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Understanding Lucene

Powering Better Search Results

By Erik Hatcher

WHAT IS LUCENE?

The Lucene Ecosystem

"Lucene" is a broadly used term. It's the original Java indexing and search library created by Doug Cutting. Lucene was then chosen as a top-level Apache Software Foundation project name — http://lucene.apache.org. The name is also used for various ports of the Java library to other languages (Lucene.Net, PyLucene, etc). The following table shows the key projects at http://lucene.apache.org.

Project	Description
Lucene - Java	Java-based indexing and search library. Also comes with extras such as highlighting, spellchecking, etc.
Solr	High-performance enterprise search server. HTTP interface. Built upon Lucene Java. Adds faceting, replication, sharding, and more.
Droids	Intelligent robot crawling framework.
Open Relevance	Aims to collect and distribute free materials for relevance testing and performance.
PyLucene	Python port of the Lucene Java project.

There are many projects and products that use, expose, port, or in some way wrap various pieces of the Apache Lucene ecosystem.

WHICH LUCENE DISTRIBUTION?

There are many ways to obtain and leverage Lucene technology. How you choose to go about it will depend on your specific needs and integration points, your technical expertise and resources, and budget/time constraints.

When *Lucene in Action* was published in 2004, before the advent of many of the projects mentioned above, we just had Lucene Java and some other open-source building blocks. It served its purpose and did so extremely well. Lucene has only gotten better since then: faster, more efficient, newer features, and more. If you've got Java skills you can easily grab lucene.jar and go for it.

However, some better and easier ways to build Lucene-based search applications are now available. Apache Solr, specifically, is a top notch server architecture, built from the ground up with Lucene. Solr factors in Lucene best practices and simplifies many aspects of indexing content and integrating search into your application as well as addressing scalability needs that exceed the capacity of single machines.

This Refcard is about the concepts of Lucene more than the specifics of the Lucene API. We'll be shining the light on Lucene internals and concepts with Solr. Solr provides some very direct ways to interact with Lucene.

We recommend you start with one of the following distributions:

- LucidWorks for Solr – certified distributions of the official Apache Solr distributions, including any critical bug fixes and key performance enhancements.
- Apache Solr – a great starting point for developers; grab a distro, write a script, integrate into UI.
- LucidWorks Enterprise – a graphically installed and configured Lucene/Solr-based system including repository and web crawling, click boosting, alerts, and much more.

Hot Tip

If you're getting started on building a search application, your quickest, easiest bet is to use LucidWorks Enterprise. LucidWorks Enterprise is Lucene and Solr, plus more. Easy to install, easy to configure and monitor. LucidWorks Enterprise is free for development, with support subscriptions available for production deployments.

Lucid Imagination offers professional services, training, and the new LucidWorks Enterprise platform. Visit http://www.lucidimagination.com.

Definitions/Glossary

There are many common terms used when elaborating on Lucene's design and usage.

Term	Definition/context/usage
Document	Returnable search result item. A document typically represents a crawled web page, a file system file, or a row from a database query.
Field	Property, metadata item, or attribute of a document. Documents typically have a unique key field, often called "id". Other common fields are "title", "body", "last_modified_date", and "categories".
Term	Searchable text, extracted from each indexed field by analysis (a process of tokenization and filtering).
tf/idf	Term frequency / inverse document frequency. This is a commonly used factor, computing the relationship between term frequency (how many uses of the query term exists in the entire index) to the inverse document frequency (how many documents in the entire collection that contain that query term, inverted).

Lucene Java and Core Lucene Concepts Explained

The design of Lucene is, at a high level, quite straightforward. Documents are "indexed".

Hot Tip

Documents are a representation of whatever types of "objects" and granularities your application needs to work with on the search/discovery side of the equation. In other words, when thinking Lucene, it is important to consider the use cases / demands of the encompassing application in order to effectively tune the indexing process with the end goal in mind.

Lucene provides APIs to open, read, write, and search an index. Documents contain "fields". Fields are the useful individually named attributes of a document used by your search application. For example, when indexing traditional files such as Word, HTML, and PDF documents, commonly used fields are "title", "body", "keywords", "author", and "last_modified_date".

DOCUMENTS

Documents, to Lucene, are the findable items. Here's where domain-specific abstractions really matter. A Lucene Document can represent a file on a file system, a row in a database, a news article, a book, a poem, an historical artifact (see collections.si.edu), and so on. Documents contain "fields". Fields represent attributes of the containing document, such as title, author, keywords, filename, file_type, lastModified, and fileSize.

"document" example

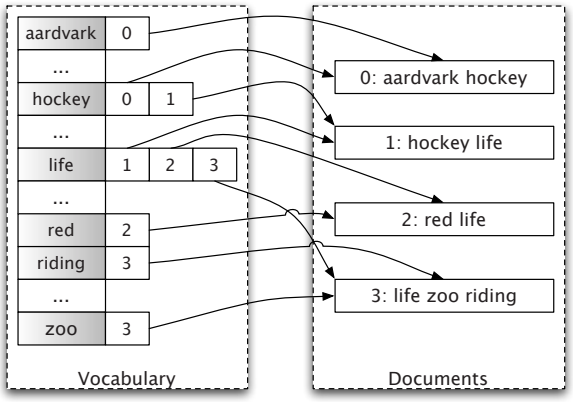
Fields have a name and one or more values. A field name, to Lucene, is arbitrary, whatever you want.

When indexing documents, the developer has the choice of what fields to add to the Document instance, their names, and how they are each handled. Field values can be stored and/or indexed. A large part of the magic of Lucene is in how field values are analyzed and how a field's terms are represented and structured.

Hot Tip

There are additional bits of metadata that can be indexed along with the terms text. Terms can optionally carry along their positions (relative position of term to previous term within the field), offsets (character offsets of the term in the original field), and payloads (arbitrary bytes associated with a term which can influence matching and scoring). Additionally, fields can store term vectors (an intra-field term/frequency data structure).

The heart of Lucene's search capabilities is in the elegance of the index structure, a form of an "inverted index". An inverted index is a data structure mapping "terms" to the documents. Indexed fields can be "analyzed", a process of tokenizing and filtering text into individual searchable terms. Often these terms from the analysis process are simply the individual words from the text. The analysis process of general text typically also includes normalization processes (lowercasing, stemming, other cleansing). There are many interesting and sophisticated ways indexing analysis tuning techniques can facilitate typical search application needs for sorting, faceting, spell checking, autosuggest, highlighting, and more.



Inverted Index

Again we need to look back at the search application needs. Almost every search application ends up with a human user interface with the infamous and ubiquitous "search box".

The trick is going from a human entered "query" to returning matching documents blazingly fast. This is where the inverted index structure comes into play. For example, a user searching for "mountain" can be readily accommodated by looking up the term in the inverted index and matching associated documents.

Not only are documents matched to a query, but they are also scored. For a given search request, a subset of the matching documents are returned to the user. We can easily provide sorting options for the results, though presenting results in "relevancy" order is more often the desired sort criteria. Relevancy refers to a numeric "score" based on the relationship between the query and the matching document. ("Show me the documents best matching my query first, please").

The following formula (straight from Lucene's `Similarity` class javadoc) illustrates the basic factors used to score a document.

$$score(q,d) = coord(q,d) \cdot queryNorm(q) \cdot \sum_{t \text{ in } q} \left(tf(t \text{ in } d) \cdot idf(t)^2 \cdot t.getBoost() \cdot norm(t,d) \right)$$

Lucene practical scoring formula

Each of the factors in this equation are explained further in the following table:

Factor	Explanation
score(q,d)	The final computed value of numerous factors and weights, numerically representing the relationship between the query and a given document.
coord(q,d)	A search-time score factor based on how many of the query terms are found in the specified document. Typically, a document that contains more of the query's terms will receive a higher score than another document with fewer query terms.
queryNorm(q)	A normalizing factor used to make scores between queries comparable. This factor does not affect document ranking (since all ranked documents are multiplied by the same factor), but rather just attempts to make scores from different queries (or even different indexes) comparable.
tf(t in d)	Correlates to the term's frequency, defined as the number of times term t appears in the currently scored document d. Documents that have more occurrences of a given term receive a higher score. Note that tf(t in q) is assumed to be 1 and, therefore, does not appear in this equation. However, if a query contains twice the same term, there will be two term-queries with that same term. Hence, the computation would still be correct (although not very efficient).

idf(t)	Stands for Inverse Document Frequency. This value correlates to the inverse of docFreq (the number of documents in which the term t appears). This means rarer terms give higher contribution to the total score. idf(t) appears for t in both the query and the document, hence it is squared in the equation.
t.getBoost()	A search-time boost of term t in the query q as specified in the query text (see query syntax), or as set by application calls to setBoost().
norm(t,d)	Encapsulates a few (indexing time) boost and length factors.

Understanding how these factors work can help you control exactly how to get the most effective search results from your search application. It's worth noting that in many applications these days, there are numerous other factors involved in scoring a document. Consider boosting documents by recency (latest news articles bubble up), popularity/ratings (or even like/dislike factors), inbound link count, user search/click activity feedback, profit margin, geographic distance, editorial decisions, or many other factors. But let's not get carried away just yet, and focus on Lucene's basic tf/idf.

So now we've briefly covered the gory details of how Lucene works for matching and scoring documents during a search. There's one missing bit of magic, going from the human input of a search box and translating that into a representative data structure, the Lucene Query object. This `string` → `Query` process is called "query parsing". Lucene itself includes a basic `QueryParser` that can parse sophisticated expressions including AND, OR, +/-, parenthetical grouped expressions, range, fuzzy, wildcarded, and phrase query clauses. For example, the following expression will match documents with a title field with the terms "Understanding" and Lucene collocated successively (provided positional information was enabled!) where the mimeType (MIME type is the document type) value is "application/pdf":

```
title:"Understanding Lucene" AND mimeType:application/PDF
```

For more information on Lucene `QueryParser` syntax, see http://lucene.apache.org/java/3_0_3/queryparsersyntax.html (or the docs for the version of Lucene you are using).

It is important to note that query parsing and allowable user syntax is often an area of customization consideration. Lucene's API richly exposes many `Query` subclasses, making it very straightforward to construct sophisticated `Query` objects using building blocks such as `TermQuery`, `BooleanQuery`, `PhraseQuery`, `WildcardQuery`, and so on.

Shining the Light on Lucene: Solr

Apache Solr embeds Java Lucene, exposing its capabilities through an easy-to-use HTTP interface. Solr has Lucene best practices built in, and provides distributed and replicated search for large scale power.

For the examples that follow, we'll be using Solr as the front-end to Lucene. This allows us to demonstrate the capabilities with simple HTTP commands and scripts, rather than coding in Java directly. Additionally, Solr adds easy-to-use faceting, clustering, spell checking, autosuggest, rich document indexing, and much more. We'll introduce some of Solr's value-added pieces along the way.

Lucene has a lot of flexibility, likely much more than you will need or use. Solr layers some general common-sense best practices on top of Lucene with a schema. A Solr schema is conceptually the same as a relational database schema. It is a way to map fields/columns to data types, constraints, and representations. Let's take a preview look at fields defined in the Solr schema (conf/schema.xml) for our running example:

```
<fields>
  <field name="id"
         type="string" indexed="true" stored="true"/>
   <field name="title"
          type="text_en" indexed="true" stored="true" />
   <field name="mimeType"
          type="string" indexed="true" stored="true" />
   <field name="lastModified"
          type="date" indexed="true" stored="true" />
</fields>
```

The schema constrains all fields of a particular name (there is dynamic wildcard matching capability too) to a "field type". A field type controls how the Lucene Field instances are constructed during indexing, in a consistent manner. We saw above that Lucene fields have a number of additional attributes and controls, including whether the field value is stored, indexed, if indexed, how so, which analysis chain, and whether positions, offsets, and/or term vectors are stored.

Our Running Example, Quick Proof-of-Concepts

The (Solr) documents we index will have a unique "id" field, a "title" field, a "mimeType" field to represent the file type for filtering/faceting purposes, and a "lastModified" date field to represent a file's last modified timestamp. Here's an example document (in Solr XML format, suitable for direct POSTing):

```
<add>
  <doc>
    <field name="id">doc01</field>
    <field name="title">Our first document</field>
    <field name="mimeType">application/pdf</field>
     <field name="lastModified">NOW</field>
  </doc>
</add>
```

That example shows indexing the metadata regarding an actual file. Ultimately, we also want the contents of the file to be searchable. Solr natively supports extracting and indexing content from rich documents. And LucidWorks Enterprise has built-in file and web crawling and scheduling along with content extraction.

Launching Solr, using its example configuration, is as straightforward as this, from a Solr installation directory:

```
cd example
java –jar start.jar
```

And from another command-shell, documents can be easily indexed. Our example document shown previously (saved as docs.xml for us) can be indexed like this:

```
cd example/exampledocs
java –jar post.jar docs.xml
```

First of all, this isn't going to work out of the box, as we have a custom schema and applications needs not supported by Solr's example configuration. Get used to it, it's the real world! The example schema is there as an example, and likely inappropriate for your application as-is. Borrow what makes sense for your own applications needs, but don't leave cruft behind.

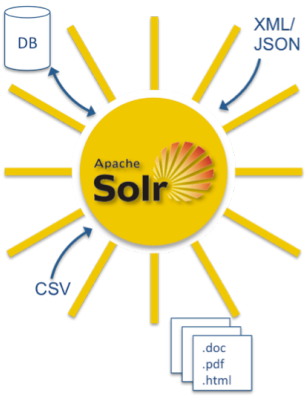
At this point, we have a fully functional search engine, with a single document, and will use this for all further examples. Solr will be running at http://localhost:8983/solr.

INDEXING

The process of adding documents to Lucene or Solr is called *indexing*. With Lucene Java, you create a new `Document` instance and call the `addDocument` method of an `IndexWriter`. This is straightforward and simple enough, leaving the burden on you to come up with the textual strings that'll comprise the document.

Contrast with Solr, which provides numerous ways out of the box to index. We've seen an example of Solr XML, one basic way to bring in documents. Here are detailed examples of various ways to index content into Solr. Solr's schema centralizes the decisions

made about how fields are indexed, freeing the indexer from any internal knowledge about how fields should be handled.



Solr XML/JSON

Solr's basic XML format can be a convenient way to map your applications "documents" into Solr. A simple HTTP post to /update is all it takes.

Posting XML to Solr can be done using the post.jar tool that comes with Solr's example data, curl (see Solr's post.sh), or any other HTTP library or tool capable of POST. In fact, most of the popular Solr client API libraries out there simply wrap an HTTP library with some convenience methods for indexing documents, packaging up documents and field values into this XML structure and POSTing it to Solr's /update handler. Documents indexed in this fashion will be updated if they share the same unique key field value (configured in schema.xml) as existing documents.

Recently, JSON support has been added so it can be even cleaner to post documents into Solr and easier to adapt to a wider variety of clients. It looks like this:

```
{"add": {
  "doc": {
    "id": "doc02",
    "title": "Solr JSON",
    "mimeType": "application/pdf"}
  }
}
```

Simply post this type of JSON to /update/json. All other Solr commands can be posted as JSON as well (delete, commit, optimize).

Comma, or Tab, Separated Values

Another extremely convenient and handy way to bring documents into Solr is through CSV (comma-separated variables; or, more generally, column-separated variables as the separator character is configurable). An example CSV file is shown here:

```
id,title,mimeType,lastModified
doc03,CSV ftw,application/pdf,2011-02-28T23:59:59Z
```

This CSV can be POSTed to the /update/csv handler, mapping rows to documents and columns to fields in a flexible, mappable manner. Using curl, this file (we named docs.csv) can be posted like this:

```
curl "http://localhost:8983/solr /update/csv?commit=true" --data-
binary @docs.csv -H 'Content-type:text/plain; charset=utf-8'
```

Note that this Content-type header is a necessary HTTP header to use for the CSV update handler.

Indexing Rich Document Types

Thus far, our indexing examples have omitted extracting and indexing file content. Numerous rich document types, such as Word, PDF, and HTML, can be processed using Solr's built-in Apache Tika integration. To index the contents and metadata of a Word document, using the HTTP command-line tool curl, this is basically all that is needed:

```
curl "http://localhost:8983/solr/update/extract?literal.id=doc04" -F
"myfile=@technical_manual.doc"
```

To index rich documents with Lucene's API, you would need to interface with one or more extractor libraries, such as Tika, extract the text, and map full text and document metadata as appropriate to Lucene fields. It's much more straightforward, with no coding, to accomplish this task with Solr.

Hot Tip

Apache Tika http://tika.apache.org/ is a toolkit for detecting and extracting metadata from various types of documents. Existing open-source extractors and parsers are bundled with Tika to handle the majority of file types folks desire to search. Tika is baked into Solr, under the covers of the /update/extract capability.

DataImportHandler

And finally, Solr includes a general-purpose "data import handler" framework that has built-in capabilities for indexing relational databases (anything with a JDBC driver), arbitrary XML, and e-mail folders. The neat thing about the DataImportHandler is that it allows aggregating data from various sources into whole Solr documents.

For more information on Solr's DataImportHandler, see http://wiki.apache.org/solr/DataImportHandler.

Deleting Documents

Documents can be deleted from a Lucene index, either by precise term matching (a unique identifier field, generally) or in bulk for all documents matching a Query.

When using Solr, deletes are accomplished by POSTing `<delete><id>refcard01</id></delete>` or `<delete><query>mimeType:application/PDF</query></delete>` XML messages to the /update handler. Or `"delete": { "id":"ID"}` or `"delete": { "query":"mimeType:application/pdf" }` messages to /update/json.

Hot Tip

Deleting by query "*:*" and committing is a handy trick for deleting all documents and starting with a fresh index; very helpful during rapid iterative development.

Committing

Lucene is designed such that documents can continuously be indexed, though the view of what is searchable is fixed to a certain snapshot of an index (for performance, caching, and versioning reasons). This architecture allows batches of documents to be indexed and only made searchable after the entire batch has been ingested. Pending changes to an index, including added and deleted documents, are made visible using a commit command. With Solr, a `<commit/>` message can be posted to the /update handler, `"commit": {}` to /update/json, or even simpler as a bodyless /update GET (or POST) with commit=true set: http://localhost:8983/solr/update?commit=true

FIELDS

As mentioned, fields have a lot of configuration flexibility. The following table details the various decisions you must make regarding each fields configuration.

Field Attribute	Effect and Uses
stored	Stores the original incoming field value in the index. Stored field values are available when documents are retrieved for search results.
term positions	Location information of terms within a field. Positional information is necessary for proximity-related queries, such as phrase queries.
term offsets	Character begin and end offset values of a term within a fields textual value. Offsets can be handy for increasing performance of generating query term highlighted field fragments. This one typically is a trade-off between highlighting performance and index size. If offsets aren't stored, they can be computed at highlighting time.
term vectors	An "inverted index" structure within a document, containing term/frequency pairs. Term vectors can be useful for more advanced search techniques, such as "more like this" where terms and their frequencies within a single document can be leveraged for finding similar documents.

In Solr's `schema.xml`, a field can be configured to have all of these bells and whistles enabled like this:

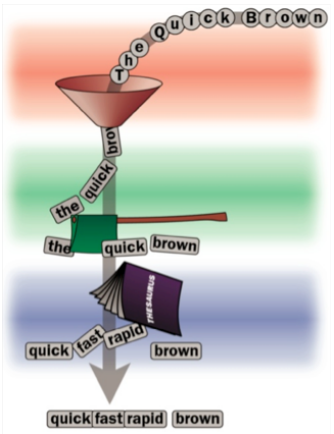
```
<field name="kitchen_sink" type="text" indexed="true" stored="true"
termVectors="true" termPositions="true" termOffsets="true" />
```

Only indexed fields have "terms". These additional term-based structures are only available on indexed fields and really only make sense when used with analyzed full-text fields.

When indexing non-textual information, such as dates or numbers, the representation and ordering of the terms in the index drastically impact the types of operations available. Especially for numeric and date types, which typically are used for range queries and sorting, Lucene (and Solr) offer special ways to handle them. When indexing dates and numerics, use the Trie*Field types in Solr, and the `NumericField/NumericTokenStream` API's with Lucene. This is a crucial reminder that what you want your end application to do with the search server greatly impacts how you index your documents. Sorting and range queries, specifically, require up-front planning to index properly to support those operations.

ANALYSIS

The Lucene analysis process consists of several stages. The text is sent initially through an optional `CharFilter`, then through a `Tokenizer`, and finally through any number of `TokenFilters`. `CharFilters` are useful for mapping diacritical characters to their ASCII equivalent, or mapping Traditional to Simplified Chinese. A `Tokenizer` is the first step in breaking a string into "tokens" (what they are called before being written to the index as "terms"). `TokenFilters` can subsequently add, remove, or modify/augment tokens in a sequential pipeline fashion.



Hot Tip Solr includes a very handy analysis introspection tool. You can access it at http://localhost:8983/sorl/admin/analysis.jsp. Specify a field name or field type, enter some text, and see how it gets analyzed through each of the processing stages.

Using the Solr admin analysis introspection tool, using the field type "text_en" with the value "Understanding Lucene Refcard", the following terms result:

org.apache.solr.analysis.ASCIIFoldingFilterFactory {luceneMatchVersion=LUCENE_40}

position	1	2	3
term text	understanding	lucene	refcard
raw bytes	[75 6e 64 65 72 73 74 61 6e 64 69 6e 67]	[6c 75 63 65 6e 65]	[72 65 66 63 61 72 64]
startOffset	0	14	21
endOffset	13	20	28
type	word	word	word

The analysis tool shows the term text that would be indexed ([understanding], [lucene]…), and the position and offset attributes we previously discussed. The analysis tool will handily show you the term output of each of the analysis stages, from tokenization through each of the filters.

SEARCHING

Now that we've got content indexed, searching it is easy! Ultimately, a Lucene `Query` object is handed to a Lucene `IndexSearcher.search()` method and results are processed. How to construct a query is the next step.

With Lucene Java, `TermQuery` is the most primitive `Query`. Then there's `BooleanQuery`, `PhraseQuery`, and many other `Query` subclasses to choose from. Programmatically, the sky's the limit in terms of query complexity. Lucene also includes a `QueryParser`, which parses a string into a `Query` object, supporting fielded, grouped, fuzzy, phrase, range, AND/OR/NOT/+/- and other sophisticated syntax.

Solr makes this all possible without coding and accepts a simple string query (q) parameter (and other parameters that can affect query parsing/generation). Solr includes a couple of general purpose query parsers, most notably a schema-aware subclass of Lucene's `QueryParser`. This Lucene query parser is the default.

Hot Tip Solr also includes a number of other specialized query parsers and the capability to mix-and-match them in rich combinations. Most notably is the "dismax" (disjunction maximum) and a new experimental "edismax" (extended dismax) query parsers that allow typical users queries to query across a number of configurable fields with individual field boosting. Dismax is the parser most often used with Solr these days.

Searching Solr is a straightforward HTTP request to /select?q=<your query>. Displaying search results in JSON (adding &wt=json) format, we get something like this:

```
{"responseHeader":{
   "status":0,
   "QTime":2,
   "params":{
     "indent":"true", "wt":"json", "q":"*:*"}},
 "response":{"numFound":3,"start":0,
   "docs":[
     {"id":"refcard01",
      "timestamp":"2011-02-17T20:44:49.064Z",
      "title":[          "Understanding Lucene"]},       {
"id":"refcard02",          "timestamp":"2011-02-17T20:48:16.862Z",
"title":[          "Refcard 2"]},       {          "id":"doc03",
"mimeType":"application/pdf",          "lastModified":"2011-02-
28T23:59:59Z",          "timestamp":"2011-02-17T21:42:31.423Z",
"title":[          "CSV ftw"]}]   }}
```

Note that Solr can return search results in a number of formats (XML, JSON, Ruby, PHP, Python, CSV, etc), choose the one that is most convenient for your environment.

Debugging Query Parsing

Query parsing is complex business. It can be very helpful in seeing a representation of the underlying Query object generated. By adding a debug=query parameter to the request, you can see how a query is parsed. For example, using the query "title:lucene AND timestamp:[NOW-1YEAR TO NOW]", the debug output returns a `parsedquery` value of:

```
parsedquery:+title:lucene +timestamp:[1266446158657 TO
1297982158657]"
```

Note that AND translated to both clauses as mandatory (leading +) and the date range values were parsed by Solr's useful date math feature and then converted to the Lucene "date" type index representation.

Explaining Result Scoring

Now that we have real documents indexed, we can take a look at Lucene's scoring first-hand. Solr provides an easy way to look at Lucene's "explain" output, which details how/why a document scored the way it did. In our Refcard lab, doing a title:lucene search matches a document and scores it like this:

```
0.8784157 = (MATCH) fieldWeight(title:lucene in 0), product of:
  1.0 = tf(termFreq(title:lucene)=1)
  1.4054651 = idf(docFreq=1, maxDocs=3)
  0.625 = fieldNorm(field=title, doc=0)
```

Add the debug=results parameter to the Solr search request to have explanation output added to the response.

BELLS AND WHISTLES

Solr includes a number of other features; some of them wrap Lucene Java add-on libraries and some of them (like faceting and rich function query/sort capability) are currently only at the Solr layer. We aren't going into any detail of these particular features here, but now that you understand Lucene, you have the foundation to understand basically how they work from the inverted index structure on up. These features include:

- **Faceting:** providing counts for various document attributes across the entire result set.
- **Highlighting:** generating relevant snippets of document text, highlighting query terms. Useful in result display to show users the context in which their queries matched.
- **Spell checking:** "Did you mean…?". Looks up terms textually close to the query terms and suggests possible intended queries.
- **More-like-this:** Given a particular document, or some arbitrary text, what other documents are similar?

Version Information

These Refcard demos use the current development branch of Lucene/Solr. This is likely to be what is eventually released from Apache as Lucene and Solr 4.0. LucidWorks Enterprise is also based on this same version. The concepts apply to all versions of Lucene and Solr, and the bulk of these examples should also work with earlier versions of Solr.

For Further Information

For all things Apache Lucene, start here: http://lucene.apache.org

Solr sports relatively decent developer-centric documentation: http://wiki.apache.org/solr

Lucene in Action (Manning): http://www.manning.com/lucene

To answer your Lucene questions, try LucidFind — http://search.lucidimagination.com — where the Lucene ecosystems e-mail lists, wikis, issue tracker, etc are made searchable for the entire Lucene community's benefit.

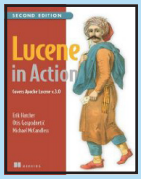
See *Apache Solr: Getting Optimal Search Results*, http://refcardz.dzone.com/refcardz/solr-essentials, for more information on Apache Solr.

ABOUT THE AUTHOR

Photo courtesy of Duncan Davidson

Erik Hatcher evangelizes and engineers at Lucid Imagination. He co-authored both *Lucene in Action* and *Java Development with Ant*. At Lucid, he has worked with many companies deploying Lucene/Solr search systems. Erik has spoken at numerous industry events including Lucene EuroCon, ApacheCon, JavaOne, OSCON, and user groups and meetups around the world.

RECOMMENDED BOOK



When Lucene first appeared, this superfast search engine was nothing short of amazing. Today, Lucene still delivers. Its high-performance, easy-to-use API features like numeric fields, payloads, near-real-time search, and huge increases in indexing and searching speed make it the leading search tool.

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ISBN-13: 978-1-936502-37-0
ISBN-10: 1-936502-37-2
50795
9 781936 502370
$7.95

Version 1.0