# Lucene

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Reading material: Chapter 1 of Lucene in Action

# Our starting point

- Index academic papers
- Start with a subset of the data (10K papers)
- Our course web site has
  - a link to the data
  - starter code for indexing and searching

- The data

Jianguos-MBP:1562 jianguolu$ pwd
/Users/jianguolu/data/citeseer2/1562
Jianguos-MBP:1562 jianguolu$

Jianguos-MBP:1562 jianguolu$ head 10.1.1.2.1562.txt
Acting and Deliberating using Golog in Robotic Soccer
| A Hybrid Architecture |

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Abstract
….

```
public class IndexAllFilesInDirectory {
static int counter = 0;
public static void main(String[] args) throws Exception {
        String indexPath = "/Users/jianguolu/data/citeseer2_index";
        String docsPath = "/Users/jianguolu/data/citeseer2";
        System.out.println("Indexing to directory '" + indexPath + "'...");
        Directory dir = FSDirectory.open(Paths.get(indexPath));
        IndexWriterConfig iwc = new IndexWriterConfig(new StandardAnalyzer());
        IndexWriter writer = new IndexWriter(dir, iwc);
        indexDocs(writer, Paths.get(docsPath));
        writer.close();
}
```

```
static void indexDocs(final IndexWriter writer, Path path) throws IOException {
  Files.walkFileTree(path, new SimpleFileVisitor<Path>() {
    public FileVisitResult visitFile(Path file, BasicFileAttributes attrs) throws IOException {
        indexDoc(writer, file);
        return FileVisitResult.CONTINUE;
}
});
}
```

```
static void indexDoc(IndexWriter writer, Path file) throws IOException {
        InputStream stream = Files.newInputStream(file);
        BufferedReader br = new BufferedReader(new InputStreamReader(stream,
StandardCharsets.UTF_8));
        String title = br.readLine();
        Document doc = new Document();
        doc.add(new StringField("path", file.toString(), Field.Store.YES));
        doc.add(new TextField("contents", br));
        doc.add(new StringField("title", title, Field.Store.YES));
        writer.addDocument(doc);
        counter++;
        if (counter % 1000 == 0)
            System.out.println("indexing " + counter + "-th file " + file.getFileName());
        }
}
```

# Search documents

```
public class SearchIndexedDocs {
public static void main(String[] args) throws Exception {
        String index = "/Users/jianguolu/data/citeseer2_index";
        IndexReader reader = DirectoryReader.open(FSDirectory.open(Paths.get(index)));
        IndexSearcher searcher = new IndexSearcher(reader);
        QueryParser parser = new QueryParser("contents", new StandardAnalyzer());
        Query query = parser.parse("information AND retrieval");
        TopDocs results = searcher.search(query, 6);
        System.out.println(results.totalHits + " total matching documents");
        for (int i = 0; i < 6; i++) {
          Document doc = searcher.doc(results.scoreDocs[i].doc);
          System.out.println((i + 1) + ". " + doc.get("path") +"\n\t"+ doc.get("title"));

        }
        reader.close();
}}
```

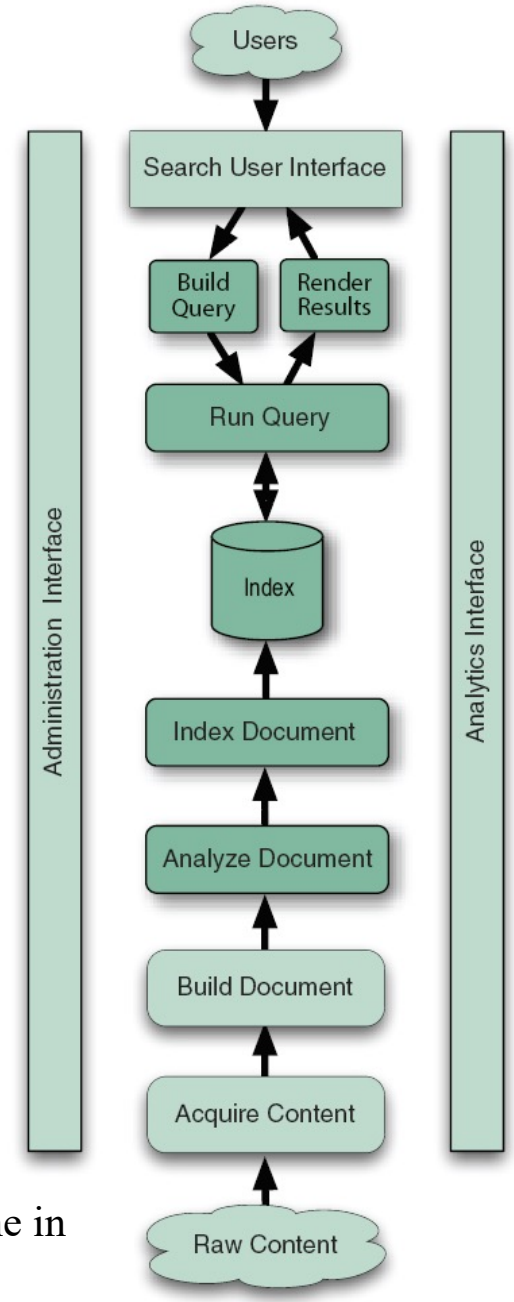
# Lucene

- Developed by Doug Cutting initially
  - Java-based. Created in 1999, Donated to Apache in 2001
- Features
  - No crawler, No document parsing, No “PageRank”
- Websites Powered by Lucene
  - IBM Omnifind Y! Edition, Technorati
  - Wikipedia, Internet Archive, LinkedIn, monster.com
- Add documents to an index via IndexWriter
  - A document is a collection of fields
  - Flexible text analysis – tokenizers, filters
- Search for documents via IndexSearcher

  Hits = search(Query,Filter,Sort,topN)
- Ranking based on tf-idf similarity with normalization

# What is Lucene

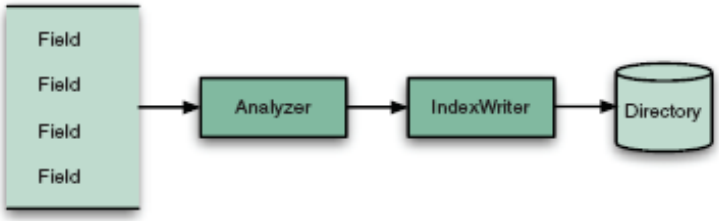
- Lucene is
  - an API
  - an Information Retrieval Library
- Lucene is not an application ready for use
  - Not a web server
  - Not a search engine
- It can be used to
  - Index files
  - Search the index
- It is open source, written in Java
- Two stages: index and search




Picture From Lucene in Action

# Indexing

- Just the same as the index at the end of a book
- Without an index, you have to search for a keyword by scanning all the pages of a book
- Process of indexing
  - Acquire content
    - Say, semantic web DBPedia
  - Build document
    - Transform to text file from other formats such as pdf, ms word
    - Lucene does not support this kind of filter
    - There are tools to do this
  - Analyze document
    - Tokenize the document
    - Stemming
    - Stop words
    - Lucene provides a string of analyzers
    - User can also customize the analyzer
  - Index document
- Key classes in Lucene Indexing
  - Document, Analyzer, IndexWriter



# Code snippets

```
Directory dir = FSDirectory.open(new File(indexDir));

writer = new IndexWriter(
        dir, new StandardAnalyzer(Version.LUCENE_30),
        true,
        IndexWriter.MaxFieldLength.UNLIMITED);

… …
Document doc = new Document();
doc.add(new Field("contents", new FileReader(f)));
doc.add(new Field("filename", f.getName(),
            Field.Store.YES, Field.Index.NOT_ANALYZED));
doc.add(new Field("fullpath", f.getCanonicalPath(),
            Field.Store.YES, Field.Index.NOT_ANALYZED));

writer.addDocument(doc);
```

Index is written In this directory

When doc is added, Use StandardAnalyzer

Create a document instance from a file

Add the doc to writer

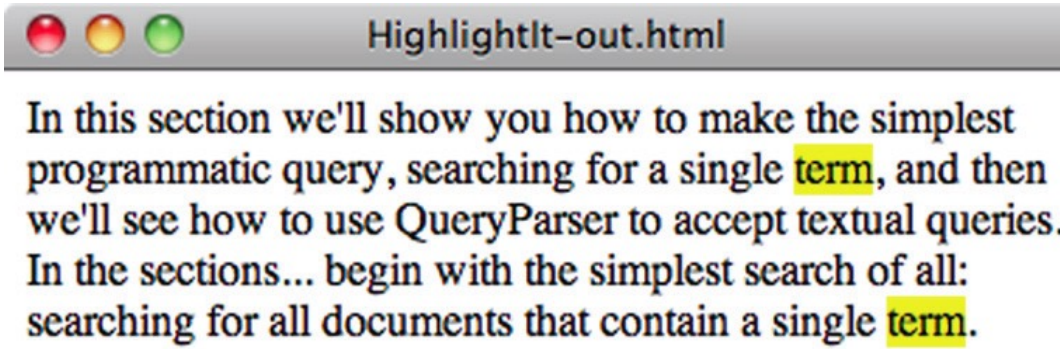
# Document and Field

```
doc.add(new Field("fullpath", f.getCanonicalPath(),
        Field.Store.YES, Field.Index.NOT_ANALYZED));
```

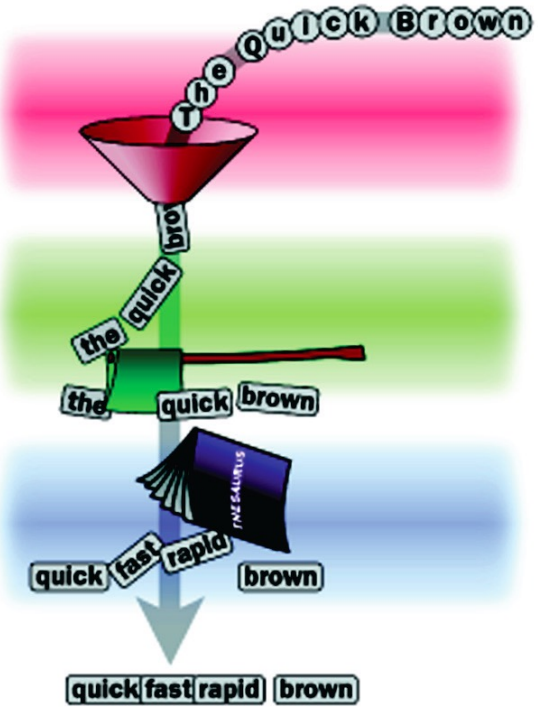
- **Construct a Field:**
  - First two parameters are field name and value
  - Third parameter: whether to store the value
    - If NO, content is discarded after it indexed. Storing the value is useful if you need the value later, like you want to display it in the search result.
  - Fourth parameter: whether and how the field should indexed

```
doc.add(new Field("contents", new FileReader(f)));
```

  - Create a tokenized and indexed field that is not stored



# Lucene analyzers




- StandardAnalyzer
  - A sophisticated general-purpose analyzer.
- WhitespaceAnalyzer
  - A very simple analyzer that just separates tokens using white space.
- StopAnalyzer
  - Removes common English words that are not usually useful for indexing.
- SnowballAnalyzer
  - A stemming that works on word roots.
- Analyzers for languages other than English

# Examples of analyzers

%java lia.analysis.AnalyzerDemo "No Fluff, Just Stuff"

Analyzing "No Fluff, Just Stuff"

org.apache.lucene.analysis.WhitespaceAnalyzer:

**[No] [Fluff,] [Just] [Stuff]**

org.apache.lucene.analysis.SimpleAnalyzer:

**[no] [fluff] [just] [stuff]**

org.apache.lucene.analysis.StopAnalyzer:

**[fluff] [just] [stuff]**

org.apache.lucene.analysis.standard.StandardAnalyzer:

**[fluff] [just] [stuff]**

# StandardAnalyser

- support
  - company name
    - XY&Z corporation → [XY&Z] [corporation]
  - Email
    - xyz@example.com --> xyz@example.com
  - Ip address
  - Serial numbers
- Support chinese and japanese

# StopAnalyser

- Default stop words:
  - "a", "an", "and", "are", "as", "at", "be", "but", "by”, "for", "if", "in", "into", "is", "it", "no", "not", "of", "on”, "or", "such", "that", "the", "their", "then", "there", "these”, "they", "this", "to", "was", "will", "with”
  - Note that there are other stop-word lists
- You can pass your own set of stop words

# Customized analyzers

- Most applications do not use built-in analyzers
- Customize
  - Stopwords
  - Application specific tokens (product part number)
  - Synonym expansion
  - Preserve case for certain tokens
  - Choosing stemming algorithm
- Solr configure the tokenizing using solrconfig.xml

# N-gram filter

```
private static class NGramAnalyzer extends Analyzer {
    public TokenStream tokenStream(String fieldName, Reader reader) {
        return new NGramTokenFilter(new KeywordTokenizer(reader), 2, 4);
    }
}
```

Lettuce →

1: [le]

2: [et]

3: [tt]

4: [tu]

5: [uc]

6: [ce]

…

# Example of SnowballAnalyzer

- stemming
- English

```
Analyzer analyzer = new SnowballAnalyzer(Version.LUCENE_30,  "English");
AnalyzerUtils.assertAnalyzesTo(analyzer, "stemming algorithms”,  new String[]
   {"stem", "algorithm"});
```

- Spanish

```
Analyzer analyzer = new SnowballAnalyzer(Version.LUCENE_30, "Spanish");
AnalyzerUtils.assertAnalyzesTo(analyzer, "algoritmos”, new String[] {"algoritm"});
```

# Lucene tokenizers and filters

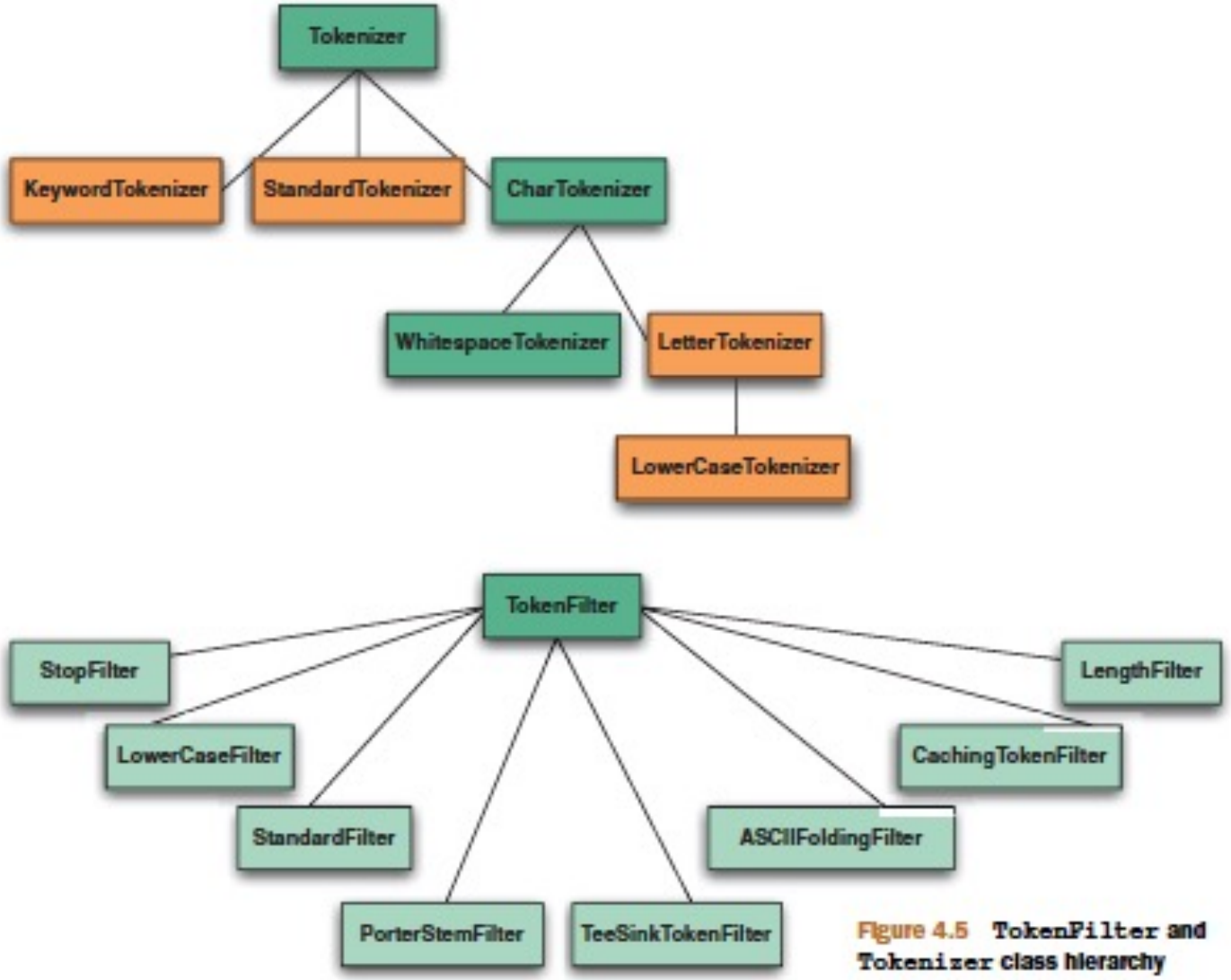
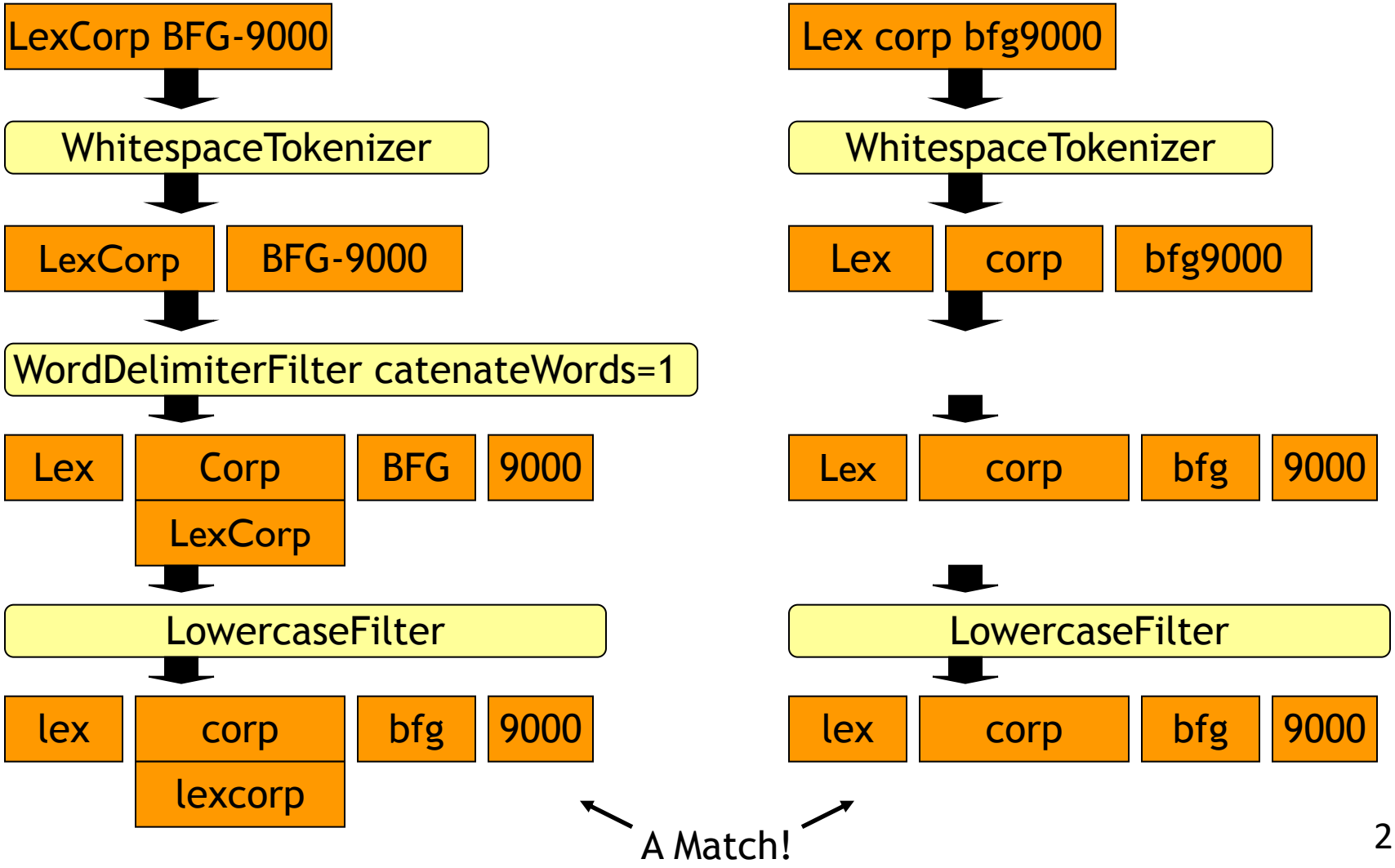



Figure 4.5 TokenFilter and Tokenizer class hierarchy

# How indexing and searching work together

# Analyzers (solr)



# Search

- Three models of search
  - Boolean
  - Vector space
  - Probabilistic
- Lucene supports a combination of boolean and vector space model
- Steps to carry out a search
  - Build a query
  - Issue the query to the index
  - Render the returns
    - Rank pages according to relevance to the query

# Search code

```
Directory dir = FSDirectory.open(new File(indexDir));
IndexSearcher is = new IndexSearcher(dir);

QueryParser parser = new QueryParser(Version.LUCENE_30, "contents",
    new StandardAnalyzer(Version.LUCENE_30));
Query query = parser.parse(q);

TopDocs hits = is.search(query, 10);
for(ScoreDoc scoreDoc : hits.scoreDocs) {
  Document doc = is.doc(scoreDoc.doc);
  System.out.println(doc.get("fullpath"));
}
```

Indicate to search which index

Parse the query

Search the query

Process the returns one by one. Note that 'fullpath' is a field added while indexing

# Result ranking

- The default is relevance ranking based on tf.idf
- Can customize the ranking
  - Sort by index order
  - Sort by one or more attributes
- Pageranking is not used

What if the document is not a text file?

# Extracting text with Apache Tika

- A toolkit detects and extracts metadata and text from over a thousand different file types
- There are many document formats
  - rtf, pdf, ppt, outlook, flash, open office
  - Html, xml
  - Zip, tar, gzip, bzip2, ..
- There are many document filters
  - Each has its own api
- A framework that hosts plug-in parsers for each document type
  - Standard api for extracting text and meta data
- Tika itself does not parse documents

# Extracting from various file formats

- Microsoft's OLE2 Compound Document Format (Excel, Word, PowerPoint, Visio, Outlook)
  - Apache POI
- Microsoft Office 2007 OOXML
  - Apache POI
- Adobe Portable Document Format (PDF)
  - PDFBox
- Rich Text Format (RTF)—currently body text only (no metadata)
  - Java Swing API (RTFEditorKit)
- Plain text character set detection ICU4J library
  - HTML CyberNeko library
- XML
  - Java's javax.xml classes

# Compressed files

- ZIP Archives
  - Java's built-in zip classes, Apache Commons Compress
- TAR Archives
  - Apache Ant, Apache Commons Compress
- AR Archives, CPIO Archives
  - Apache Commons Compress
- GZIP compression
  - Java's built-in support (GZIPInputStream) , Apache Commons Compress
- BZIP2 compression
  - Apache Ant, Apache Commons Compress

# multimedia

- Image formats (metadata only)
  - Java's javax.imageio classes
- MP3 audio (ID3v1 tags)
  - Implemented directly
- Other audio formats (wav, aiff, au) J
  - ava's built-in support (javax.sound.*)
- OpenDocument
  - Parses XML directly
- Adobe Flash
  - Parses metadata from FLV files directly
- MIDI files (embedded text, eg song lyrics)
  - Java's built-in support (javax.audio.midi.*)
- WAVE Audio (sampling metadata)
  - Java's built-in support (javax.audio.sampled.*)

# Program code

- Java class files
  - ASM library (JCR-1522)
- Java JAR files
  - Java's built-in zip classes and ASM library, Apache Commons Compress

Example:
Search engine of source code (e.g., from github)

# New requirements

- Tokenization
  - Variable names
    - deletionPolicy vs. deletion policy vs. deletion_policy
  - Symbols: normally discarded symbols now important
    - For (int I =0;i<10;i++)
  - Stop words
    - Better to keep all the words
- Common tokens
  - ( ,
  - Group into bigrams, to improve performance
    - if (

# Query syntax

- Search requirements
  - Search for class or method names
  - Search for Structurally similar code
  - Search for questions and answers (e.g. from stackoverflow.com)
  - Deal with Includes and imports
- The query syntax may no longer be keywords search or boolean search
- Need to parse the source code
  - Different programming language has different grammar and parser
  - Parser generators

# Substring search

- Wildcard search is more important
- Names in programs are often combinations of several words
- Example: Search for ldap
- Source code contains getLDAPconfig
- The query is: *ldap*
- Implementation
  - new approach of tokenization. getLDAPcofig→[get] [LDAP] [config]
  - Permuterm index
  - Ngram
    - getLDAPconfig → Get etl tld …

# Krugle: source code search

- Described in the book Lucene in Action
- Indexed millions of lines of code

# SIREN

- Searching semi-structured documents
- Case study 2 of the lucene book
- Semantic information retrieval
- 50 million structured data
- 1 billion rdf triples

# Case study 3 of the lucene book

- Search for people in LinkedIn
- Interactive query refinement
- e.g., search for java programmer

# Related tools

- Apache Solr: is the search server built on top of Lucene
  - Lucene focuses on the indexing, not a web application
  - Build web-based search engines
- ElasticSearch
- Apache Nutch: for large scale crawling
  - Can run on multiple machines
  - Support regular expression to filter what is needed
  - support .robots.txt