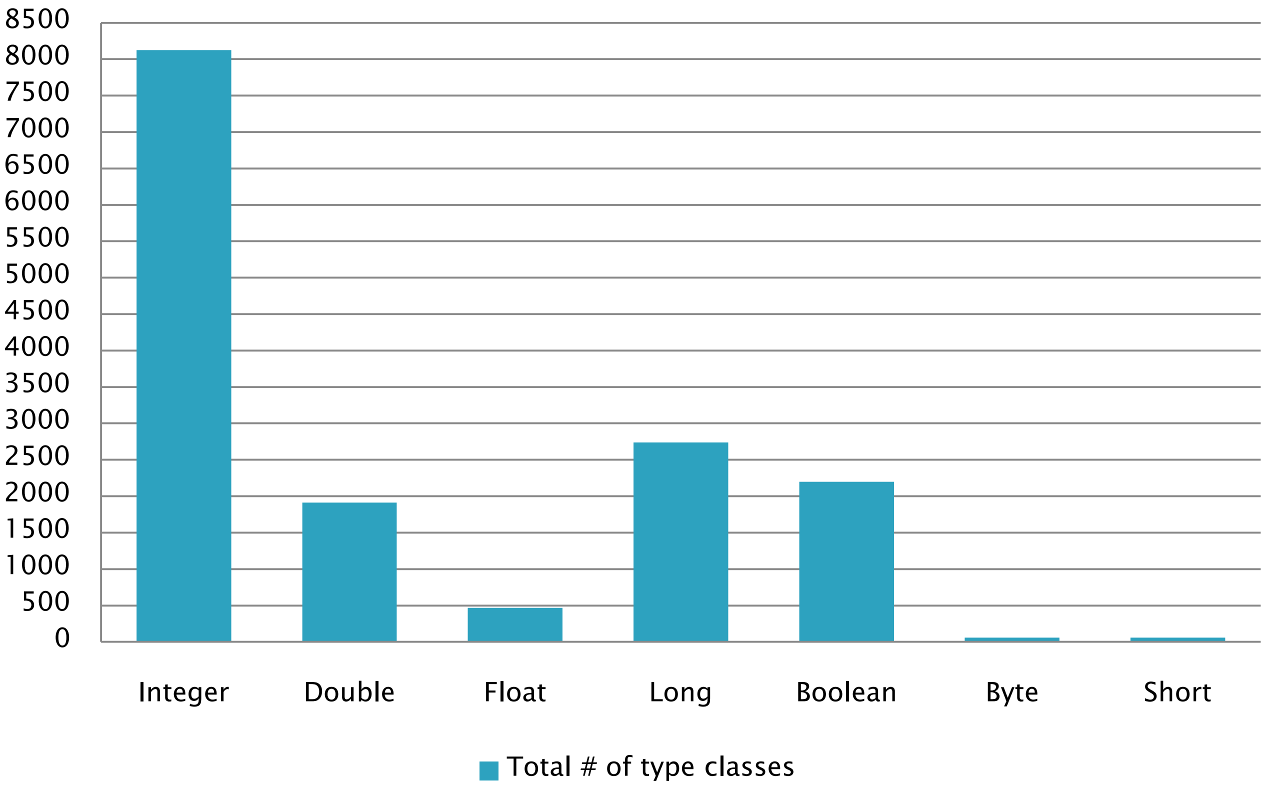
Try/Catch Statements per Method



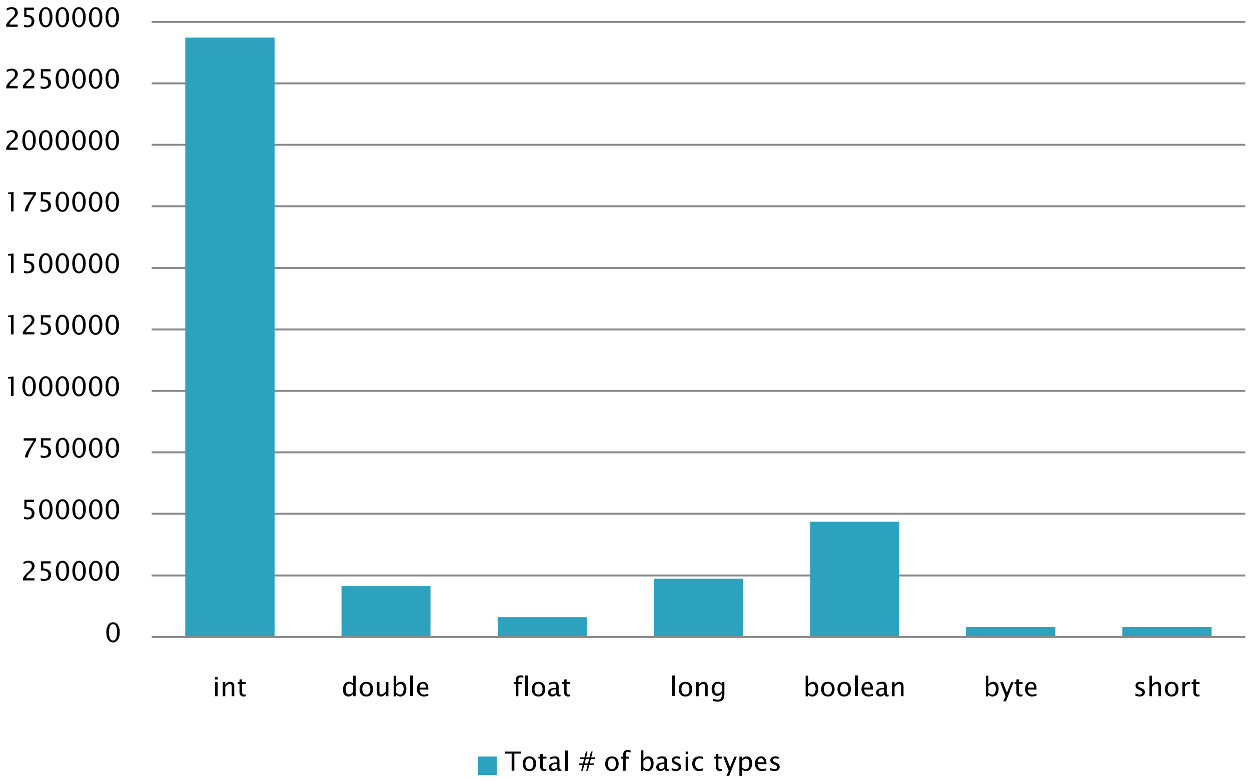
Local Variables and Types

- 818,358 local variables
  - 10% final
- Use primitive types much more than corresponding class-based types

Type Classes



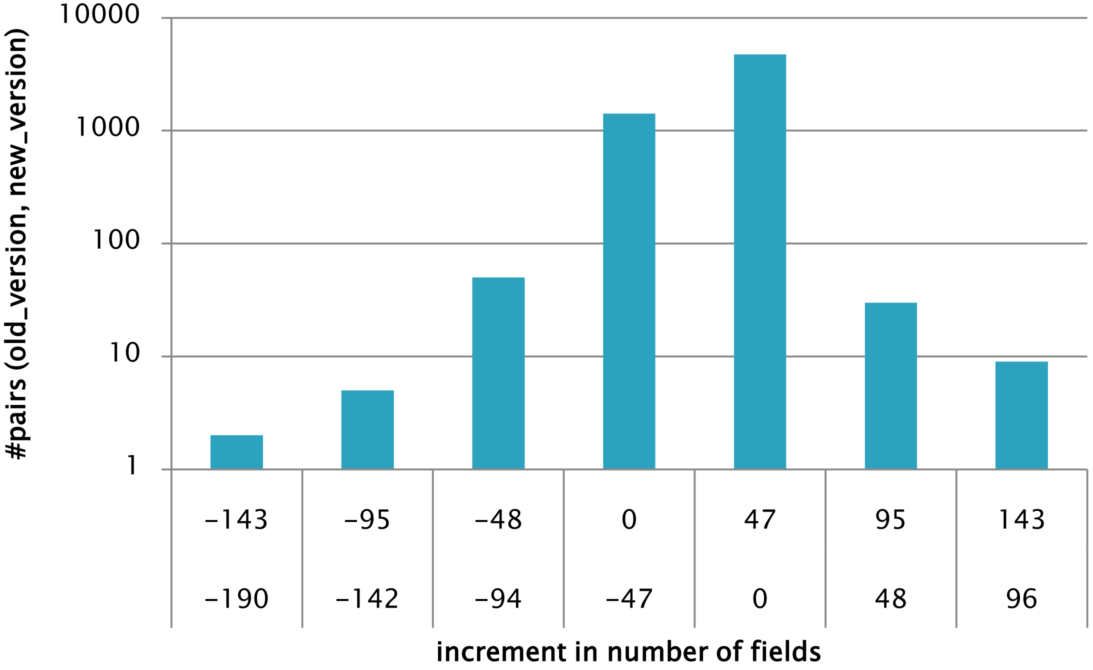
Primitive Type



Evolution and Maintenance

- Select applications which have at least 2 versions
  - Total 2,427 versions range from 2-24
    - 6,249 removed/added fields between versions
    - 7,861 removed/added methods between versions
    - 5,713 removed/added classes between versions

Added/Removed Number of Fields across Versions



Related Work

- Infrastructure
  - FlOSSMole
    - Metadata on collaboration purpose
  - SourcererDB
- Empirical study

Conclusions

- Built the infrastructure
- Obtained insights into 2,080 Java applications
- Posed 32 research questions

- Future work
  - Deep dive
    - Extreme cases
    - Correlations
    - Rationale

Thanks

- http://www.cs.wm.edu/semeru/treasure/