# Information Retrieval

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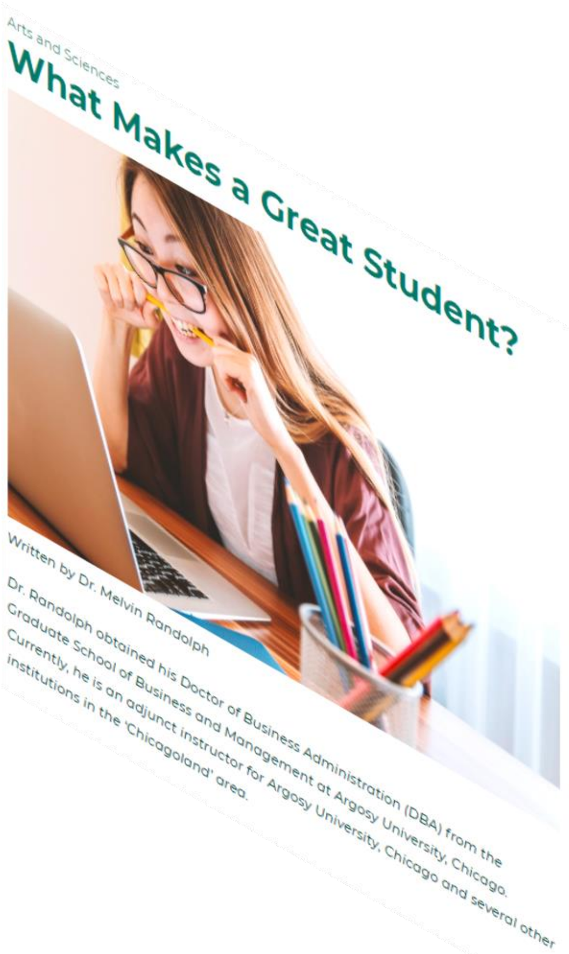
Indian Institute of Information Technology, Sri City

**Mission defines strategy, and strategy defines structure.**
**– Peter Drucker.**

# Documents with Structure

- So far, we discussed unstructured text.
- Many documents in reality have a structure.
  - They are composed of Zones and Fields.



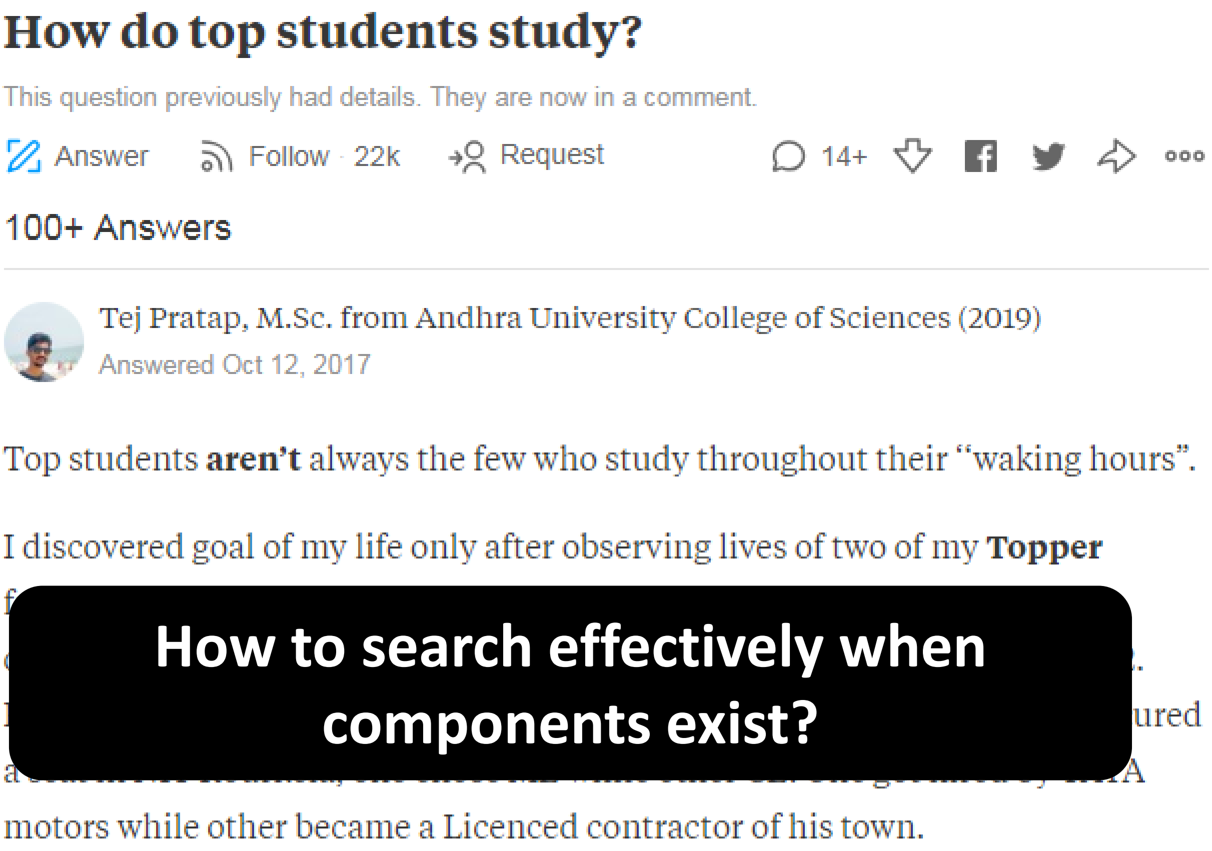
Arts and Sciences

What Makes a Great Student?

Written by Dr. Melvin Randolph

Dr. Randolph obtained his Doctor of Business Administration (DBA) from the Graduate School of Business and Management at Argosy University, Chicago. Currently, he is an adjunct instructor for Argosy University, Chicago and several other institutions in the 'Chicagoland' area.

# Identify Some Key Components



**How do top students study?**

This question previously had details. They are now in a comment.

100+ Answers

Tej Pratap, M.Sc. from Andhra University College of Sciences (2019)
Answered Oct 12, 2017

Top students **aren't** always the few who study throughout their "waking hours".

I discovered goal of my life only after observing lives of two of my **Topper**
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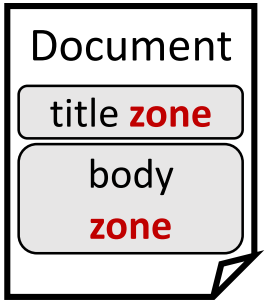
**How to search effectively when components exist?**

# Zones and Fields

- A document is associated with *metadata* which are useful in search.

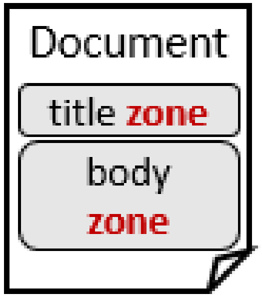


**METADATA Fields**
**filename**
**author**
**title**
**date of creation**

- **Sample Query**: find documents authored by William Shakesphere in 1601 containing the phrase "you brutus"
- **Sample Query**: find documents with merchant in the title and william in the author list and the phrase gentle rain in the body

# Zones and Fields

- Zones are arbitrary free text.
- Fields may take relatively small set of values.
  - Fields may call for *range query* (year between 1600 and 1700) support

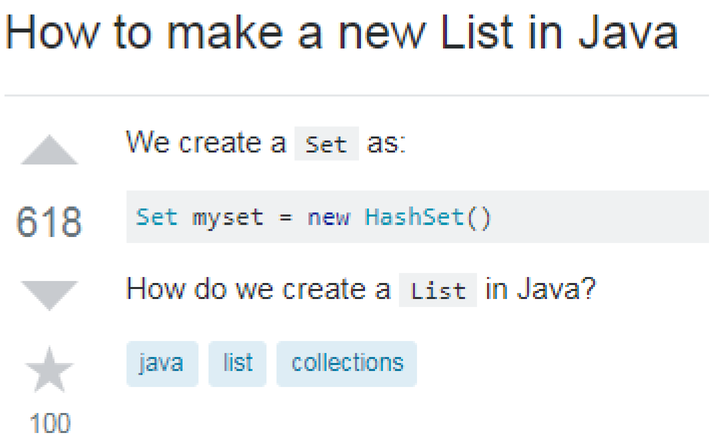


**METADATA Fields**
filename
author
title
date of creation

**How to index zones and fields?**

# Quiz

- Assume we are indexing stackoverflow data. Which of the following are zones?
  - question
  - answer
  - number of answers
  - comments
  - number of comments
  - code blocks



How to make a new List in Java

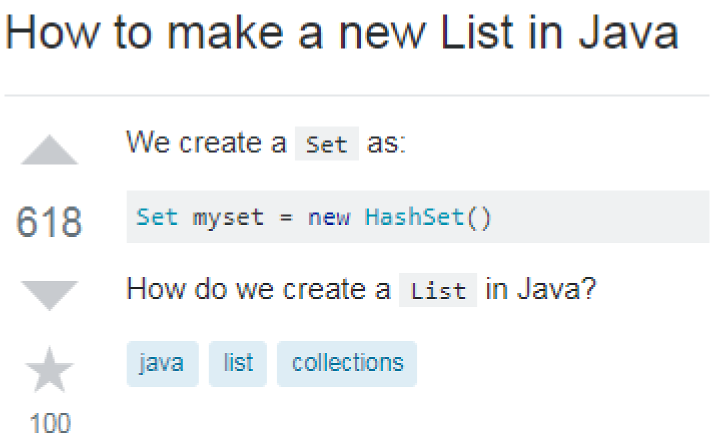
We create a `Set` as:

```
Set myset = new HashSet()
```

How do we create a `List` in Java?

# Quiz

- Assume we are indexing stackoverflow data. Which of the following are zones?
  - **question**
  - **answer**
  - number of answers
  - **comments**
  - number of comments
  - **code blocks**



How to make a new List in Java

618

We create a `Set` as:

```
Set myset = new HashSet()
```

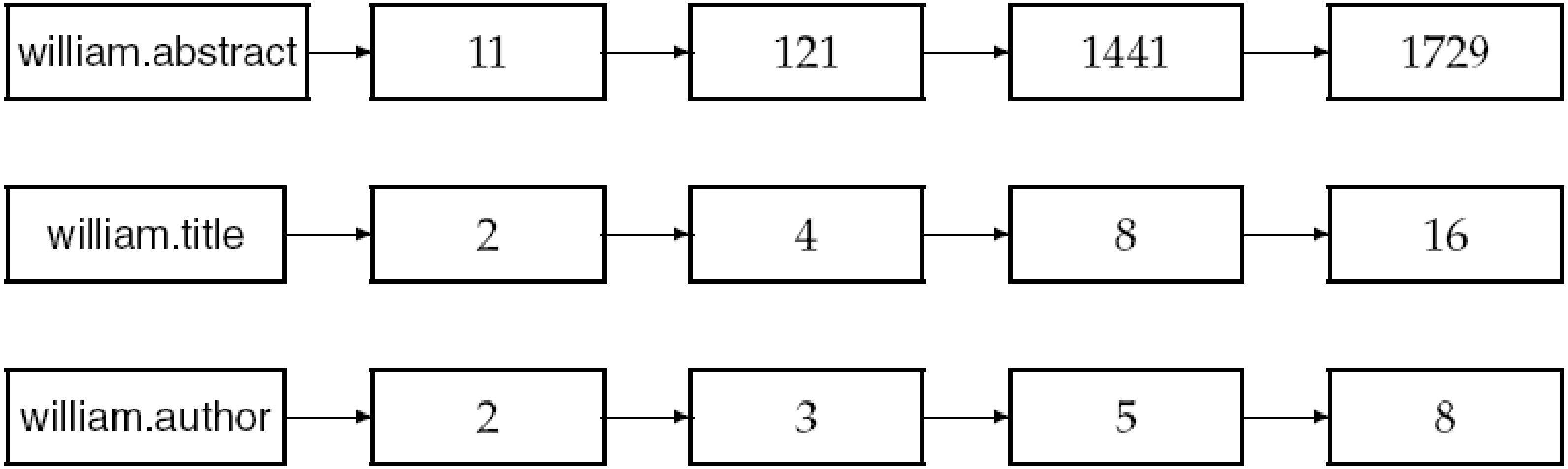
How do we create a `List` in Java?

java list collections

100

# Indexing Zones and Fields

- Create separate Index for each field and each zone.
  - Standard Inverted Index +
  - Parametric Indexes (one for each field) +
  - Zone Indexes (one for each zone)

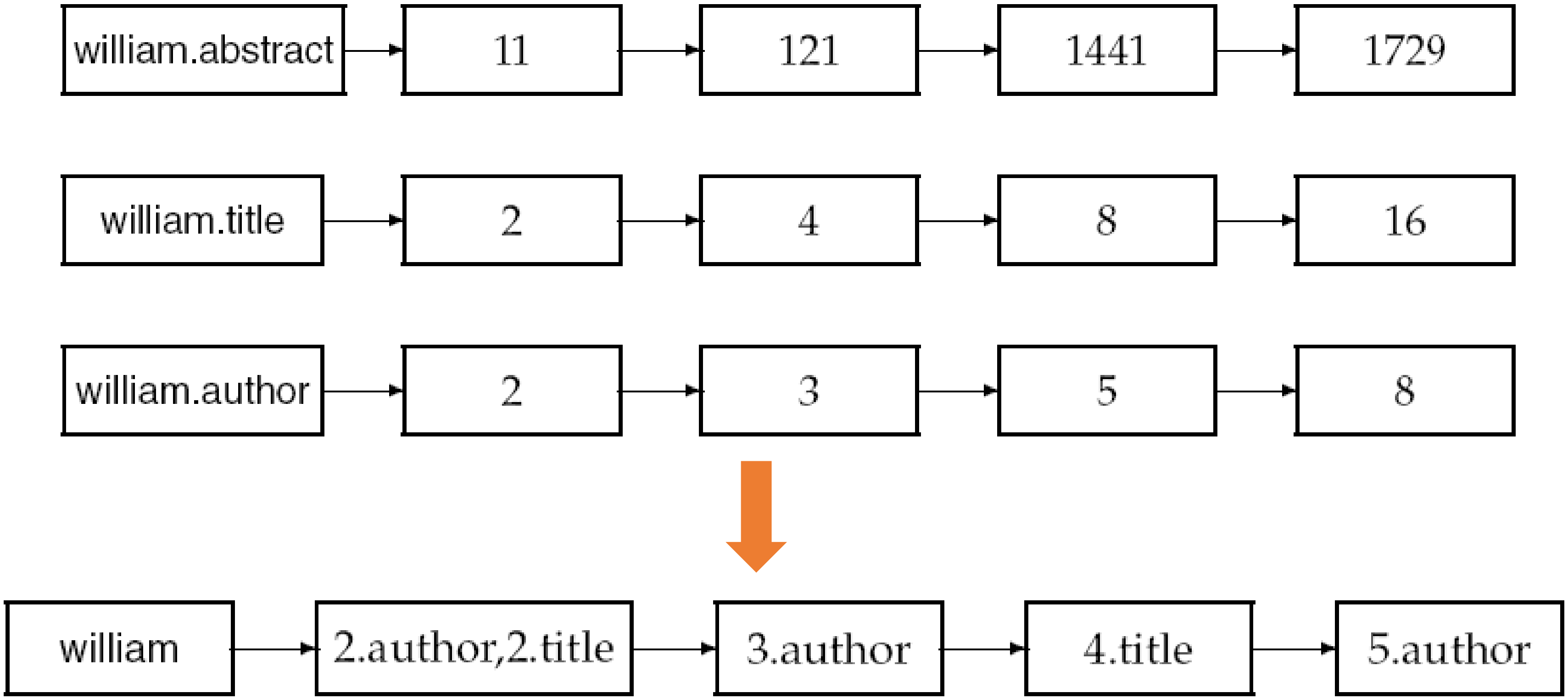


Zone Index Example

Is there a better way to index zones and fields?

# We can do better…

- Encode zones in postings.



william.abstract → 11 → 121 → 1441 → 1729

william.title → 2 → 4 → 8 → 16

william.author → 2 → 3 → 5 → 8

william → 2.author,2.title → 3.author → 4.title → 5.author

# Weighted Zones

- Not all zones are equally important!
- Consider a collection where documents have three zones (*l* = 3):
  - author (least important)
  - title (more important)
  - body (most important)
- We can associate a weight, $g_i$ to each zone
  - author ($g_1$ = 0.2)
  - title ($g_2$ = 0.3)
  - body ($g_3$ = 0.5)

$$\sum_{i=1}^{l} g_i = 1$$

$$g_i \in [0,1]$$

# Weighted Zone Scoring

- If all query terms appear in i<sup>th</sup> zone,
  - we say $s_i$ = 1.
- Then, we score the document as

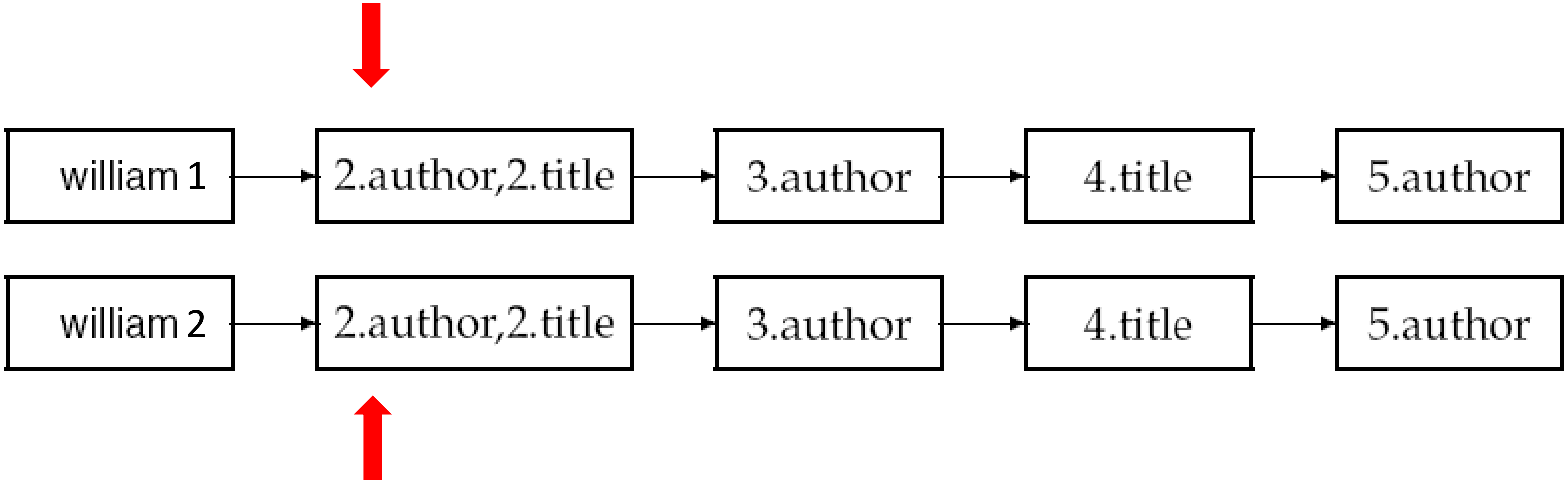
$$\sum_{i=1}^{l} \mathrm{g_i}\, s_i$$

# Quiz

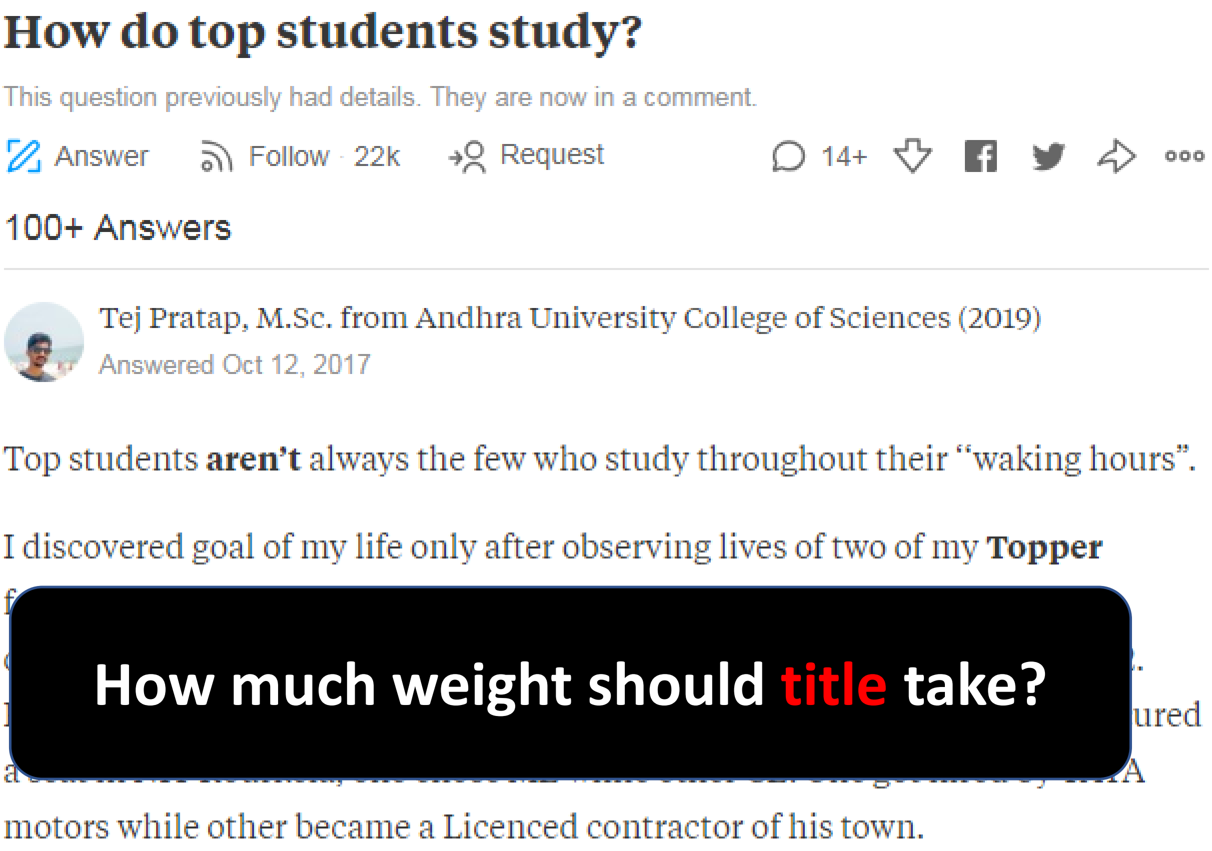
- Consider a collection with the following zone weights
    - author ($g_1 = 0.2$)
    - title ($g_2 = 0.3$)
    - body ($g_3 = 0.5$)
- If the term *Shakespeare* were to appear in the title and body zones but not in author zone, the score of the document would be **0.8** .

# Weighted Zone Scoring on Inverted Index

A Match Found? Add **$g_i$** to an array **score[docID]**.
This array is often called **Accumulator**.



# How to assign zone weights?



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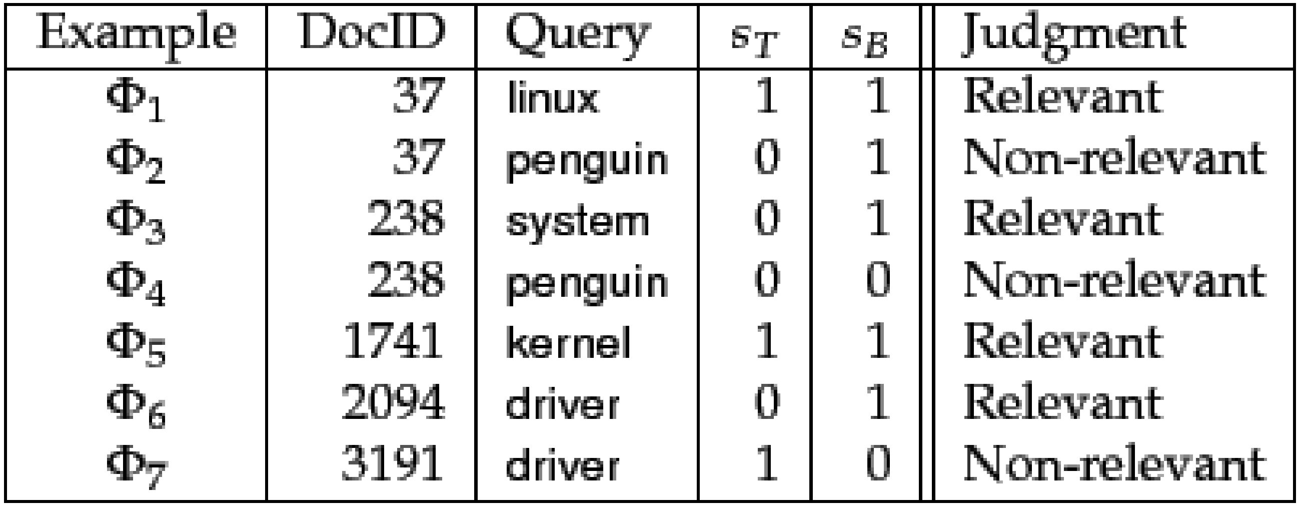
**How much weight should title take?**

# Machine Learned Relevance

- Use human annotated training examples
- Consider:
  - Only two zones exist: title and body.
  - $S_T$(d,q)= 1 if query term exists in title.
  - $S_B$(d,q)= 1 if query term exists in body.



| Example | DocID | Query | $s_T$ | $s_B$ | Judgment |
|---|---|---|---|---|---|
| $\Phi_1$ | 37 | linux | 1 | 1 | Relevant |
| $\Phi_2$ | 37 | penguin | 0 | 1 | Non-relevant |
| $\Phi_3$ | 238 | system | 0 | 1 | Relevant |
| $\Phi_4$ | 238 | penguin | 0 | 0 | Non-relevant |
| $\Phi_5$ | 1741 | kernel | 1 | 1 | Relevant |
| $\Phi_6$ | 2094 | driver | 0 | 1 | Relevant |
| $\Phi_7$ | 3191 | driver | 1 | 0 | Non-relevant |

# Learning Weights (without ML)

| Query | DocID | User Judgment |
|---|---|---|
| linux | 37 | 1 |
| system | 238 | 1 |
| kernel | 1741 | 1 |
| driver | 2094 | 1 |

Judgment of 1 implies the document is relevant.

| Query | DocID | In Title? ($S_T$) | In Body? ($S_B$) | Our Score |
|---|---|---|---|---|
| linux | 37 | 1 | 1 | ? |
| system | 238 | 0 | 1 | ? |
| kernel | 1741 | 1 | 1 | ? |
| driver | 2094 | 0 | 1 | ? |

Assume zone weights: title ($g_1 = 0.3$) and body ($g_2 = 1 - 0.3 = 0.7$)

# Learning Weights

| Query | DocID | User Judgment |
|---|---|---|
| linux | 37 | 1 |
| system | 238 | 1 |
| kernel | 1741 | 1 |
| driver | 2094 | 1 |

| Query | DocID | In Title? ($S_T$) | In Body? ($S_B$) | Our Score |
|---|---|---|---|---|
| linux | 37 | 1 | 1 | 1 |
| system | 238 | 0 | 1 | 0.7 |
| kernel | 1741 | 1 | 1 | 1 |
| driver | 2094 | 0 | 1 | 0.7 |

# Quiz

- If g is the title weight, how to quantify the error?

| Query | DocID | User Judgment |
|---|---|---|
| linux | 37 | 1 |
| system | 238 | 1 |
| kernel | 1741 | 1 |
| driver | 2094 | 1 |

| $s_T$ | $s_B$ | Score |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 - g |
| 1 | 0 | g |
| 1 | 1 | 1 |

| Query | DocID | In Title? ($S_T$) | In Body? ($S_B$) | Our Score |
|---|---|---|---|---|
| linux | 37 | 1 | 1 | 1 |
| system | 238 | 0 | 1 | 1 – g |
| kernel | 1741 | 1 | 1 | 1 |
| driver | 2094 | 0 | 1 | 1 - g |

# Learning Weights

$$score = \mathrm{g}.\, sT + (1 - \mathrm{g}).\mathrm{sB}$$

Then the error,

$$\epsilon = (\mathrm{relevance} - score)^2$$

Our objective is to find g such that we minimize the total error,

$$\sum_{all\ documents} \epsilon$$

# For the 01 Case…

- How to quantify the error?

| Query | DocID | User Judgment |
|---|---|---|
| linux | 37 | 1 |
| system | 238 | 1 |
| kernel | 1741 | 1 |
| driver | 2094 | 1 |

| $s_T$ | $s_B$ | Score |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 - g |
| 1 | 0 | g |
| 1 | 1 | 1 |

| Query | DocID | In Title? ($S_T$) | In Body? ($S_B$) | Our Score |
|---|---|---|---|---|
| linux | 37 | 1 | 1 | 1 |
| system | 238 | 0 | 1 | 1 – g |
| kernel | 1741 | 1 | 1 | 1 |
| driver | 2094 | 0 | 1 | 1 - g |

*What if we have non-relevant judgments also?

# For 01 case…

**Error =** $[1-(1-g)]^2 n_{01r} + [0-(1-g)]^2 n_{01n}.$

# Total Error

$$(n_{01r} + n_{10n})g^2 + (n_{10r} + n_{01n})(1 - g)^2 + n_{00r} + n_{11n}.$$

**Can you guess the optimal value of g for which the total error is minimum?**

# Total Error

$$(n_{01r} + n_{10n})g^2 + (n_{10r} + n_{01n})(1 - g)^2 + n_{00r} + n_{11n}.$$

**Differentiate w.r.t g and equate to zero**

$$\frac{n_{10r} + n_{01n}}{n_{10r} + n_{10n} + n_{01r} + n_{01n}}$$

# Thank You!