

## 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 (*documents*)

## Characteristics of FTS

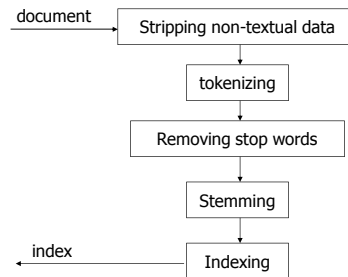
- ◆ Vs. Databases
  - Relevancy ranking
  - "Fuzzy" query processing

## 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
sshd/login errors:
...</p>
</body>
</html>
  
```

### ◆ Text-only

```

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

## Tokenizing

[the] [solution] [for] [sshd] [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]~~ [sshd] [login] [errors]  
...

*Problem of stop word removal??*

## Stemming

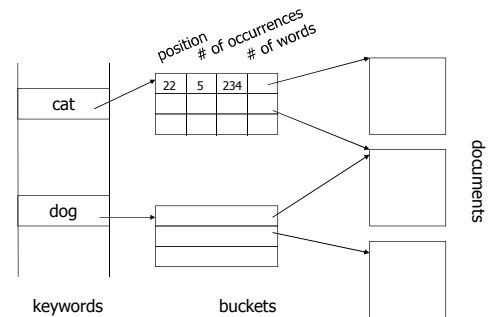
◆ Reduce a word to its stem or root form.

◆ Examples:

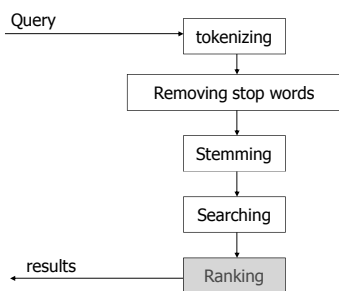
connection, connections  
connected, connecting  
connective → connect

[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\\_0\\_1/api/core/index.html](http://lucene.apache.org/java/3_0_1/api/core/index.html)

## Example 1: Index Text Files

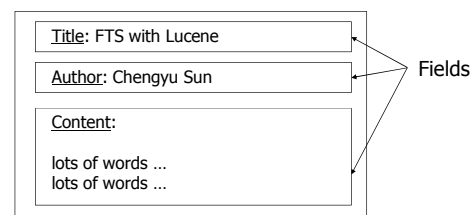
- ◆ Directory
- ◆ Document and Field
- ◆ Analyzer
- ◆ IndexWriter

## Directory

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

## Document

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



## Types of Fields

- ◆ Indexed – whether the field is indexed
  - Tokenized
  - Untokenized
- ◆ Stored – whether the original text is stored together with the index

## Common Usage of Field Types

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

## 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()

## Example 2: Search

- ◆ Query and QueryParser
- ◆ IndexSearcher
- ◆ Hits
- ◆ 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 )
- ◆ close()

## Hits

- ◆ A ranked list of documents used to hold search results
- ◆ Methods
  - Document doc( int n )
  - int id( int n )
  - int length()
  - float score( int n ) – normalized score

## 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 name )
  - Field getField( String name )

## Handle Rich Text Documents

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

## Further Readings

- ◆ *Lucene in Action* by Otis Gospodnetic and Erik Hatcher

## FTS in PostgreSQL

- ◆ Since 8.3
  - tsearch/tsearch2 module before 8.3
- ◆ <http://www.postgresql.org/docs/8.4/integrate/textsearch.html>

## 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 Hibernate

- ◆ [http://www.hibernate.org/hib\\_docs/v3/reference/en/html/queriesql.html](http://www.hibernate.org/hib_docs/v3/reference/en/html/queriesql.html)
- ◆ Example:

```
SQLQuery query = session.createSQLQuery("select * from messages");
query.addEntity( Message.class );
List messags = query.list();
```

## Named Query ...

In Hibernate mapping file:

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

## ... Named Query

In DAO code:

```
public List searchMessages( String query )
{
  return getHibernateTemplate()
    .findByNameQuery("message.search", query);
}
```



## Search Forum Posts in CSNS

- ◆ csns-create.sql
- ◆ Post.java
- ◆ Post.hbm.xml
- ◆ PostDao.java
- ◆ PostDaoImpl.java

## FTS in Databases vs. Standalone Libraries

- ◆ Pros??
- ◆ Cons??