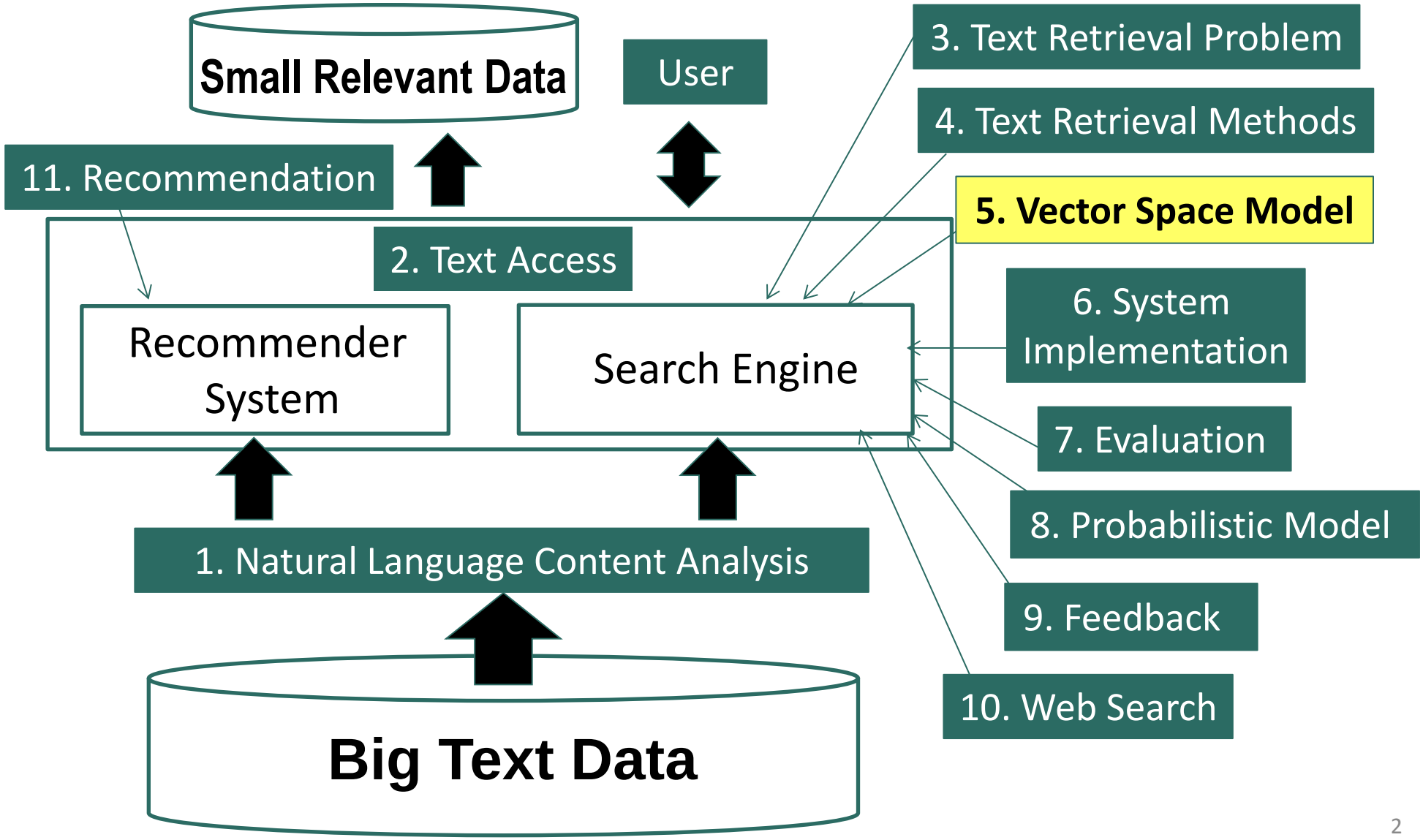
# Text Retrieval and Search Engines

## Vector Space Retrieval Model: Improved Instantiation

ChengXiang "Cheng" Zhai
Department of Computer Science
University of Illinois at Urbana-Champaign

# Course Schedule



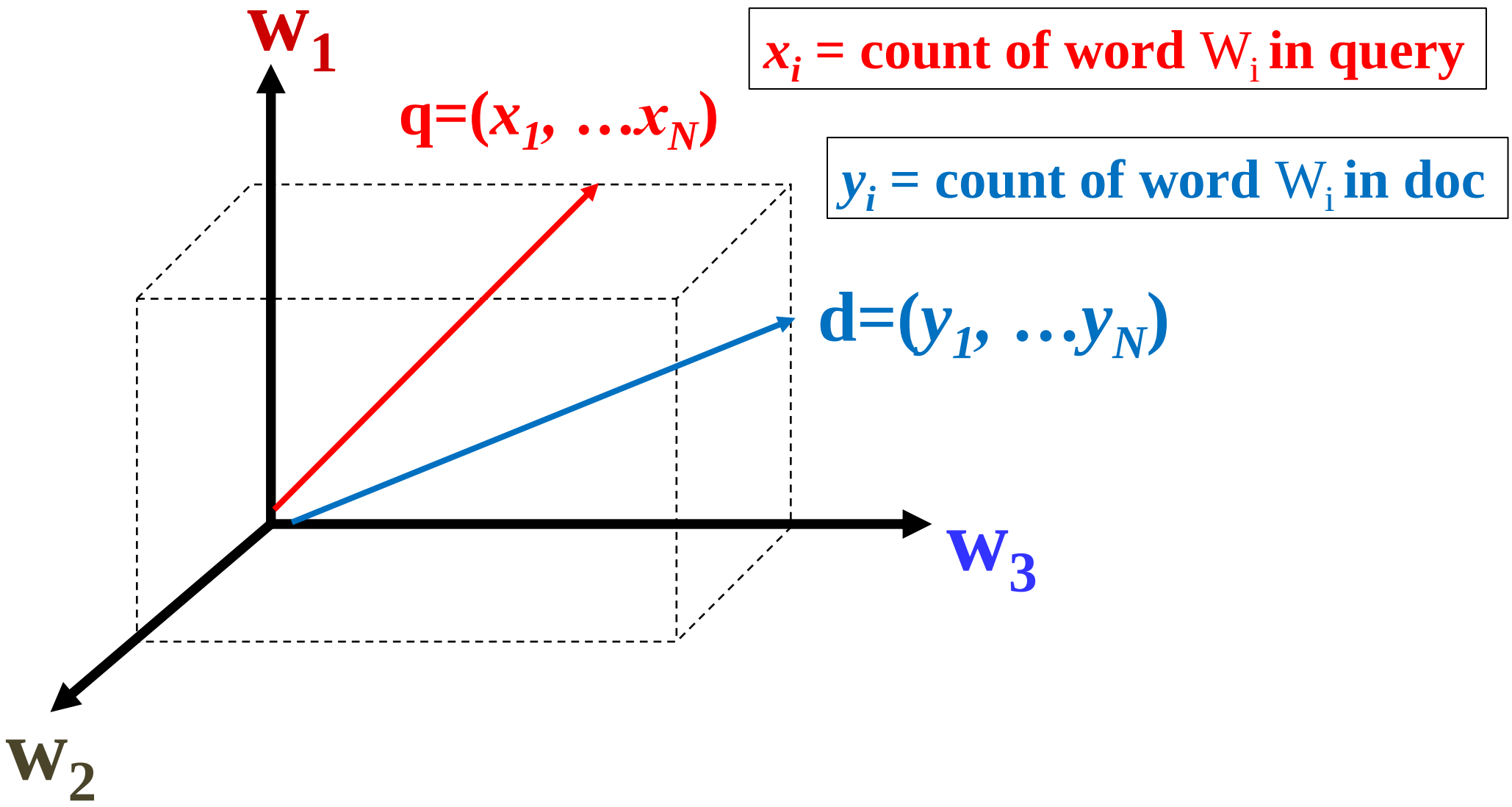
# Two Problems of the Simplest VSM

**Query = "news about presidential campaign"**

| | | |
|---|---|---|
| d2 | … **news about** organic food **campaign**… | **f(q,d2)=3** |
| d3 | … **news** of **presidential campaign** … | **f(q,d3)=3** |
| d4 | … **news** of **presidential campaign** …<br>… **presidential** candidate … | **f(q,d4)=3** |

1. Matching "presidential" more times deserves more credit
2. Matching "presidential" is more important than matching "about"

# **Improved Vector Placement**: Term Frequency Vector



# Improved VSM with Term Frequency Weighting

$q=(x_1, \ldots x_N)$ $x_i$ = count of word $W_i$ in query

$d=(y_1, \ldots y_N)$ $y_i$ = count of word $W_i$ in doc

$$Sim(q,d)=q.d= x_1 y_1 + \ldots + x_N y_N = \sum_{i=1}^{N} x_i y_i$$

What does this ranking function intuitively capture?

Does it fix the problems of the simplest VSM?

# Ranking Using Term Frequency (TF) Weighting

d2 … **news about** organic food **campaign**… f(q,d2)=3

**q= (1, 1, 1, 1, 0, …)**
**d2= (1, 1, 0, 1, 1, …)**

d3 … **news** of **presidential campaign** … f(q,d3)=3

**q= (1, 1, 1, 1, 0, …)**
**d3= (1, 0, 1, 1, 0, …)**

d4 … **news** of **presidential campaign** …
… **presidential** candidate … **f(q,d4)=4!**

**q= (1, 1, 1, 1, 0, …)**
**d4= (1, 0, 2, 1, 0, …)**

# How to Fix Problem 2 ("presidential" vs. "about")

d2 … **news about** organic food **campaign**…

d3 … **news** of **presidential campaign** …

V= {news, about, presidential, campaign, food …. }

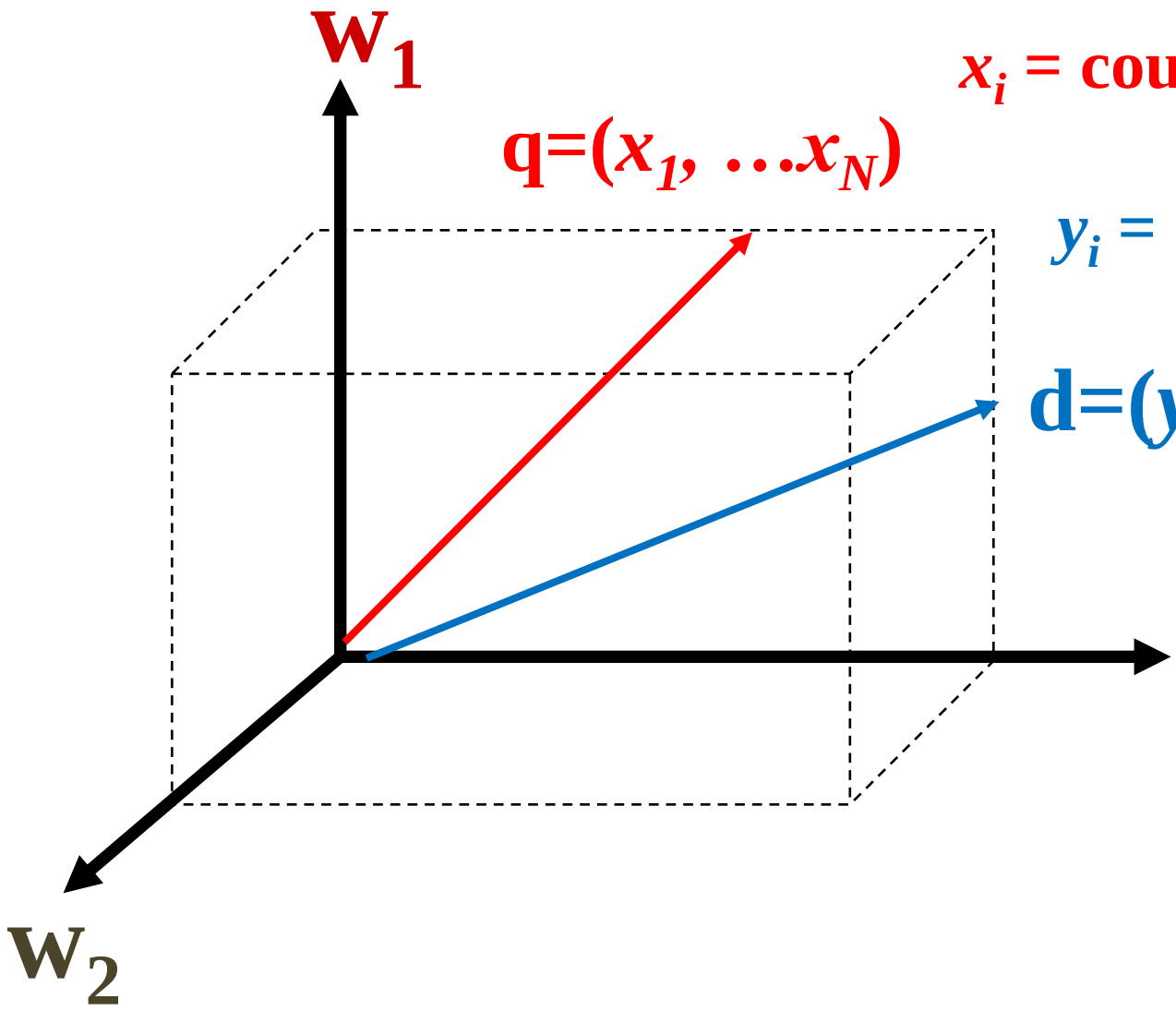
**q= (1, 1, 1, 1, 0, …)**
**d2= (1, 1, 0, 1, 1, …)**

f(q,d2)<3

**q= (1, 1, 1, 1, 0, …)**
**d3= (1, 0, 1, 1, 0, …)**

f(q,d3)>3

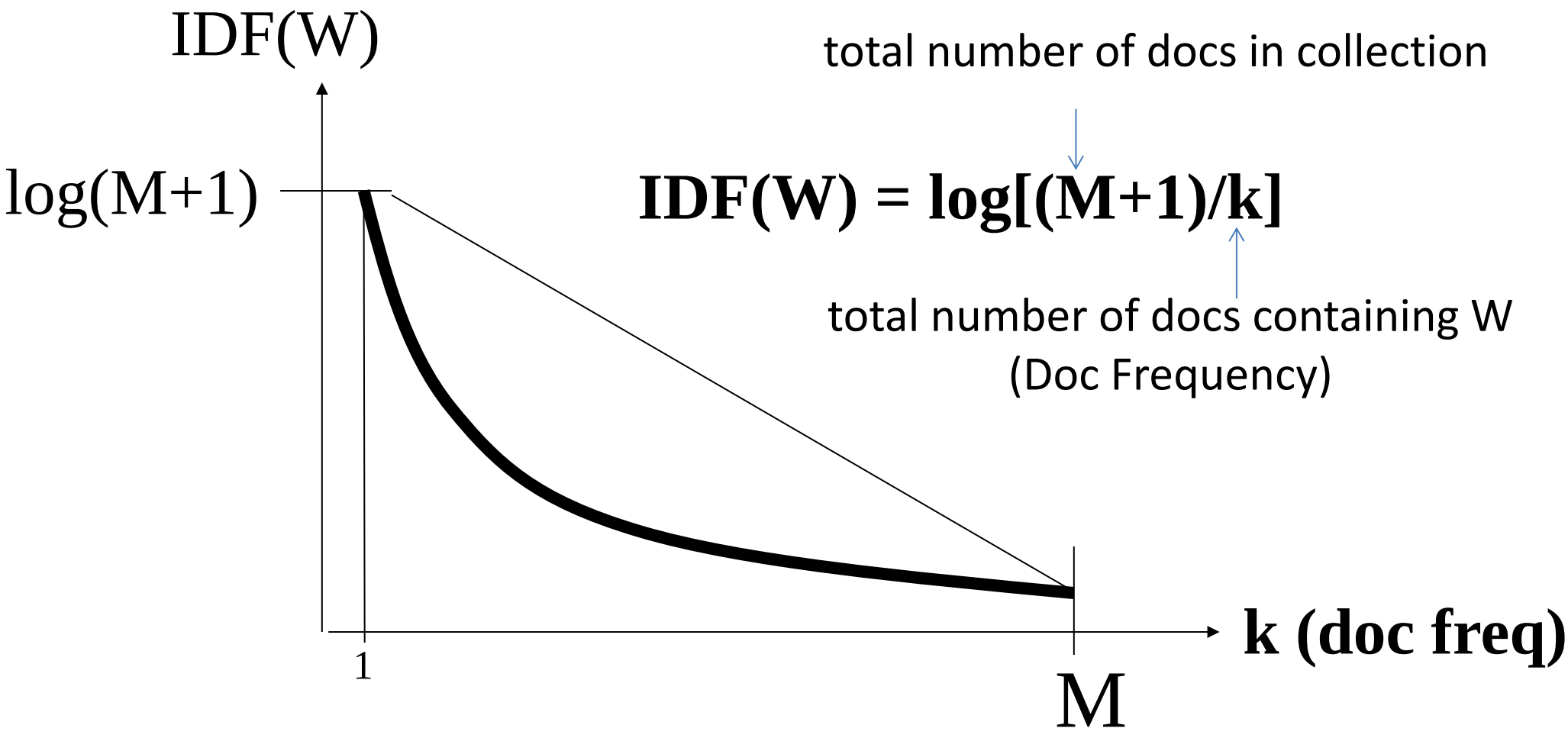
# Further Improvement of Vector Placement: Adding Inverse Document Frequency (IDF)




$x_i$ = count of word $W_i$ in query

$y_i = c(W_i, d)$ *$IDF(W_i)$

# IDF Weighting: Penalizing Popular Terms



# Solving Problem 2 ("Presidential" vs "About")

d2 … **news about** organic food **campaign**…

d3 … **news** of **presidential campaign** …

V= {news, about, presidential, campaign, food …. }

**IDF(W)= 1.5 1.0 2.5 3.1 1.8**

q= (1, 1, 1, 1, 0, …)

d2= (1*1.5, 1*1.0, 0, 1*3.1, 0, …)

q= (1, 1, 1, 1, 0, …)

d3= (1*1.5, 0, 1*2.5, 1*3.1, 0, …)

**f(q,d2) = 5.6 < f(q,d3)=7.1**

# How Effective Is VSM with TF-IDF Weighting?

**Query = "news about presidential campaign"**

| | | |
|---|---|---|
| d1 | … **news about** … | f(q,d1)=2.5 |
| d2 | … **news about** organic food **campaign**… | f(q,d2)=5.6 |
| d3 | … **news** of **presidential campaign** … | f(q,d3)=7.1 |
| d4 | … **news** of **presidential campaign** …<br>… **presidential** candidate … | f(q,d4)=9.6 |
| d5 | … **news** of organic food **campaign**…<br>**campaign**…**campaign**…**campaign**… | **f(q,d5)=13.9!** |

# Summary

- Improved VSM
  - Dimension = word
  - Vector = TF-IDF weight vector
  - Similarity = dot product
  - Working better than the simplest VSM
  - Still having problems