Introduction to Lucene

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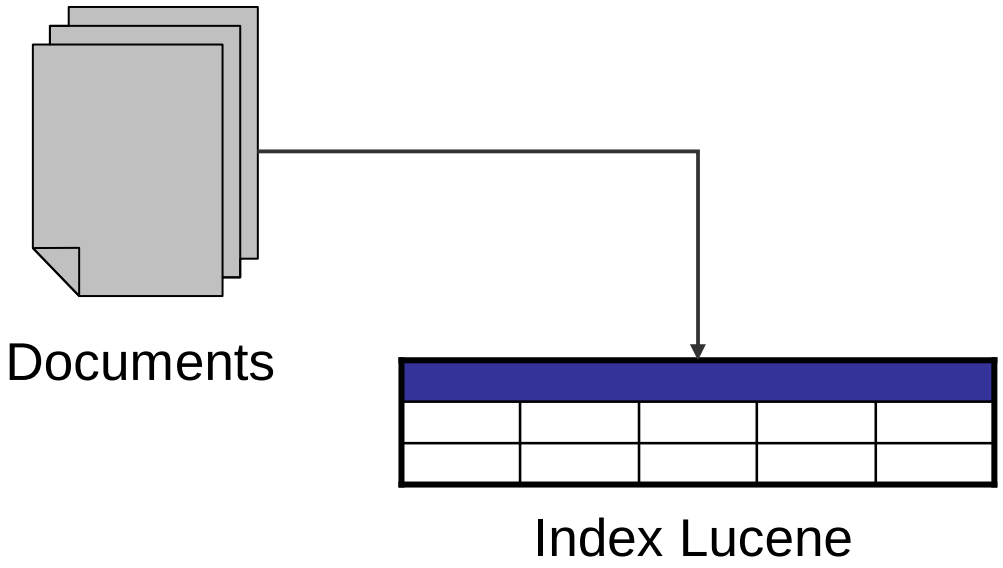
What is Lucene?

- Powerful, high-performance, scalable full text search engine library
- Open source under Apache Software License
- Originally written in Java by Doug Cutting
- Ported to C#, C++, Delphi, Perl, Python, PHP, Ruby
- Initial release in 2000 (current version 8.2.0)
- We use Lucene version 8.2.0 in this lab

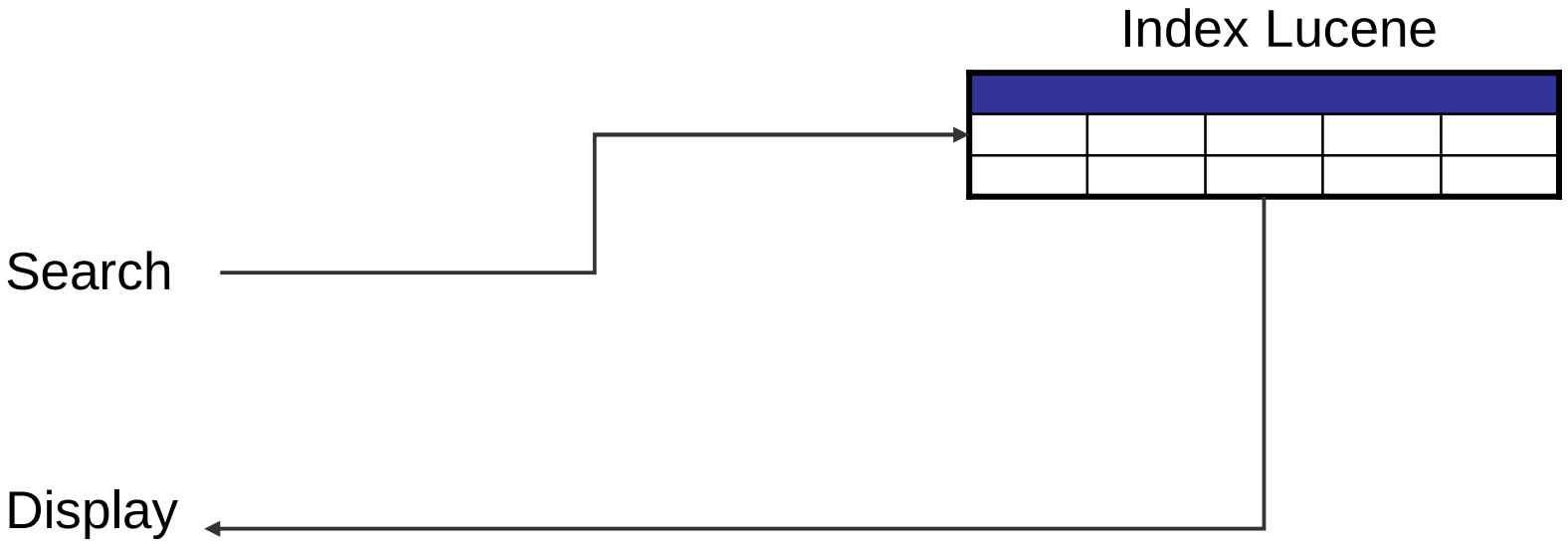
Building Applications using Lucene (1)

- Step 1: Index Data
  - Convert files to a format for quick look-up
  - Data structure that allows fast random access to words stored inside



Building Applications using Lucene (2)

- Step 2: Search
  - Lookup words to find the documents that are relevant for the search
  - Support for different type of queries
  - Display results: speed, ranking



Lucene Definitions

Fundamental concepts in Lucene:

- **Index:** contains a sequence of documents
- **Document:** is a sequence of fields
- **Field:** is a named sequence of terms
- **Term:** is a sequence of bytes

The terms are represented as a pair: the string naming the field, and the bytes within the field.

Lucene Classes (1)

- **Document:** `org.apache.lucene.document.Document`
  - Indexed data is organized into documents
- **IndexWriter:** `org.apache.lucene.index.IndexWriter`
  - Writes data / documents into index
- **IndexReader:** `org.apache.lucene.index.IndexReader`
  - Reads the index (abstract class)
- **DirectoryReader:** `org.apache.lucene.index.DirectoryReader`
  - Reads indexes in a directory
- **IndexSearcher:** `org.apache.lucene.search.IndexSearcher`
  - Searches the index (using the IndexReader)

Lucene Classes (2)

- **Field:** `org.apache.lucene.document.Field`
  - A field is a section of a Document. Each document can contain different named fields.
    - **IntPoint:** A field that indexes int values for efficient range filtering and sorting. If you also need to store the value, you should add a separate **StoredField** instance
    - **StringField:** A field that is indexed but not tokenized (the entire String value is indexed as a single token).
    - **TextField:** A field that is indexed and tokenized, without term vectors.
    - **Field:** A general purpose field that allows specifying each part of a field (name, value and type). Use this instead of TextField to be able to access the Term Vector of the field.

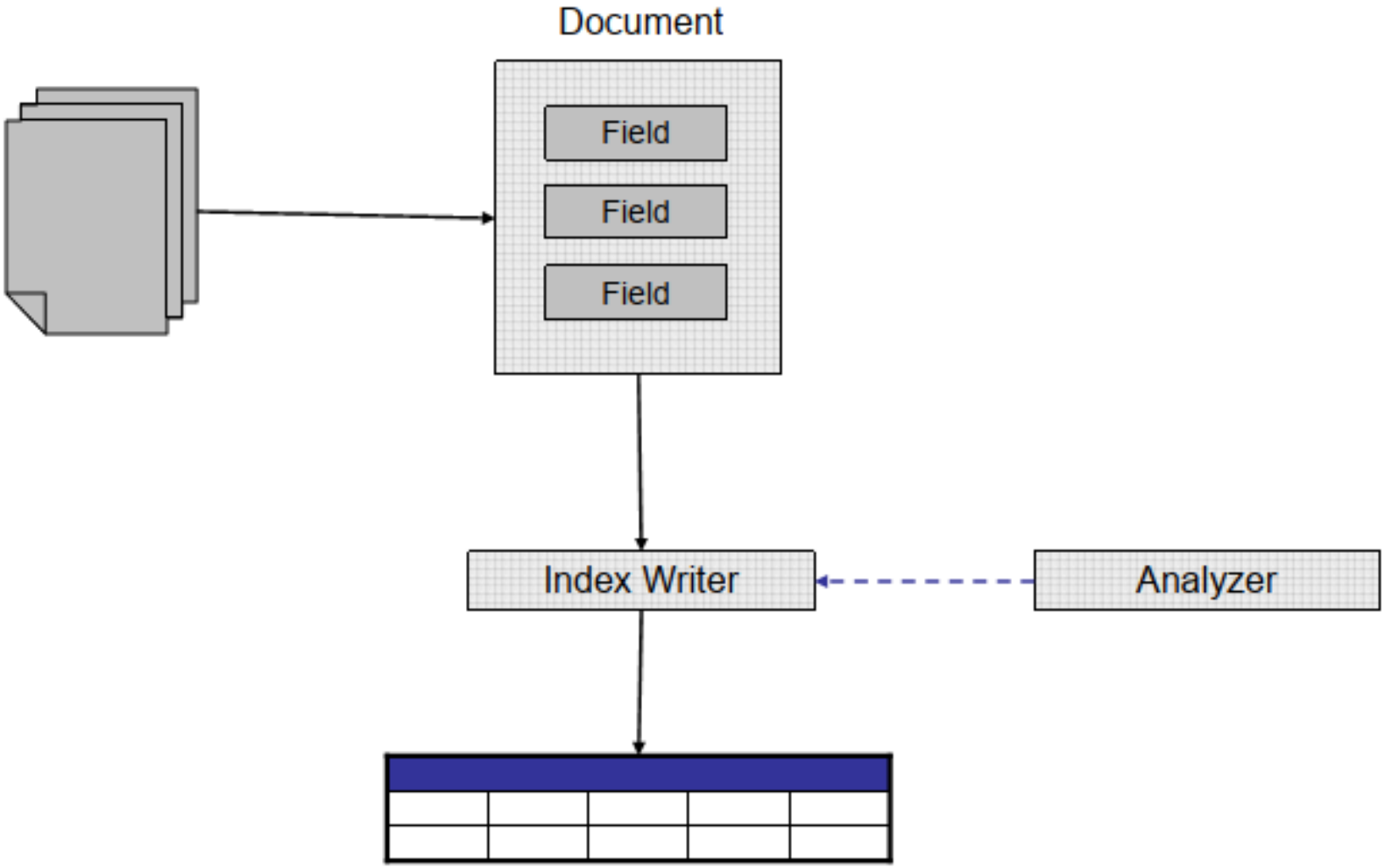
Lucene Analyzer (1)

- **Analyzer:** `org.apache.lucene.analysis.Analyzer`
  - Converts text into tokens for indexing / searching
  - Use the *same analyzer* for indexing and searching
  - Abstract class
- **WhitespaceAnalyzer:** `org.apache.lucene.analysis.core.WhitespaceAnalyzer`
  - Uses a whitespace tokenizer
- **StopAnalyzer:** `org.apache.lucene.analysis.core.StopAnalyzer`
  - LetterTokenizer: divides text at non-letters
  - Lowercase
  - Removes stopwords (predefined English stopwords)

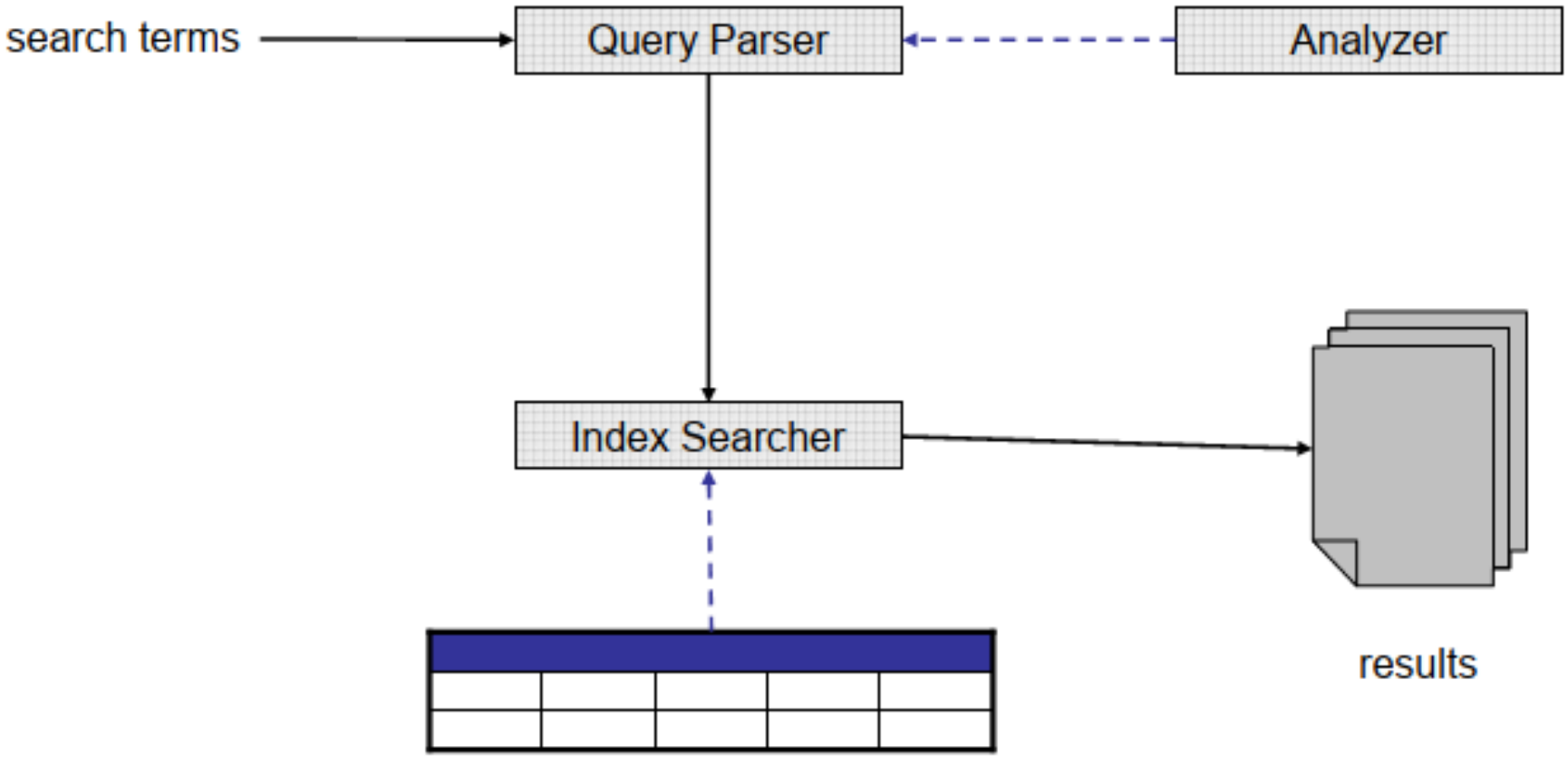
Lucene Analyzer (2)

- **StandardAnalyzer:**
  `org.apache.lucene.analysis.standard.StandardAnalyzer`
  - StandardTokenizer: grammar-based tokenizer
- **EnglishAnalyzer:**
  `org.apache.lucene.analysis.en.EnglishAnalyzer`
  - Stemming (e.g. studying -> study, administration -> administr)
  - Support for different languages: English, French, German, etc.
- **Shingling:**
  `org.apache.lucene.analysis.shingle.ShingleAnalyzerWrapper`
  - Standard analyzer + Shingling (e.g. "information retrieval")
  - Size of shingles (min and max size)

Lucene Indexing Flow



Lucene Searching Flow



Lucene Queries

- **TermQuery:** matches all the documents that contain the specified Term (which is a word that occurs in a certain field)
- **BooleanQuery:** contains multiple queries with an operator
  - SHOULD
  - MUST
  - MUST NOT
- **PhraseQuery:** finds documents containing certain phrases
- **Numeric Queries:** matches all documents that occur in a numeric range for example **IntPoint.newRangeQuery()**
- **PrefixQuery:** identifies all documents with terms that begin with a certain string
- **QueryParser:** converts the query into an index searchable form

Lucene Demo: Indexing

```
// 1.1. create an analyzer
Analyzer analyzer = new StandardAnalyzer();
// 1.2. create an index writer config
IndexWriterConfig iwc = new IndexWriterConfig(analyzer);
iwc.setOpenMode(OpenMode.CREATE); // create and replace existing index
iwc.setUseCompoundFile(false); // not pack newly written segments in a compound file:
//keep all segments of index separately on disk
// 1.3. create index writer
Path path = FileSystems.getDefault().getPath("index");
Directory dir = FSDirectory.open(path);
IndexWriter indexWriter = new IndexWriter(dir, iwc);
// 1.4. create document
Document doc = new Document();
// 1.5. create fields
FieldType fieldType = new FieldType(); // describes properties of a field
fieldType.setIndexOptions(IndexOptions.DOCS); // controls how much information
//is stored in the postings lists.
fieldType.setTokenized(true); // tokenize the field's contents using configured analyzer
fieldType.freeze(); // prevents future changes
Field field = new Field("summary", cacm.getSummary(), fieldType);
...
// 1.6. add fields to document
doc.add(field);
...
// 1.7. add document to index
indexWriter.addDocument(doc);
// 1.8 close index writer
indexWriter.close();
dir.close();
```

for each document

for each field

Lucene Demo: Searching

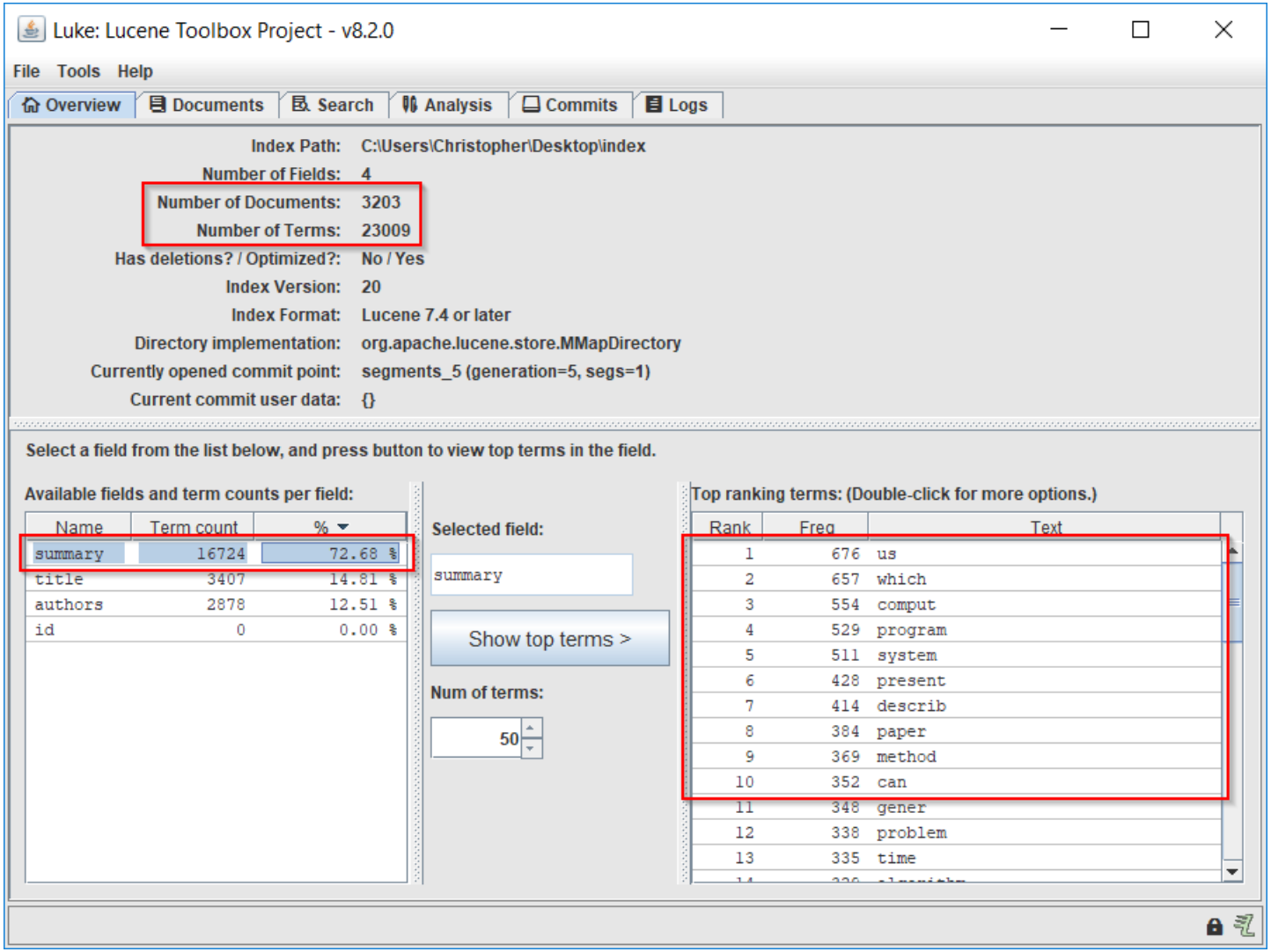
```
// 2.1. create query parser
QueryParser parser = new QueryParser("summary", analyzer);
// 2.2. parse query
Query query = parser.parse("compiler program");

// 3.1. create index reader
Path path = FileSystems.getDefault().getPath("index");
Directory dir = FSDirectory.open(path);
IndexReader indexReader = DirectoryReader.open(dir);
// 3.2. create index searcher
IndexSearcher indexSearcher = new IndexSearcher(indexReader);
// 3.3. search query
ScoreDoc[] hits = indexSearcher.search(query, 1000).scoreDocs;
// 3.4. retrieve results
System.out.println("Results found: " + hits.length);
for (ScoreDoc hit: hits) {
    Document doc = indexSearcher.doc(hit.doc)
    System.out.println(doc.get("id") + ": " + doc.get("title") + " (" + hit.score + ")");
}
// 3.5. close index reader
indexReader.close();
dir.close();
```

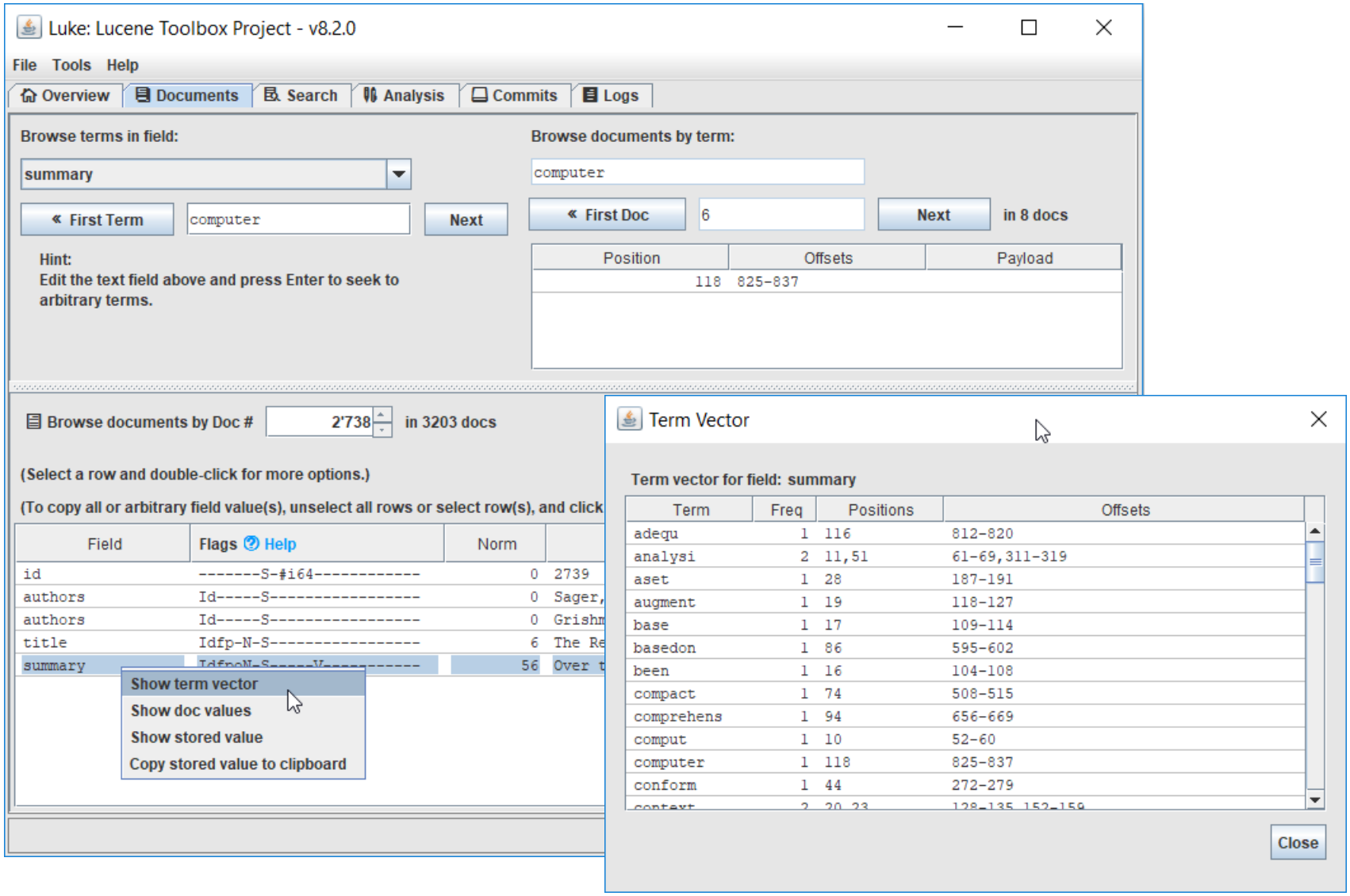
Luke

- A GUI tool written in Java
- Browse the contents of a Lucene index
- Examine individual documents
- Run queries over the index

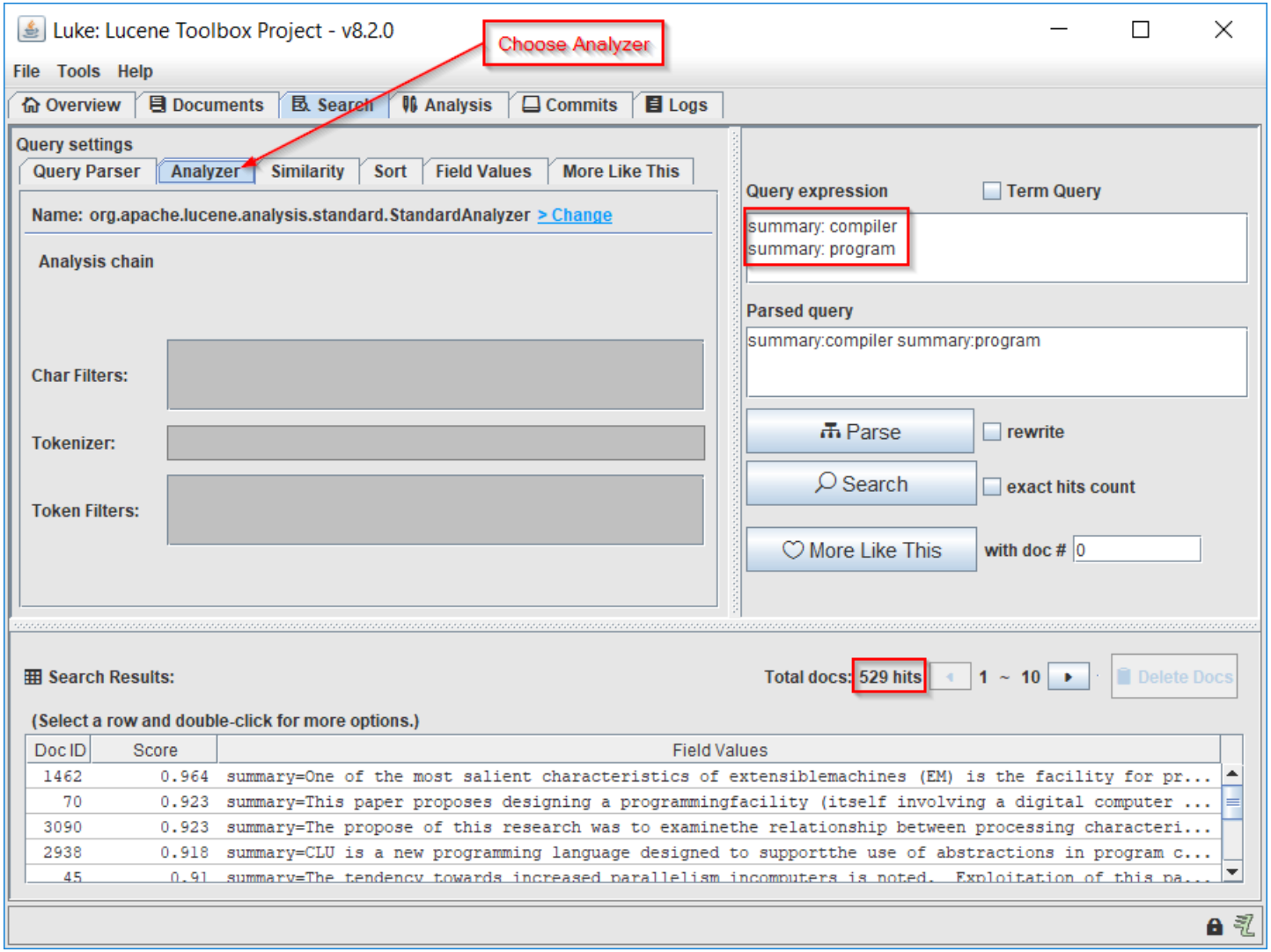
Luke: Index


Luke: Lucene Toolbox Project - v8.2.0
File Tools Help
Overview Documents Search Analysis Commits Logs
Index Path: C:\Users\Christopher\Desktop\index
Number of Fields: 4
Number of Documents: 3203
Number of Terms: 23009
Has deletions? / Optimized?: No / Yes
Index Version: 20
Index Format: Lucene 7.4 or later
Directory implementation: org.apache.lucene.store.MMapDirectory
Currently opened commit point: segments_5 (generation=5, segs=1)
Current commit user data: {}
Select a field from the list below, and press button to view top terms in the field.
Available fields and term counts per field:
Name Term count %
summary 16724 72.68 %
title 3407 14.81 %
authors 2878 12.51 %
id 0 0.00 %
Selected field:
summary
Show top terms >
Num of terms:
50
Top ranking terms: (Double-click for more options.)
Rank Freq Text
1 676 us
2 657 which
3 554 comput
4 529 program
5 511 system
6 428 present
7 414 describ
8 384 paper
9 369 method
10 352 can
11 348 gener
12 338 problem
13 335 time

Luke: TermVector



Luke: Search


Luke: Lucene Toolbox Project - v8.2.0
Choose Analyzer
File Tools Help
Overview Documents Search Analysis Commits Logs
Query settings
Query Parser Analyzer Similarity Sort Field Values More Like This
Name: org.apache.lucene.analysis.standard.StandardAnalyzer > Change
Analysis chain
Char Filters:
Tokenizer:
Token Filters:
Query expression
Term Query
summary: compiler
summary: program
Parsed query
summary:compiler summary:program
Parse
rewrite
Search
exact hits count
More Like This
with doc # 0
Search Results:
Total docs: 529 hits
1 ~ 10
Delete Docs
(Select a row and double-click for more options.)
Doc ID Score Field Values
1462 0.964 summary=One of the most salient characteristics of extensiblemachines (EM) is the facility for pr...
70 0.923 summary=This paper proposes designing a programmingfacility (itself involving a digital computer ...
3090 0.923 summary=The propose of this research was to examinethe relationship between processing characteri...
2938 0.918 summary=CLU is a new programming language designed to supportthe use of abstractions in program c...
45 0.91 summary=The tendency towards increased parallelism incomputers is noted. Exploitation of this pa...

References

- Apache Lucene: http://lucene.apache.org/core/8_2_0/index.html
- Tutorials
  - https://www.ionos.fr/digitalguide/serveur/configuration/apache-lucene/