# 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

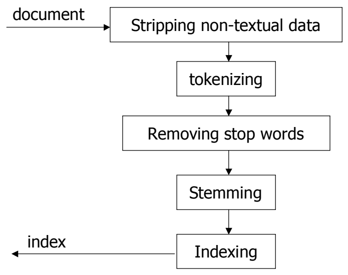
- Vs. Databases
  - Relevancy ranking
  - "Fuzzy" query processing

## 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??*

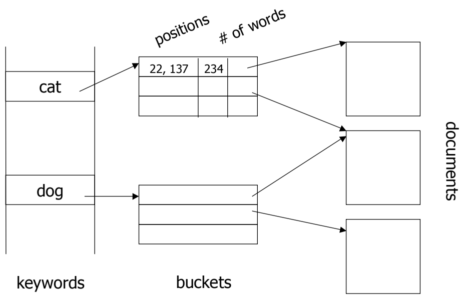
## Stemming

- ◈Reduce a word to its stem or root form.
- ◈Examples:

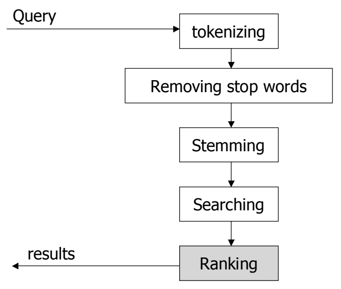
connection, connections
connected, connecting → connect
connective

[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

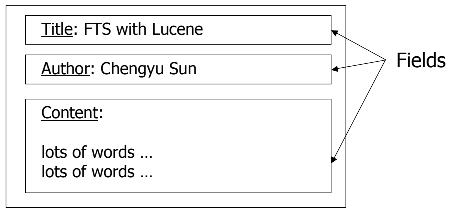
- Pre-processing the document or query text – tokenization, stop words removal, stemming …
- Lucene built-in analyzers
  - WhitespaceAnalyzer, SimpleAnalyzer, StopAnalyzer
  - StandardAnalyzer
    - Grammar-based
    - Recognize special tokens such as email addresses
    - Handle CJK text

## 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/interactive/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.createNaiveQuery(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();
```

## Search Mailing List Messages in CSNS2

- Message.java
- csns-create.sql
- NamedQueries.hbm.xml
  - Hibernate automatically searches under *classpath* for `*.hbm.xml` files
- MessageDaoImpl.java
- MessageDaoTests.java

## FTS in Databases vs. Standalone Libraries

- Pros??
- Cons??