Introduction to Informa I

Lecture 4: Dictionaries a t retrieval

This lecture

- Dictionary data structures
- "Tolerant" retrieval

  - Wild-card
  - Spelling co

  - Soundex

Dictionary data structures for inverted indexes

- The dictionary data structure stores the term vocabulary, document frequency, pointers to each postings list … in what data structure?

A naïve dictionary

- An array of struct:

char[20]	int	Postings *
20 bytes	4/8 bytes	4/8 bytes

- How do we store a dictionary in memory efficiently?
- How do we quickly look up elements at query time?

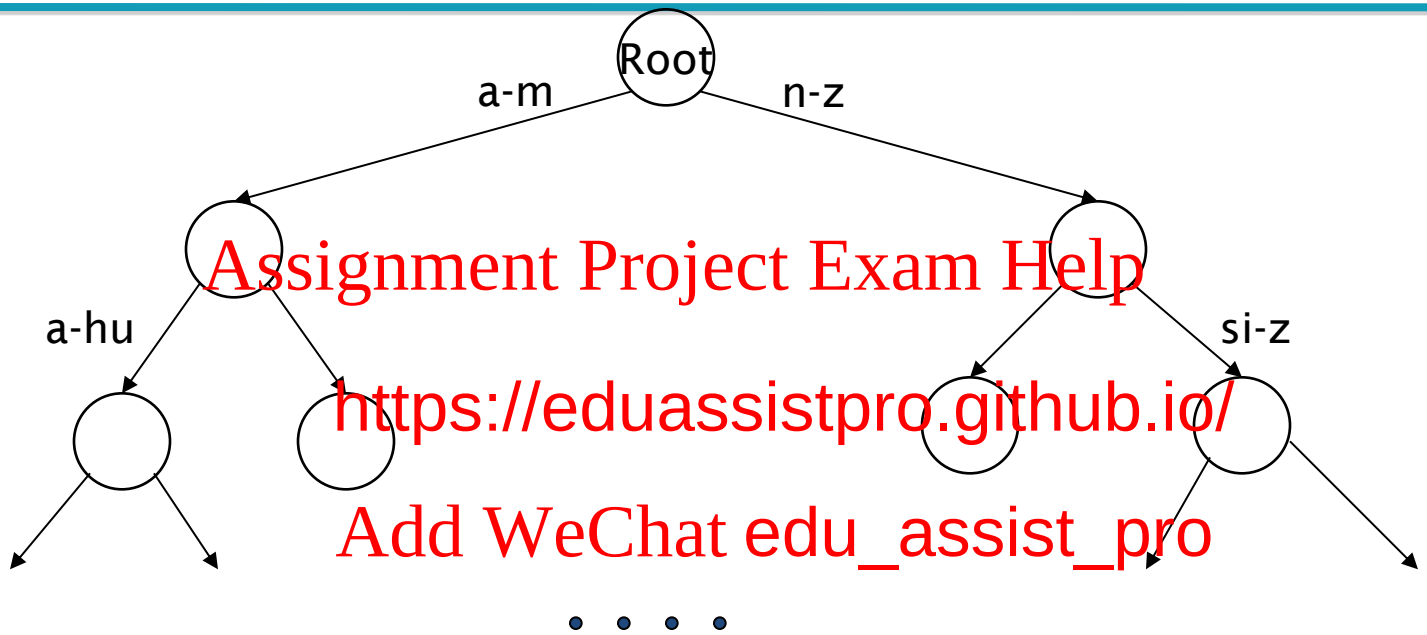
Dictionary data str

- Two main choices:
  - Hash table
  - Tree
- Some IR syste trees

Hashes

- Each vocabulary term is hashed to an integer
  - (We assume you've seen hashtables before)
- Pros:
  - Lookup is fas
- Cons:
  - No easy way to find minor v
    - judgment/judgement
  - No prefix search [tolerant retrieval]
  - If vocabulary keeps growing, need to occasionally do the expensive operation of rehashing *everything*

Tree: binary tree



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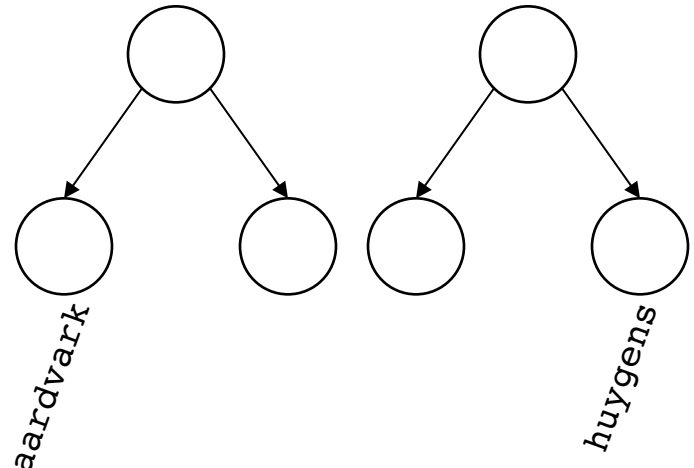
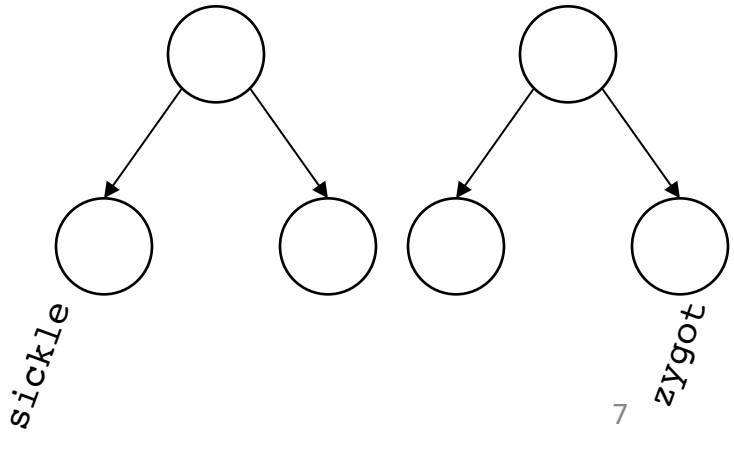
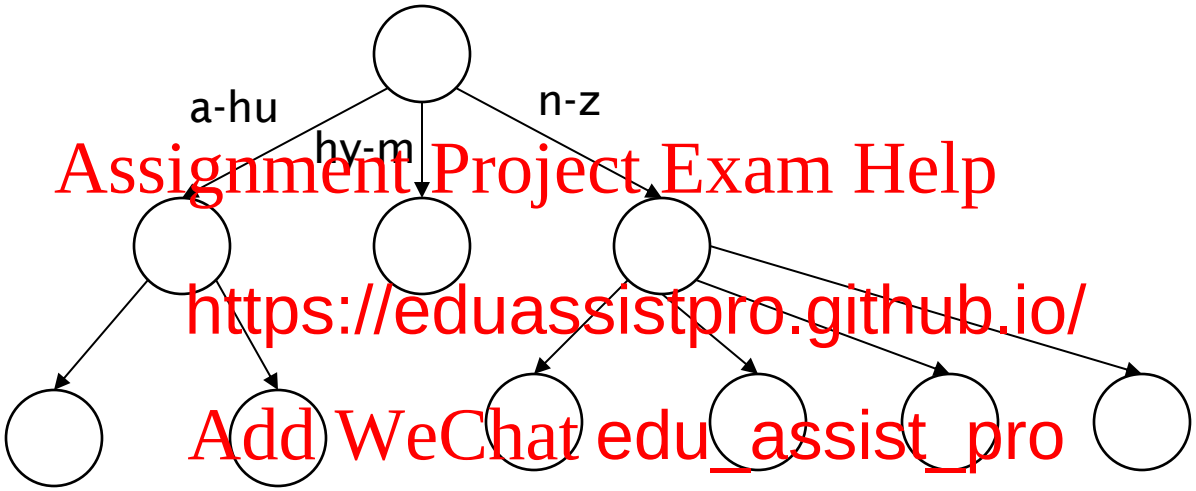




Tree: B-tree



- Definition: Every internal nodel has a number of children in the interval [*a*,*b*] where *a, b* are appropriate natural numbers, e.g., [2,4].

Trees

- Simplest: binary tree
- More usual: B-trees
- Trees require a standard ordering of characters and hence strings … but we
- Pros:
  - Solves the prefix problem (i.e., with *hyp*)
- Cons:
  - Slower: O(log *M*) [and this requires *balanced* tree]
  - Rebalancing binary trees is expensive
    - But B-trees mitigate the rebalancing problem

Tries

- Pros:
  - Fast exact search: O(|Q|) time
  - Support other functionalities, e.g., longest-prefix match
- Cons:
  - Naïve imple ce.

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WILD-CARD QUERIES

Wild-card queries:

- ***mon*:*** find all docs containing any word beginning "mon".

- Easy with bin xicon: retrieve all words in ran

- ****mon:*** find words ending harder

  - Maintain an additional B-tree for terms *backwards.*

  Can retrieve all words in range: ***nom ≤ w < non.***

Exercise: from this, how can we enumerate all terms meeting the wild-card query ***pro*cent*** ?

Query processing

- At this point, we have an enumeration of all terms in the dictionary that match the wild-card query.
- We still have to look up the postings for each enumerated t
- E.g., consider the query:

  se*ate *AND* ***fil*er***

  This may result in the execution of many Boolean *AND* queries.

B-trees handle *'s at the end of a query term

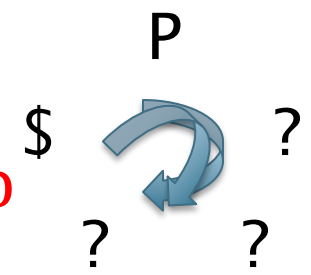
- How can we handle *'s in the middle of query term?
  - ***co*tion***
- We could look up ***co**** AND ****tion*** in a B-tree and intersect the t
  - Expensive
  - Still need *verification* to rem *sitives*

- The solution: transform wild-card queries so that the *'s occur at the end
- This gives rise to the **Permuterm** Index.

Permuterm Index

- For term ***hello***, index under:
  - ***hello$, ello$h, llohe, lohel, o$hell***

  where $ is a special symbol.



- Queries:
  - **P** Exact match **P$**
  - **P*** Range match **$P***
  - ***P** Range match **P$***
  - ***P*** Range match **P***
  - **P*Q** Range match **Q$P***
  - **P*Q*R** ??? Exercise!

hy not **P*$***

Query = ***hel*o***
P=*hel*, Q=*o*
Lookup ***o$hel****

Permuterm query ing

- Rotate query wild-card to the right
- Now use B-tree lookup as before.
- *Permuterm pr exicon size*

Bigram (*k*-gram) in

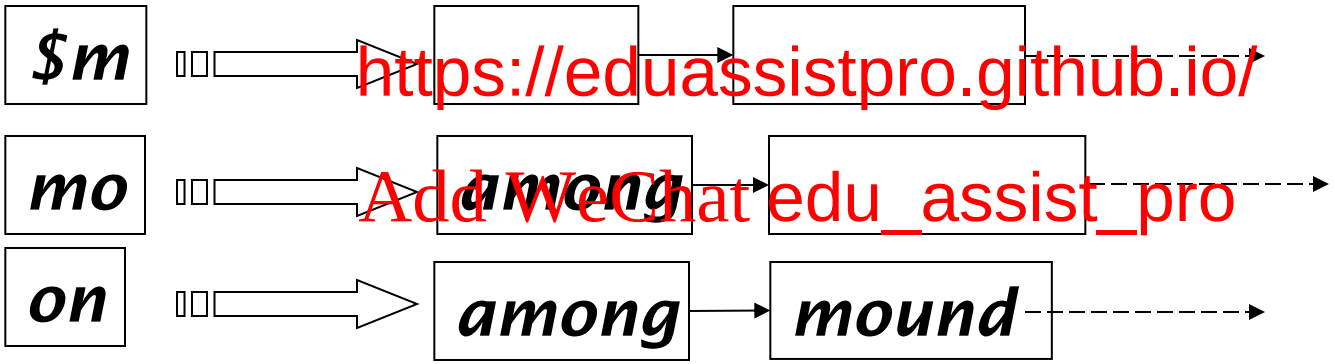
- Enumerate all *k*-grams (sequence of *k* chars) occurring in any term
- *e.g.,* from text "***April is the cruelest month***" we get the 2-grams (

a,ap,pr,ri,il,l, i,is,s, t,th,he,e, $c,cr,ru, ue,el,le,es,st,t$, m,mo,on,nt,h

  - $ is a special word boundary symbol
- Maintain a *second* inverted index *from bigrams to dictionary terms* that match each bigram.

Bigram index exam

- The *k*-gram index finds *terms* based on a query consisting of *k*-grams (here *k*=2).



Processing wild-cards

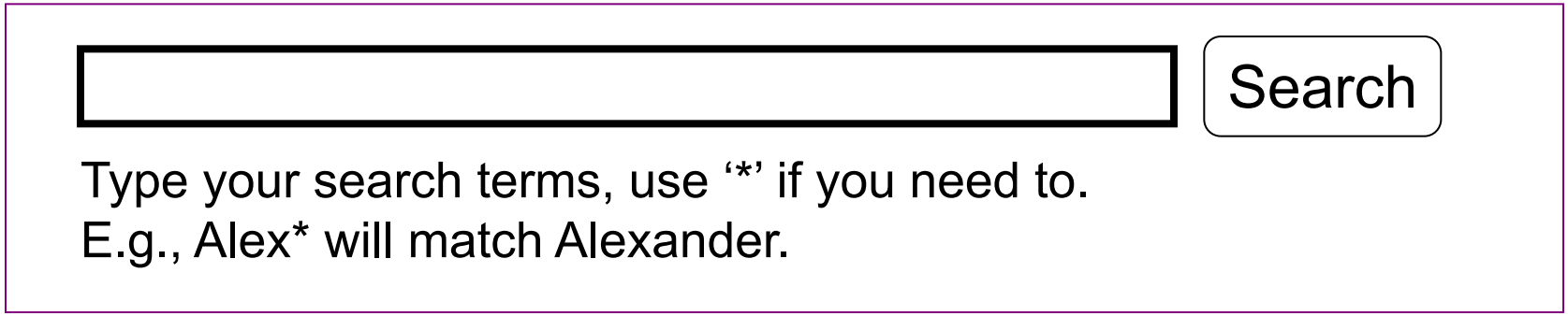
- Query ***mon**** can now be run as
  - ***$m*** *AND* ***mo*** *AND* ***on***
- Gets terms that match AND version of our wildcard query.
- But we'd enumerate ***moon***.
- Must verify these terms ag .
- Surviving enumerated terms are then looked up in the term-document inverted index.
- Fast, space efficient (compared to permuterm).

Processing wild-cards

- As before, we must execute a Boolean query for each enumerated, filtered term.
- Wild-cards can result in expensive query execution (very large dis

  - pyth* AND prog*

- If you encourage "laziness" l respond!



- Which web search engines allow wildcard queries?

Resources

- IIR 3, MG 4.2
- Efficient spell retrieval:
  - K. Kukich. Techniques for automatically correcting words in text. ACM Computing Surveys 24(4), Dec 1992.
  - J. Zobel and P. [illegible] ches in large lexicons. Softw [illegible] 5(3), March 1995. http://citeseer.ist.psu.edu/zobel95find
  - Mikael Tillenius: Efficient Generation a [illegible] pelling Error Corrections. Master's thesis at Sweden's Royal Institute of Technology. http://citeseer.ist.psu.edu/179155.html
- **Nice, easy reading on spell correction:**
  - Peter Norvig: How to write a spelling corrector

http://norvig.com/spell-correct.html