Mining Word Associations: General Ideas

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  - Compute context similarity
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  - Compare their co-occurrences with their individual occurrences
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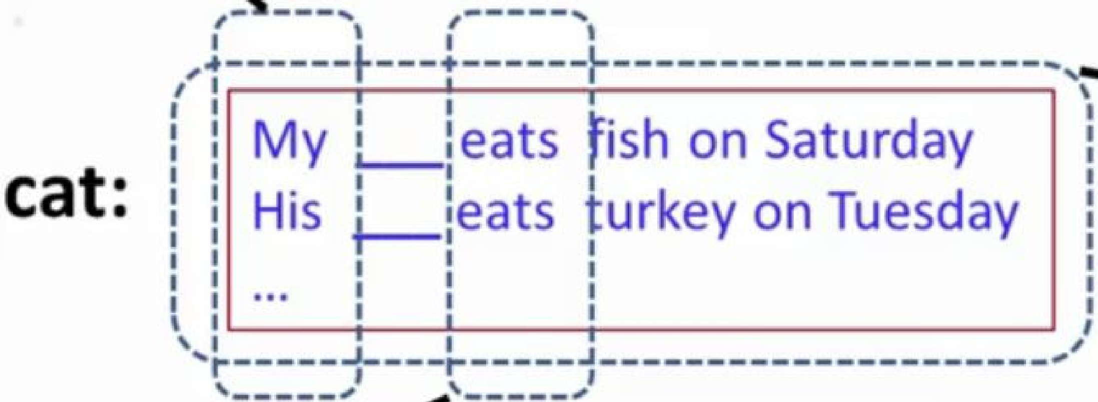
  - Words with **high co-occurrences but relatively low individual occurrences** likely have syntagmatic relation
- Paradigmatically related words tend to have syntagmatic relation with the same word ➔ **joint discovery** of the two relations

Word Context as “Pseudo Document”

Left1(“cat”) = {“my”, “his”, “big”, “a”, “the”,…}



Window8(“cat”) = {“my”, “his”, “big”, “eats”, “fish”, …}

Right1(“cat”) = {“eats”, “ate”, “is”, “has”, ….}

Context = pseudo document = “bag of words”
Context may contain adjacent or non-adjacent words

Measuring Context Similarity

Sim("Cat" , "Dog") =

Sim(Left1("cat"), Left1("dog"))

+ Sim(Right1("cat"), Right1("dog")) +

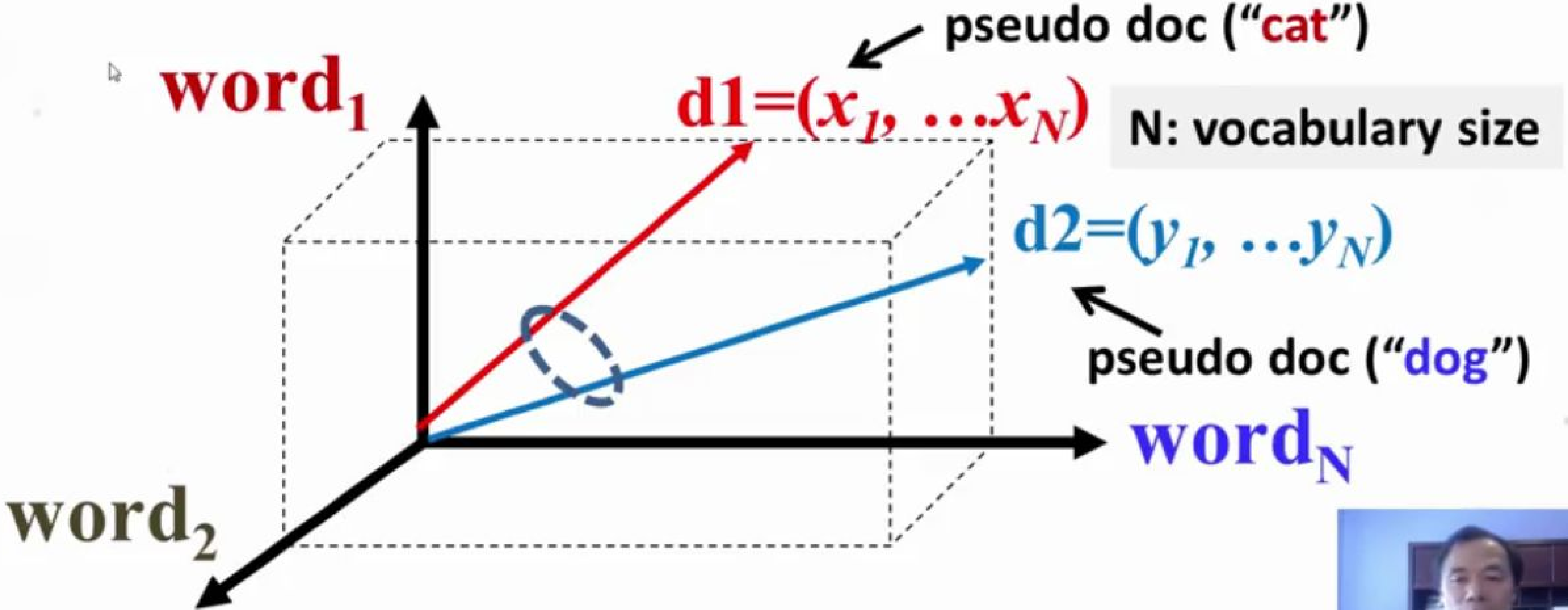
...

+ Sim(Window8("cat"), Window8("dog"))=?

High sim(word1, word2)

→ word1 and word2 are **paradigmatically related**

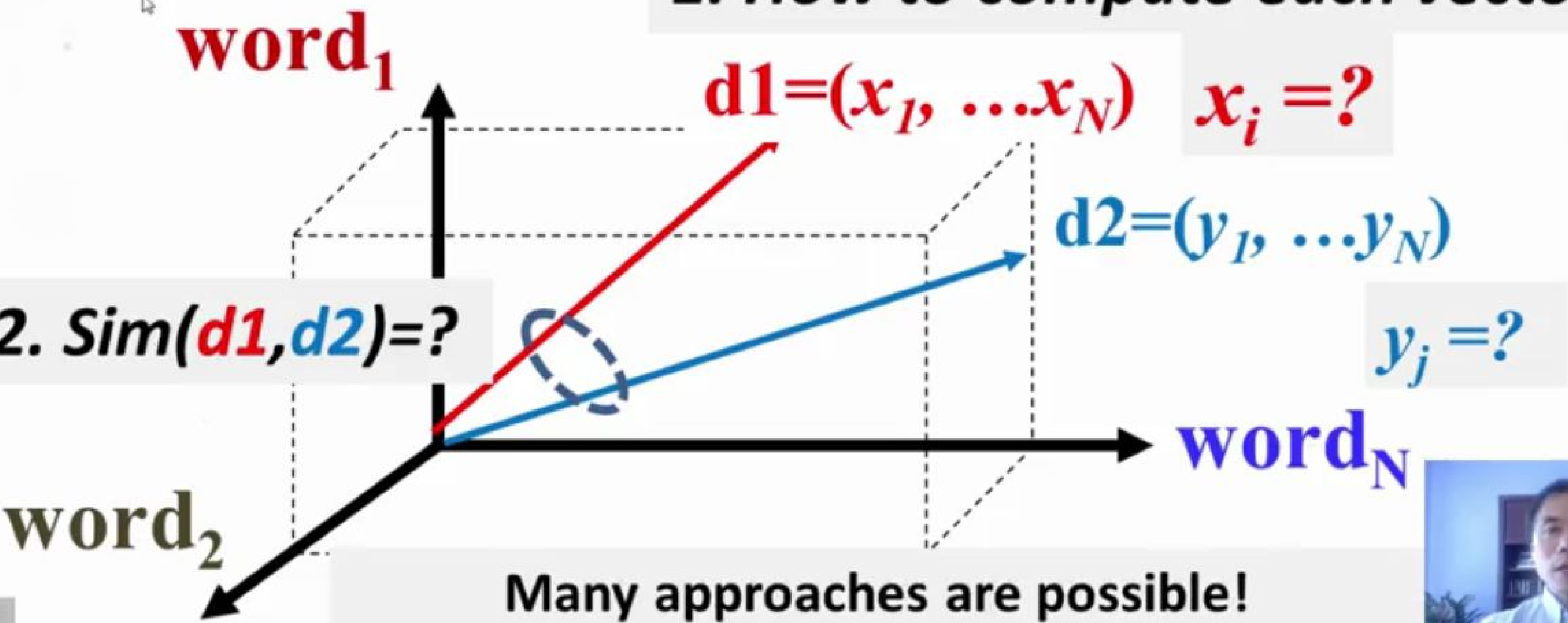
Bag of Words ➔ Vector Space Model (VSM)



Terms:	"eats"	"ate"	"is"	"has"	….	
Vector:	(5,	3,	10,	3	….	)

VSM for Paradigmatic Relation Mining

1. How to compute each vector?



2. Sim(d1,d2)=?

Many approaches are possible!
(most developed originally for text retrieval)

Expected Overlap of Words in Context (EOWC)

Probability that a randomly picked word from d1 is wi

Count of word wi in d1

$$d1=(x_1, \ldots x_N) \quad x_i = c(w_i, d1)/|d1|$$

$$d2=(y_1, \ldots y_N) \quad y_i = c(w_i, d2)/|d2|$$

Total counts of words in d1

$$Sim(d1,d2)=d1.d2= x_1 y_1 + \ldots + x_N y_N = \sum_{i=1}^{N} x_i y_i$$

Probability that two randomly picked words from d1 and d2, respectively, are identical.

Would EOWC Work Well?

- Intuitively, it makes sense: The more overlap the two context documents have, the higher the similarity would be
- However
  - it favors matching one frequent term very well over matching more distinct terms
  - it treats every word equally (overlap on “the” isn’t as so meaningful as overlap on “eats”)

Improving EOWC with Retrieval Heuristics

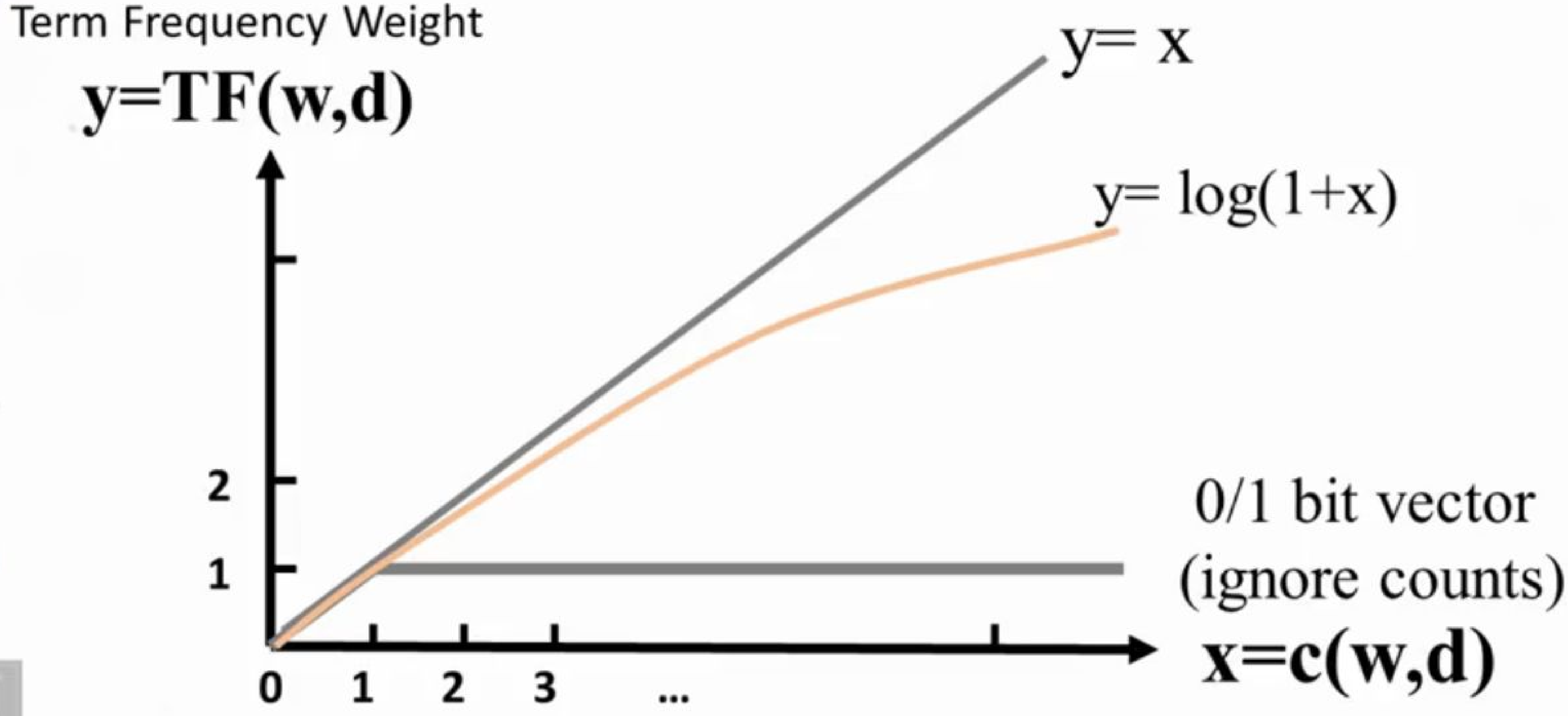
- It favors matching one frequent term very well over matching more distinct terms

→ **Sublinear transformation of Term Frequency (TF)**

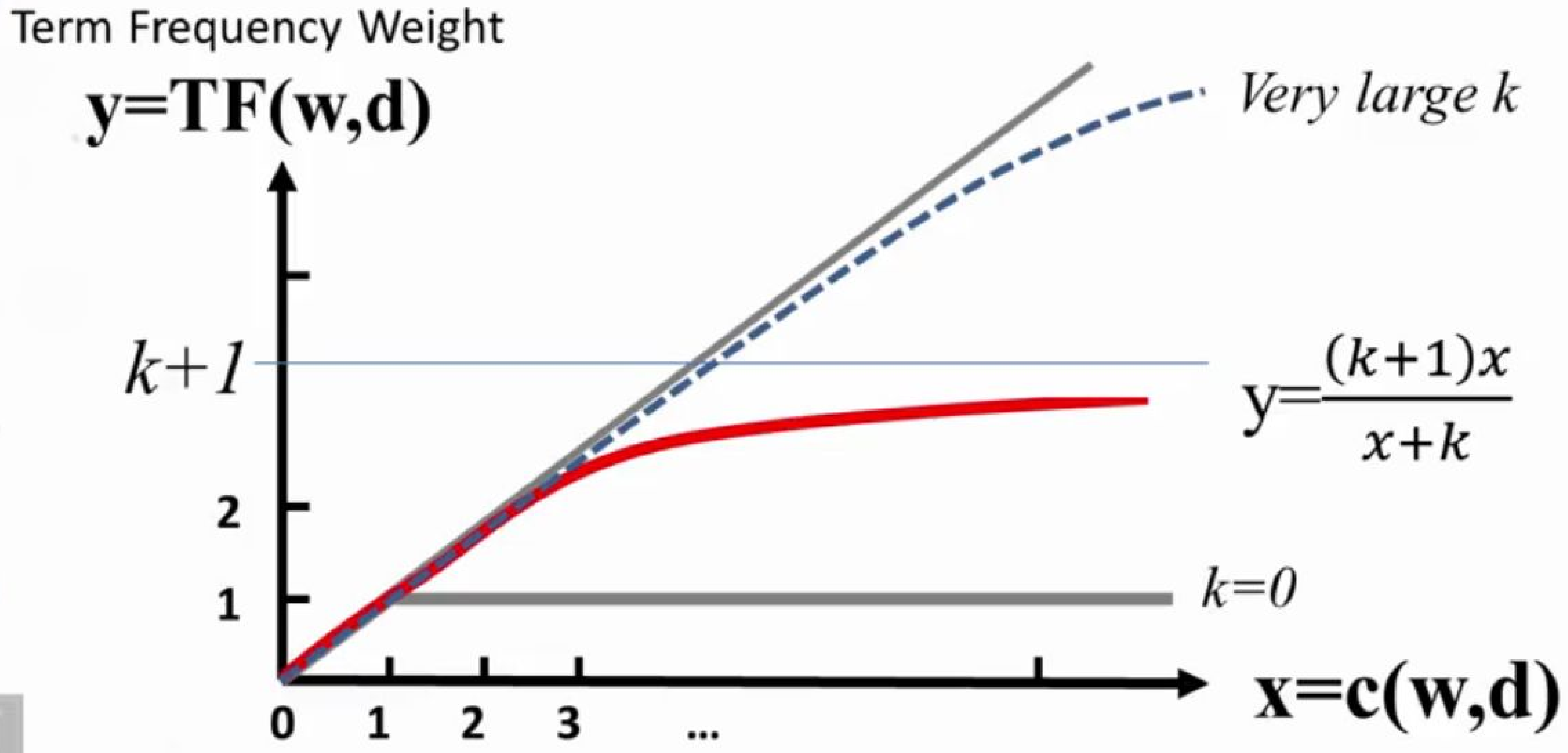
- It treats every word equally (overlap on "the" isn't as so meaningful as overlap on "eats")

→ **Reward matching a rare word: IDF term weighting**

TF Transformation: c(w,d)➔TF(w,d)

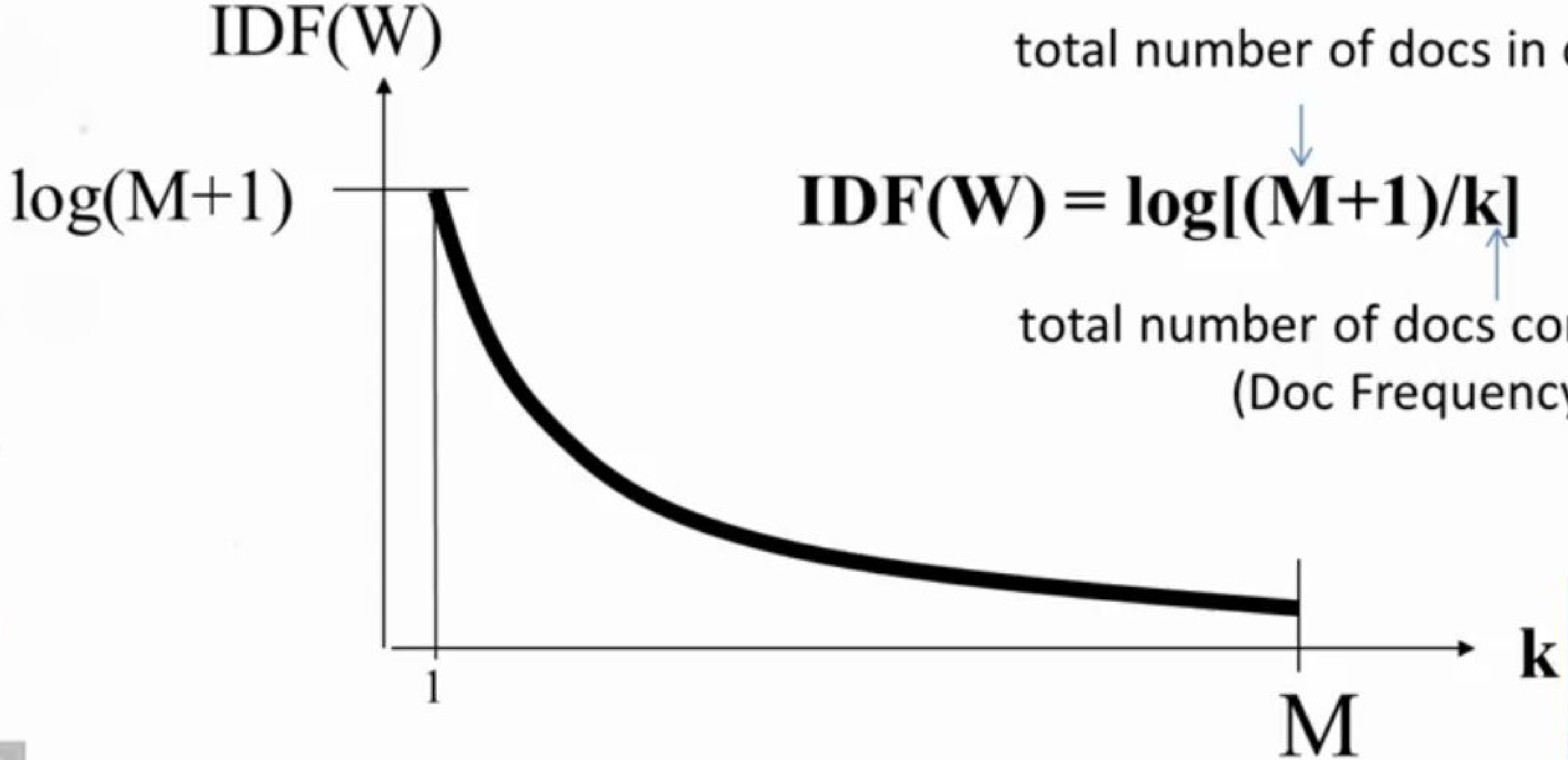


TF Transformation: BM25 Transformation



$$y = \frac{(k+1)x}{x+k}$$

IDF Weighting: Penalizing Popular Terms



total number of docs in collection

$$\mathbf{IDF(W) = \log[(M+1)/k]}$$

total number of docs containing W
(Doc Frequency)

Adapting BM25 Retrieval Model for Paradigmatic Relation Mining

$d1=(x_1, \ldots x_N)$ $$BM25(w_i, d1) = \frac{(k+1)c(w_i, d1)}{c(w_i, d1) + k(1 - b + b^* |d1| / avdl)}$$

$$x_i = \frac{BM25(w_i, d1)}{\sum_{j=1}^{N} BM25(w_j, d1)}$$

$$b \in [0,1]$$
$$k \in [0, +\infty)$$

$d2=(y_1, \ldots y_N)$ **y_i is defined similarly**

$$Sim(d1,d2)=\sum_{i=1}^{N} IDF(w_i)\, x_i\, y_i$$

BM25 can also Discover Syntagmatic Relations

$d1=(x_1, \ldots x_N)$

$$BM25(w_i, d1) = \frac{(k+1)c(w_i, d1)}{c(w_i, d1) + k(1 - b + b^* |d1| / avdl)}$$

$$x_i = \frac{BM25(w_i, d1)}{\sum_{j=1}^{N} BM25(w_j, d1)}$$

$b \in [0,1]$

$k \in [0, +\infty)$

IDF-weighted $d1=(x_1{}^*IDF(w_1), \ldots, x_N{}^*IDF(w_N))$

The highly weighted terms in the context vector of word w are likely syntagmatically related to w

Summary

- Main idea for discovering paradigmatic relations
  - Collecting the context of a candidate word to form a pseudo document (bag of words)
  - Computing similarity of the corresponding context documents of two candidate words
  - Highly similar word pairs can be assumed to have paradigmatic relations
- Many different ways to implement this general idea
- Text retrieval models can be easily adapted for computing similarity of two context documents
  - BM25 + IDF weighting represents the state of the art
  - Syntagmatic relations can also be discovered as a "by product"