

CS520 Web Programming

Full Text Search

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Search Text

- ◆ Web search
- ◆ Desktop search
- ◆ Applications
 - Search posts in a bulletin board
 - Search product descriptions at an online retailer
 - ...

Database Query

- ◆ Find the posts regarding "SSHD login errors".

```
select * from posts
  where content like '%SSHD login errors%';
```

Here are the steps to take to fix the SSHD login errors:
...

Please help! I got SSHD login errors!

Problems with Database Queries

Please help! I got an error when I tried to login through SSHD!

There a problem recently discovered regarding SSHD and login. The error message is usually ...

The solution for sshd/login errors: ...

- ◆ And how about performance??

Full Text Search (FTS)

- ◆ More formally known as Information Retrieval (IR)
- ◆ Search LARGE amount of textual data

Characteristics of FTS

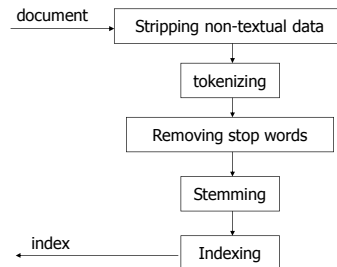
- ◆ Vs. Databases
 - "Fuzzy" query processing
 - Relevancy ranking

Accuracy of FTS

$$\text{Precision} = \frac{\text{\# of relevant documents retrieved}}{\text{\# of documents retrieved}}$$

$$\text{Recall} = \frac{\text{\# of relevant documents retrieved}}{\text{\# of relevant documents}}$$

Journey of a Document



Document

Original

```

<html>
<body>
<p>The solution for
sshhd/login errors:
...</p>
</body>
</html>
  
```

Text-only

```

The solution for
sshhd/login errors:
...
  
```

Tokenizing

```

[the] [solution] [for] [sshhd] [login] [errors]
...
  
```

Chinese Text Example

Text: 今天天气不错。

Unigram:

[今][天][天][气][不][错]

Bigram:

[今天][天天][天气][气不][不错]

Grammar-based:

[今天][天气][不错]

Stop Words

◆ Words that do not help in search and retrieval

■ Function words: a, an, and, the, of, for ...

◆ After stop words removal:

```

[the] [solution] [for] [sshhd] [login] [errors]
...
  
```

Problem of stop word removal??

Stemming

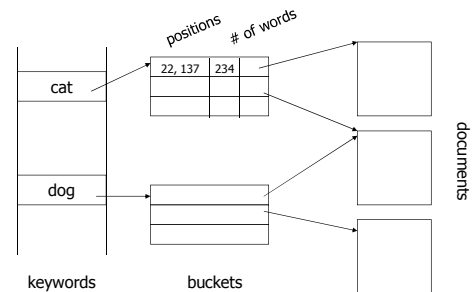
◆ Reduce a word to its stem or root form.

◆ Examples:

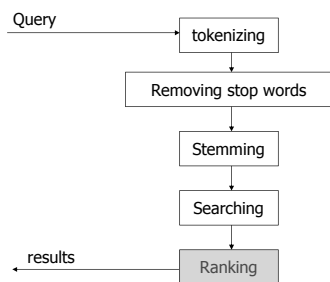
connection, connections
connected, connecting → connect
connective

[solution] [sshd] [login] [errors] → [solve] [sshd] [login] [error]
...

Inverted Index



Query Processing



Ranking

- ◆ How well the document matches the query
 - E.g. weighted vector distance
- ◆ How "important" the document is
 - E.g. based on ratings, citations, and links

FTS Implementations

- ◆ Databases
 - MySQL: MyISAM tables only
 - PostgreSQL (since 8.3)
 - Oracle, DB2, MS SQL Server, ...
- ◆ Standard-alone IR libraries
 - Lucene, Egothor, Xapian, MG4J, ...

FTS from the Perspective of Application Developers

- ◆ Prepare data
- ◆ Create query
- ◆ Display result
- ◆ (Index)
- ◆ (Ranking)

Lucene Overview

- ◆ <http://lucene.apache.org/>
- ◆ Originally developed by Doug Cutting
- ◆ THE full text search solution for Java applications
- ◆ Handles text only – needs external converters to convert other document types to text
- ◆ Java API - http://lucene.apache.org/java/3_4_0/api/core/index.html

Example 1: Index Text Files

- ◆ Directory
- ◆ Document and Field
- ◆ Analyzer
- ◆ IndexWriter

Directory

- ◆ A place where the index files will be stored
- ◆ `FSDirectory` – file system directory
- ◆ `RAMDirectory` – virtual directory in memory

Analyzer

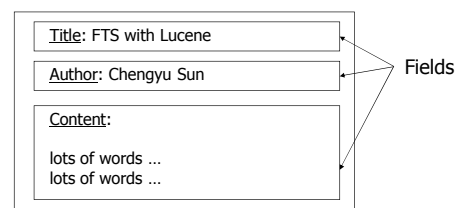
- ◆ Pre-processing the document or query text – tokenization, stop words removal, stemming
- ...
- ◆ Lucene built-in analyzers
 - `WhitespaceAnalyzer`, `SimpleAnalyzer`, `StopAnalyzer`
 - `StandardAnalyzer`
 - Grammar-based
 - Recognize special tokens such as email addresses
 - Handle CJK text

IndexWriter

- ◆ `addDocument(Document)`
- ◆ `close()`
- ◆ `optimize()`

Document

- ◆ A document consists of a number of user-defined fields



Types of Fields

- ◆ Indexed – whether the field is indexed
 - Analyzed
 - Not analyzed
- ◆ Stored – whether the original text is stored together with the index

Common Usage of Field Types

Field	Indexed	Analyzed	Stored
String	Y	Y	Y
Large text file	Y	Y	
ID, people's name, date	Y		Y
Non-searchable data			Y

Example 2: Search

- ◆ Query and QueryParser
- ◆ IndexSearcher
- ◆ TopDocs and ScoreDoc
- ◆ Document (again)

Queries

full text search

+full +text search

+full +text -search

+title:"text search"

+(title:full title:text) -author:"john doe"

IndexSearcher

- ◆ search(Query, int n) – returns the top n results for the query

TopDocs and ScoreDoc

- ◆ TopDocs contains an array of ScoreDoc, which has a *document id* and the *relevancy score* of the document

Factors in Lucene Score

- ◆ # of times a term appears in a document
- ◆ # of documents that contain the term
- ◆ # of query terms found
- ◆ length of a field
- ◆ boost factor - field and/or document
- ◆ query normalizing factor – does not affect ranking

See the API documentation for the Similarity class.

Document (again)

- ◆ Methods to retrieve data stored in the document
 - String get(String fieldName)

Handle Rich Text Documents

- ◆ HTML
 - NekoHTML
- ◆ PDF
 - PDFBox
- ◆ MS Word
 - POI
- ◆ More at Lucence FAQ -
<http://wiki.apache.org/jakarta-lucene/LuceneFAQ>

Further Readings

- ◆ *Lucene in Action (2ed Ed)* by Michael McCandless, Erik Hatcher and Otis Gospodnetic

FTS in PostgreSQL

- ◆ Since 8.3
 - tsearch/tsearch2 module before 8.3
- ◆ <http://www.postgresql.org/docs/9.1/inteactive/textsearch.html>

Text Search Configuration

- ◆ Specify the options to transform a document to a `tsvector` – tokenization, stop words removal, stemming etc.
- ◆ psql commands
 - \dF
 - show default_text_search_config;
 - set default_text_search_config=english;
- ◆ Change default text search configuration in `$DATA/postgresql.conf`

Sample Schema

```
create table messages (  
  id      serial primary key,  
  subject varchar(4092),  
  content text,  
  author  varchar(255)  
);
```

Basic Data Types and Functions

◆ Data types

- tsvector
- tsquery

◆ Functions

- to_tsvector
- to_tsquery
- plainto_tsquery

Query Syntax

plainto_tsquery	to_tsquery
full text search	full & text & search
↓	full & text search
full & text & search	full & !text search
	(! full text) & search

The Match Operator @@

- ◆ tsvector @@ tsquery
- ◆ tsquery @@ tsvector
- ◆ text @@ tsquery
 - to_tsvector(text) @@ tsquery
- ◆ text @@ text
 - to_tsvector(text) @@ plainto_tsquery(text)

Note that there is no tsquery @@ text.

Query Examples

- ◆ Find the messages that contain "computer programs" in the content
- ◆ Find the messages that contain "computer programs" in either the content or the subject

Create an Index on Text Column(s)

```
create index messages_content_index  
on messages  
using gin(to_tsvector('english', content));
```

- ◆ Expression (function) index
- ◆ The *language* parameter is required in both index construction and query

Use a Separate Column for Text Search

- ◆ Create a tsvector column
- ◆ Use a trigger to update the column

Create an Index on the tsvector Column

```
create index messages_tsv_index
on messages
using gin(tsv);
```

- ◆ The *language* parameter is no longer required

More Functions

- ◆ `setweight(tsvector, "char")`
 - A: 1.0
 - B: 0.4
 - C: 0.2
 - D: 0.1
- ◆ `ts_rank(tsvector, tsquery)`
- ◆ `ts_headline(text, tsquery)`

Function Examples

- ◆ Set the weight of *subject* to be "A" and the weight of *content* to be "D"
- ◆ List the results by their relevancy scores and highlight the query terms in the results

Using Native SQL in JPA

```
String sql = "select * from employees where id = ?";
entityManager.createNativeQuery(sql, Employee.class)
    .setParameter(1, employeeId)
    .getResultList();
```

Named Query in Entity Class

```
@Entity
@Table( name="employees" )
@NamedQueries({
    @NamedQuery( name="employee.findAll",
        query="select * from employees" ),
    @NamedQuery( name="employee.findById",
        query="from Employee where id = :id" )
})
public class Employee { .... }
```

A named query can be JPQL or SQL.

Named Query in Hibernate Mapping File

```
<sql-query name="message.search">
  <return class="Message" />
  <![CDATA[
    select * from messages
    where tsv @@ plainto_tsquery(?)
  ]]>
</sql-query>
```

Using Named Query in DAO

```
entityManager
.createNamedQuery("employee.findAll", Employee.class)
.getResultList();

entityManager
.createNamedQuery("employee.findById", Employee.class)
.setParameter("id", employeeId )
.getSingleResult();
```

Example: Course Search in CSNS2

- ◆ Course
- ◆ CourseDao and CourseDaoImpl
- ◆ NamedQueries.hbm.xml
- ◆ csns-create.sql

FTS in Databases vs. Standalone Libraries

- ◆ Pros??
- ◆ Cons??