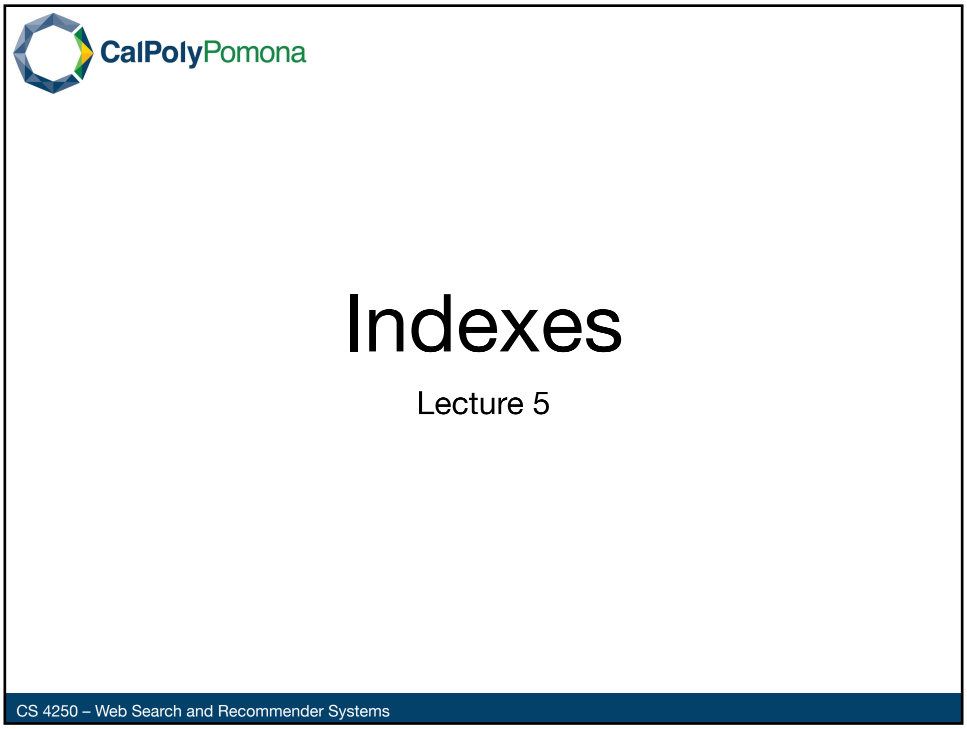


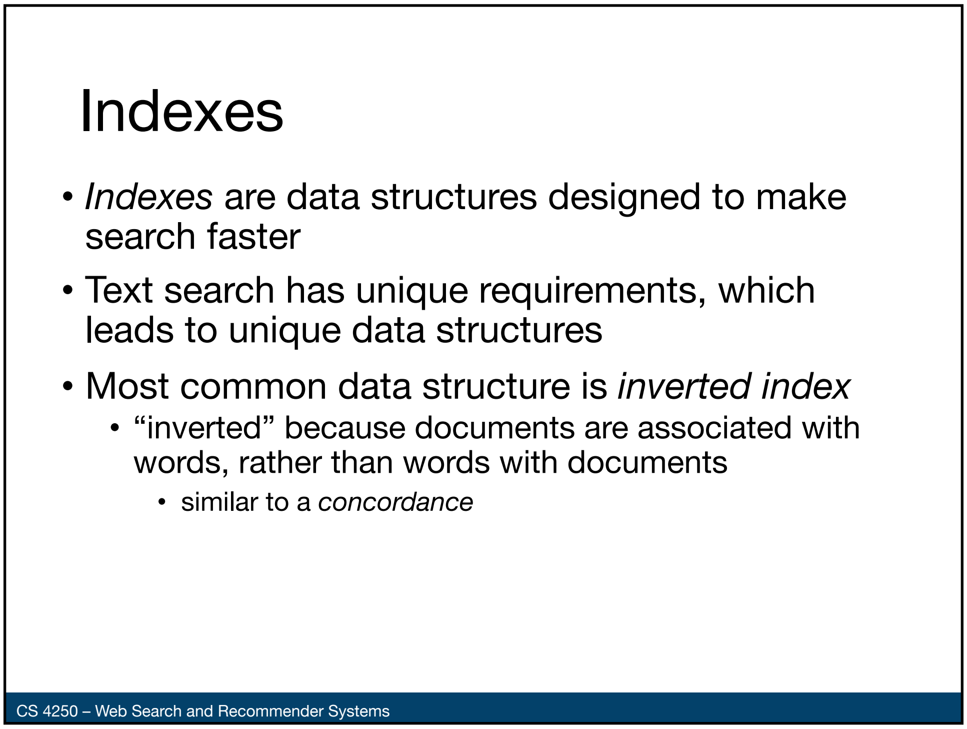
CalPolyPomona

Indexes

Lecture 5

CS 4250 – Web Search and Recommender Systems

1



Indexes

- *Indexes* are data structures designed to make search faster
- Text search has unique requirements, which leads to unique data structures
- Most common data structure is *inverted index*
  - "inverted" because documents are associated with words, rather than words with documents
    - similar to a *concordance*

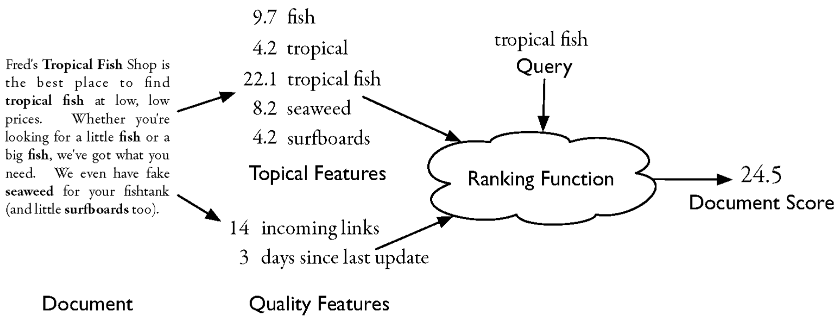
CS 4250 – Web Search and Recommender Systems

2

Indexes and Ranking

- Indexes are designed to support *search*
  - faster response time, supports updates
- Text search engines use a particular form of search: *ranking*
  - documents are retrieved in sorted order according to a score computing using the document representation, the query, and a *ranking algorithm*
- What is a reasonable abstract model for ranking?
  - enables discussion of indexes without details of retrieval model

Abstract Model of Ranking

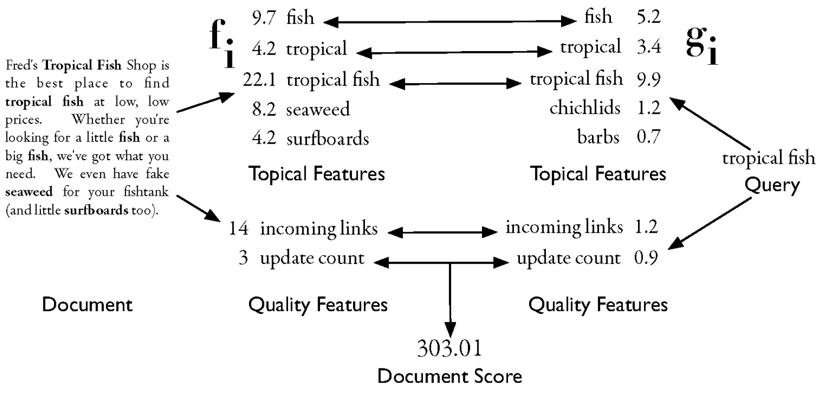


Fred's **Tropical Fish** Shop is the best place to find **tropical fish** at low, low prices. Whether you're looking for a little **fish** or a big **fish**, we've got what you need. We even have fake **seaweed** for your fishtank (and little **surfboards** too).

More Concrete Model

$$R(Q,D) = \sum_i g_i(Q) f_i(D)$$

f_i is a document feature function
g_i is a query feature function



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$\mathbf{f_i}$

9.7	fish
4.2	tropical
22.1	tropical fish
8.2	seaweed
4.2	surfboards

Topical Features

$\mathbf{g_i}$

fish	5.2
tropical	3.4
tropical fish	9.9
chichlids	1.2
barbs	0.7

Topical Features

tropical fish
Query

14	incoming links
3	update count

incoming links	1.2
update count	0.9

Document

Quality Features

Quality Features

303.01
Document Score

Inverted Index

- Each index term is associated with an *inverted list*
  - Contains lists of documents, or lists of word occurrences in documents, and other information
  - Each entry is called a *posting*
  - The part of the posting that refers to a specific document or location is called a *pointer*
  - Each document in the collection is given a unique number
  - Lists are usually *document-ordered* (sorted by document number)

Example “Collection”

S_1 Tropical fish include fish found in tropical environments around the world, including both freshwater and salt water species.

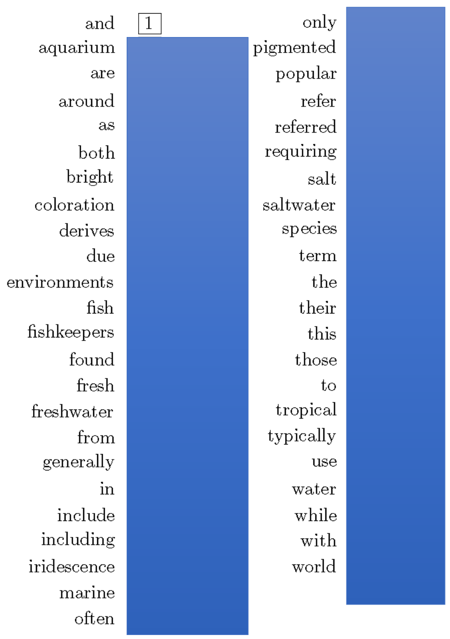
S_2 Fishkeepers often use the term tropical fish to refer only those requiring fresh water, with saltwater tropical fish referred to as marine fish.

S_3 Tropical fish are popular aquarium fish, due to their often bright coloration.

S_4 In freshwater fish, this coloration typically derives from iridescence, while salt water fish are generally pigmented.

Four sentences from the Wikipedia entry for *tropical fish*

Simple Inverted Index



and
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derives
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fish
fishkeepers
found
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freshwater
from
generally
in
include
including
iridescence
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often
only
pigmented
popular
refer
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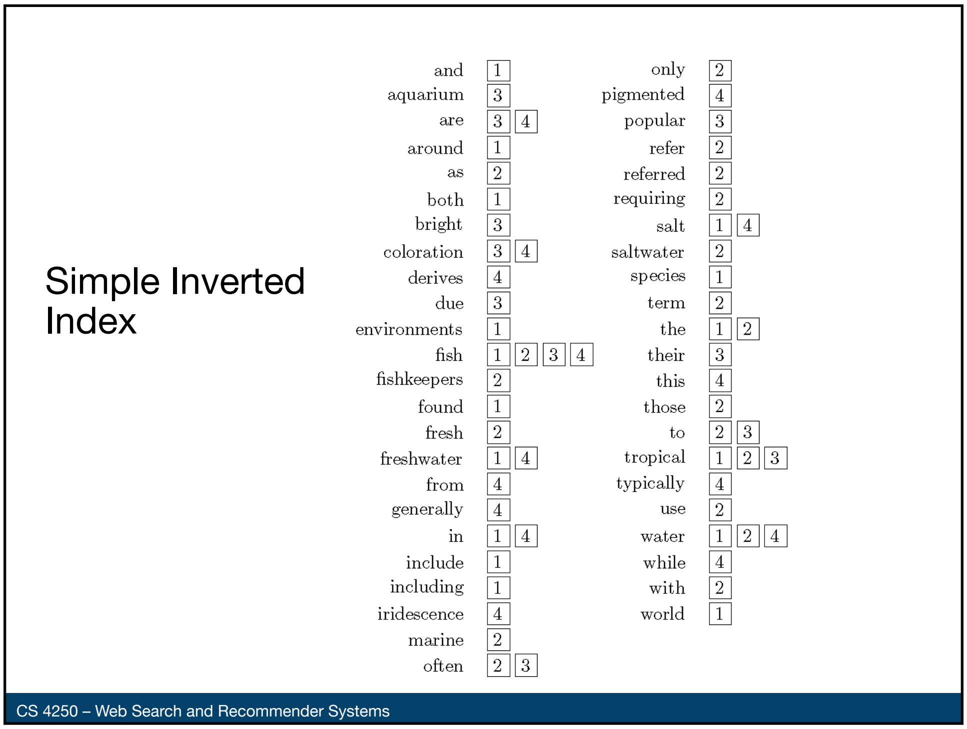
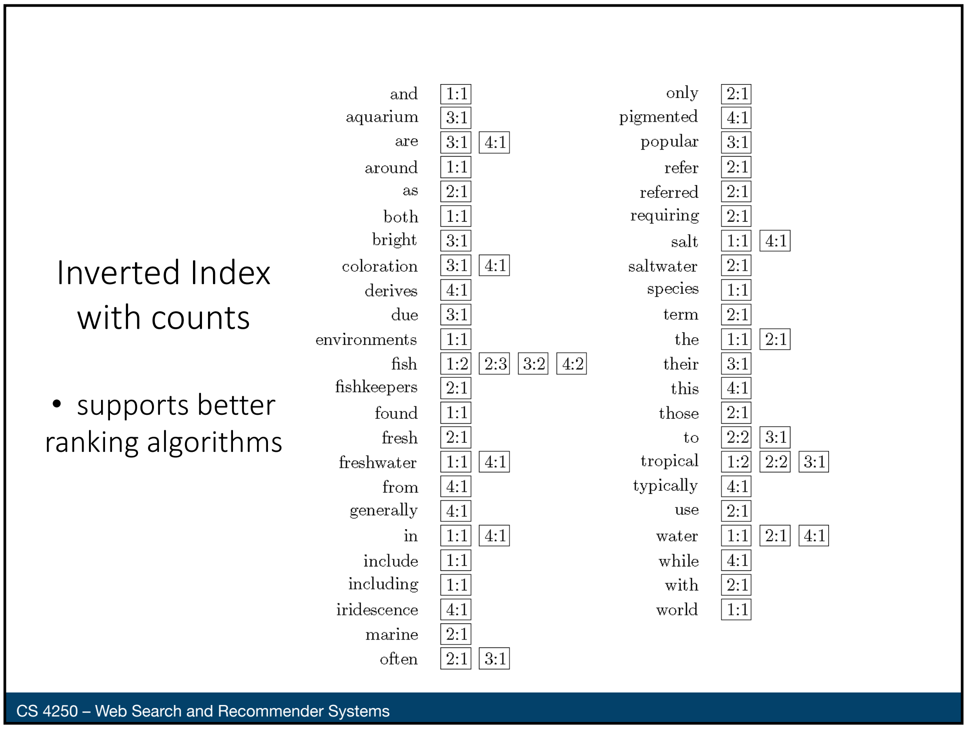


Simple Inverted Index

and	1			
aquarium	3			
are	3	4		
around	1			
as	2			
both	1			
bright	3			
coloration	3	4		
derives	4			
due	3			
environments	1			
fish	1	2	3	4
fishkeepers	2			
found	1			
fresh	2			
freshwater	1	4		
from	4			
generally	4			
in	1	4		
include	1			
including	1			
iridescence	4			
marine	2			
often	2	3		
only	2			
pigmented	4			
popular	3			
refer	2			
referred	2			
requiring	2			
salt	1	4		
saltwater	2			
species	1			
term	2			
the	1	2		
their	3			
this	4			
those	2			
to	2	3		
tropical	1	2	3	
typically	4			
use	2			
water	1	2	4	
while	4			
with	2			
world	1			



Inverted Index with counts

- supports better ranking algorithms

and	1:1			
aquarium	3:1			
are	3:1	4:1		
around	1:1			
as	2:1			
both	1:1			
bright	3:1			
coloration	3:1	4:1		
derives	4:1			
due	3:1			
environments	1:1			
fish	1:2	2:3	3:2	4:2
fishkeepers	2:1			
found	1:1			
fresh	2:1			
freshwater	1:1	4:1		
from	4:1			
generally	4:1			
in	1:1	4:1		
include	1:1			
including	1:1			
iridescence	4:1			
marine	2:1			
often	2:1	3:1		
only	2:1			
pigmented	4:1			
popular	3:1			
refer	2:1			
referred	2:1			
requiring	2:1			
salt	1:1	4:1		
saltwater	2:1			
species	1:1			
term	2:1			
the	1:1	2:1		
their	3:1			
this	4:1			
those	2:1			
to	2:2	3:1		
tropical	1:2	2:2	3:1	
typically	4:1			
use	2:1			
water	1:1	2:1	4:1	
while	4:1			
with	2:1			
world	1:1			

Inverted Index with positions

- supports proximity matches

and	1,15
aquarium	3,5
are	3,3 4,14
around	1,9
as	2,21
both	1,13
bright	3,11
coloration	3,12 4,5
derives	4,7
due	3,7
environments	1,8
fish	1,2 1,4 2,7 2,18 2,23 3,2 3,6 4,3 4,13
fishkeepers	2,1
found	1,5
fresh	2,13
freshwater	1,14 4,2
from	4,8
generally	4,15
in	1,6 4,1
include	1,3
including	1,12
iridescence	4,9

marine	2,22
often	2,2 3,10
only	2,10
pigmented	4,16
popular	3,4
refer	2,9
referred	2,19
requiring	2,12
salt	1,16 4,11
saltwater	2,16
species	1,18
term	2,5
the	1,10 2,4
their	3,9
this	4,4
those	2,11
to	2,8 2,20 3,8
tropical	1,1 1,7 2,6 2,17 3,1
typically	4,6
use	2,3
water	1,17 2,14 4,12
while	4,10
with	2,15
world	1,11

Proximity Matches

- Matching phrases or words within a window
  - e.g., "`tropical fish`", or “find tropical within 5 words of fish”
- Word positions in inverted lists make these types of query features efficient
  - e.g.,

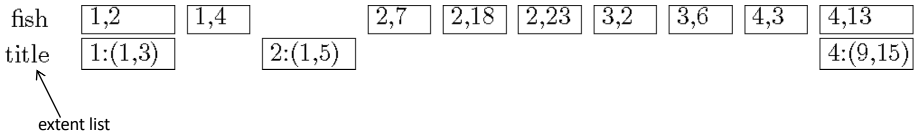
tropical	1,1		1,7	2,6	2,17		3,1			
fish	1,2	1,4		2,7	2,18	2,23	3,2	3,6	4,3	4,13

Fields and Extents

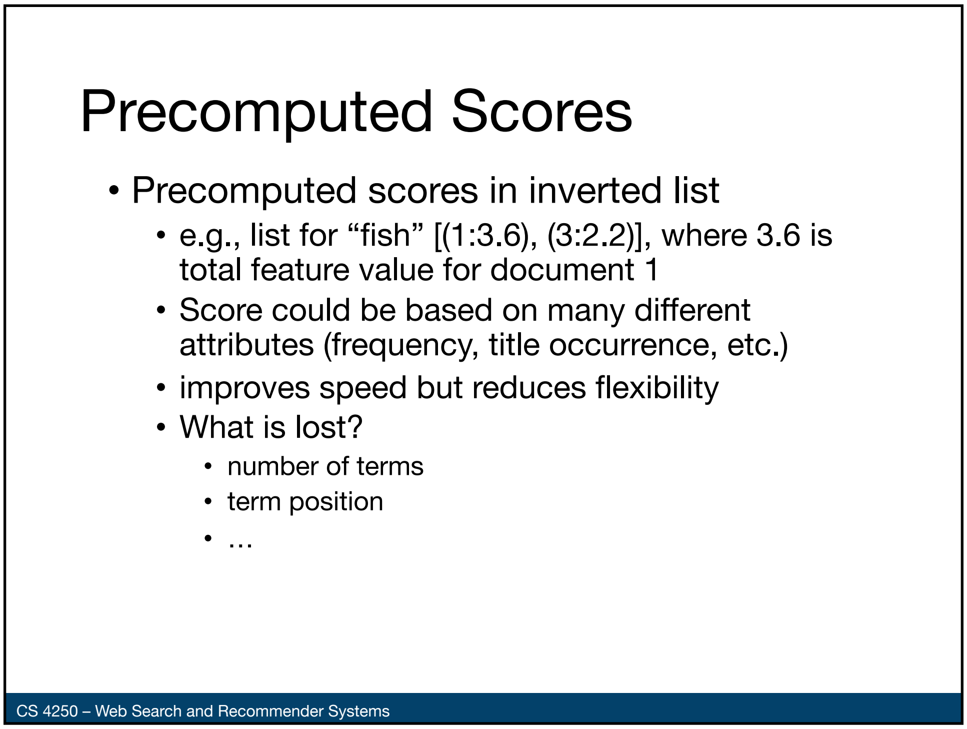
- Document structure is useful in search
  - *field* restrictions
    - e.g., date, from:, etc.
  - some fields more important
    - e.g., title
- Options:
  - separate inverted lists for each field type
  - add information about fields to postings
  - use *extent lists*

Extent Lists

- An *extent* is a contiguous region of a document
  - represent extents using word positions
  - inverted list records all extents for a given field type
  - e.g.,



fish	1,2	1,4		2,7	2,18	2,23	3,2	3,6	4,3	4,13
title	1:(1,3)		2:(1,5)							4:(9,15)



Precomputed Scores

- Precomputed scores in inverted list
  - e.g., list for “fish” [(1:3.6), (3:2.2)], where 3.6 is total feature value for document 1
  - Score could be based on many different attributes (frequency, title occurrence, etc.)
  - improves speed but reduces flexibility
  - What is lost?
    - number of terms
    - term position
    - …

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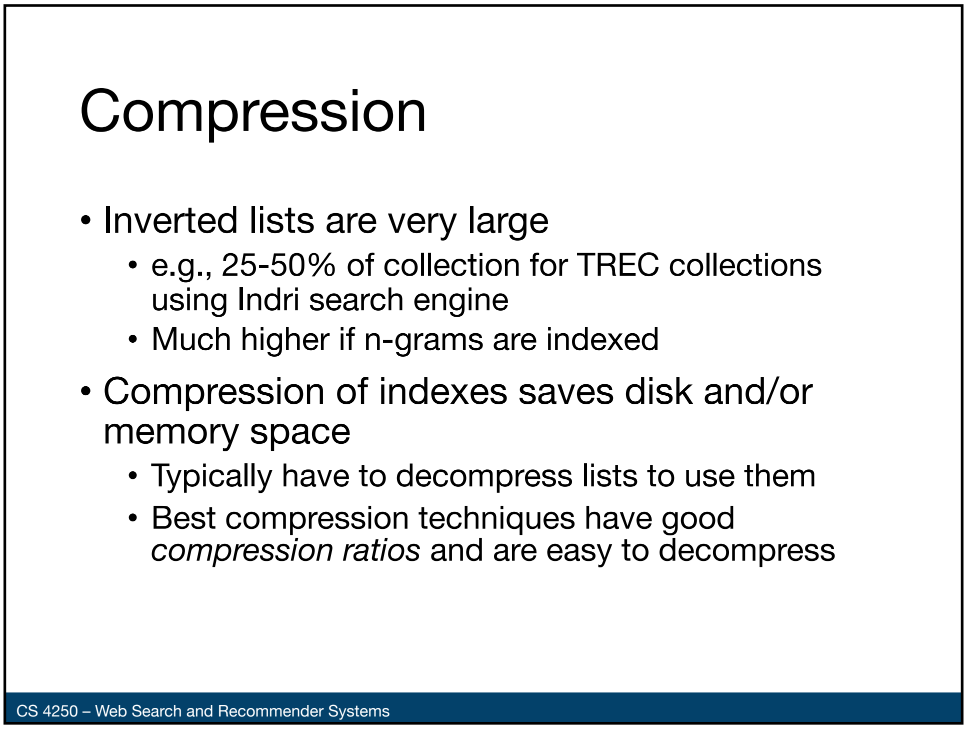

Compression

- Inverted lists are very large
  - e.g., 25-50% of collection for TREC collections using Indri search engine
  - Much higher if n-grams are indexed
- Compression of indexes saves disk and/or memory space
  - Typically have to decompress lists to use them
  - Best compression techniques have good *compression ratios* and are easy to decompress

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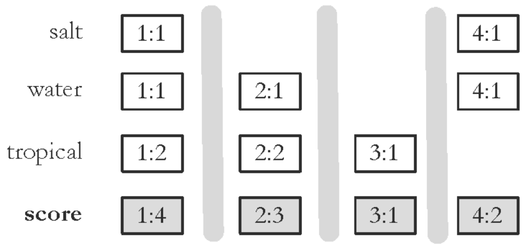
Query Processing

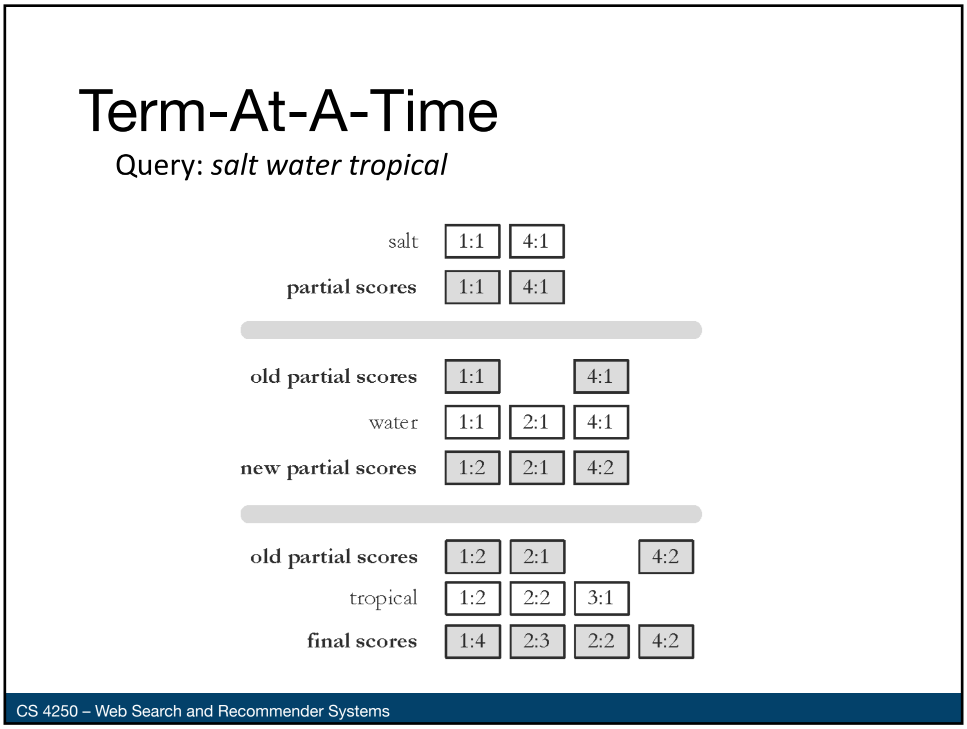
- Document-at-a-time
  - Calculates complete scores for documents by processing all term lists, one document at a time
- Term-at-a-time
  - Accumulates scores for documents by processing term lists one at a time
- Both approaches have optimization techniques that significantly reduce time required to generate scores

Document-At-A-Time

Query: *salt water tropical*



salt	1:1			4:1
water	1:1	2:1		4:1
tropical	1:2	2:2	3:1	
score	1:4	2:3	3:1	4:2



Term-At-A-Time

Query: *salt water tropical*

salt	1:1	4:1		
partial scores	1:1	4:1		
old partial scores	1:1		4:1	
water	1:1	2:1	4:1	
new partial scores	1:2	2:1	4:2	
old partial scores	1:2	2:1		4:2
tropical	1:2	2:2	3:1	
final scores	1:4	2:3	2:2	4:2

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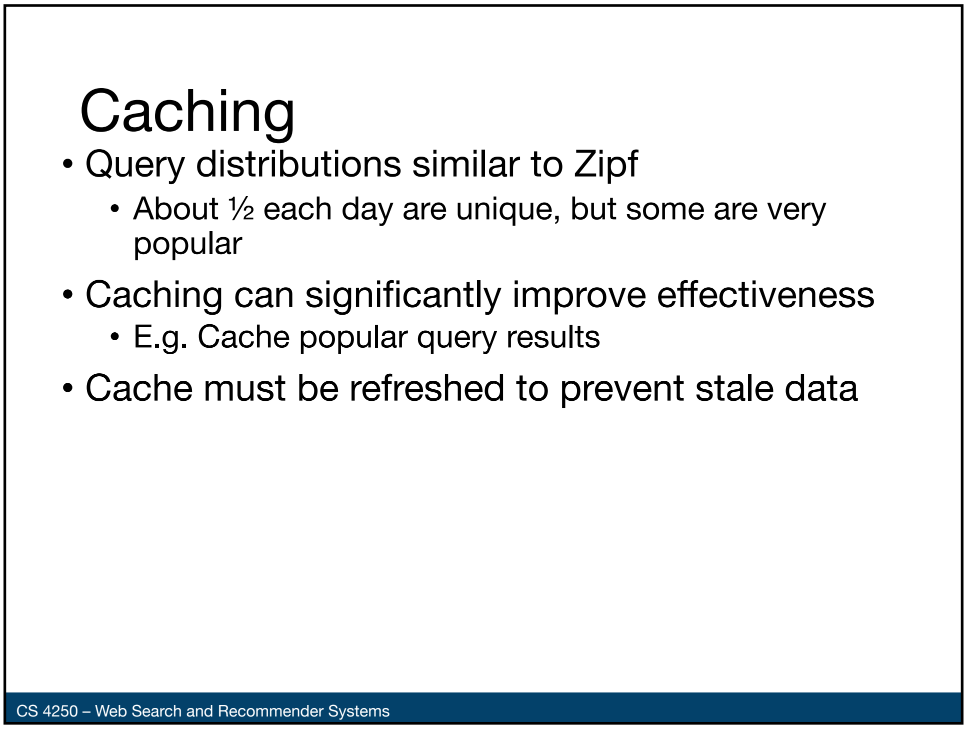

Caching

- Query distributions similar to Zipf
  - About ½ each day are unique, but some are very popular
- Caching can significantly improve effectiveness
  - E.g. Cache popular query results
- Cache must be refreshed to prevent stale data

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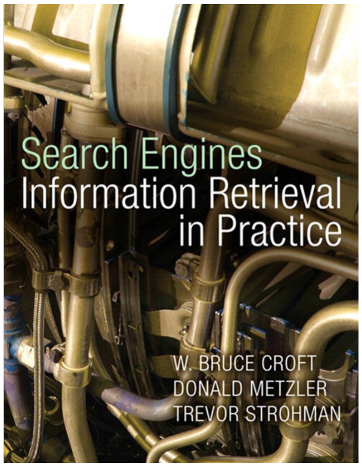
Reading

- Chapter 5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