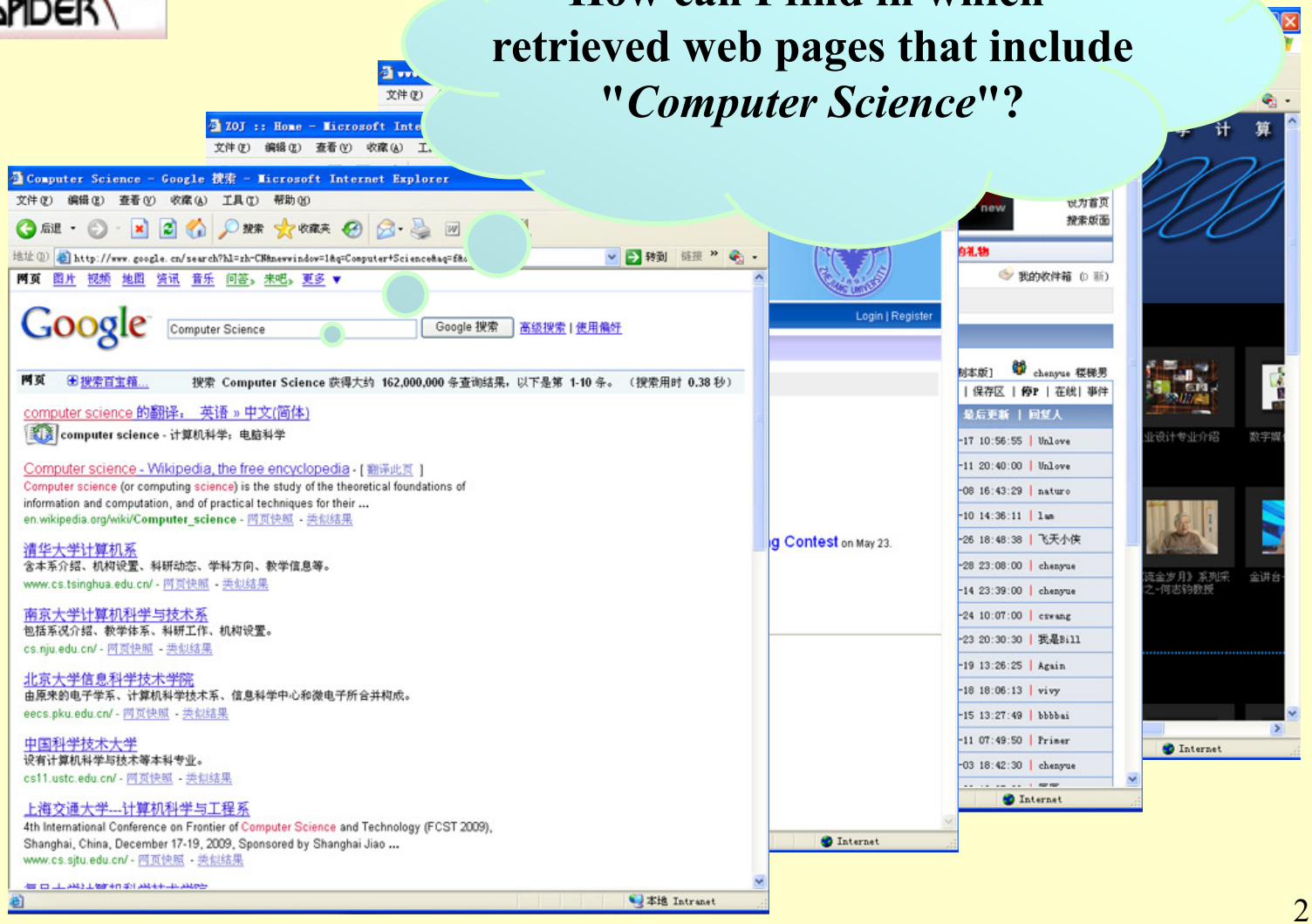
Inverted File Index

How can I find in which retrieved web pages that include "*Computer Science*"?



☞ **Solution 1:** **Scan each page for the string "Computer Science".**

☞ Solution 2: Term-Document Incidence Matrix

〖Example〗 Document sets

Doc	Text
1	Gold silver truck
2	Shipment of gold damaged in a fire
3	Delivery of silver arrived in a silver truck
4	Shipment of gold arrived in a truck

	1	2	3	4
a	0	1	1	1
arrived	0	0	1	1
damaged	0	1	0	0
delivery	0	0	1	0
fire	0	1	0	0
gold	1	1	0	1
of	0	1	1	1
in	0	1	1	1
shipment	0	1	0	1
silver	1	0	1	0
truck	1	0	1	1

silver & truck

☞ Solution 3: Compact Version - Inverted File Index

【Definition】 Index is a mechanism for locating a given term in a text.

【Definition】 Inverted file contains a list of pointers (e.g. the number of a page) to all occurrences of that term in the text.

Doc	Text
1	Gold silv
2	Shipment of g… damaged in a fire
3	Delivery of silver arrived in a silver truck
4	Shipment of gold arrived in a truck

Inverted because it lists for a *term*, all documents that contain the term

Index

No.	Term	Times; Documents
		…2,3,4>
		…1; 3>
5	fire	<1; 2>
6	gold	<3; 1,2,4>
7	of	<3; 2,3,4>
8	in	<3; 2,3,4>
9	shipment	<2; 2,4>
10	silver	<2; 1,3>
11	truck	<3; 1,3,4>

Doc	Text
1	Gold silver truck
2	Shipment of gold damaged in a fire
3	Delivery of silver arrived in a silver truck
4	Shipment of gold arrived in a truck

No.	Term	Times; Documents Words
1	a	<3; (2;6),(3;6),(4;6)>
2	arrived	<2; (3;4),(4;4)>
3	damaged	<1; (2;4)>
4	delivery	<1; (3;1)>
5	fire	<1; (2;7)>
6	gold	<3; (1;1),(2;3),(4;3)>
7	of	<3; (2;2),(3;2),(4;2)>
8	in	<3; (2;5),(3;5),(4;5)>
9	shipment	<2; (2;1),(4;1)>
10	silver	<2; (1;2),(3;3,7)>
11	truck	<3; (1;3),(3;8),(4;7)>

Term Dictionary

Posting List

How to easily print the sentences which contain the words and highlight the words?

Why do we keep “times” (frequency)?

Index Generator

```
while ( read a document D ) {
    while ( read a term T in D ) {
        if ( Find( Dictionary, T ) == false )
            Insert( Dictionary, T );
        Get T's posting list;
        Insert a node to T's posting list;
    }
}
Write the inverted index to disk;
```

Token Analyzer
Stop Filter

Vocabulary
Scanner

Vocabulary
Insertor

Memory management

While reading a term ……

✂ ***Word Stemming***

Process a word so that only its stem or root form is left.

〖Example〗 Process, processing, processes, processed → process; says, said, saying → say

✂ ***Stop Words***

Some words are so common that almost every document contains them, such as "a" "the" "it". It is useless to index them. They are called *stop words*. We can eliminate them from the original documents.

While accessing a term ……

- **Solution 1:** **Search trees (*B- trees, B+ trees, Tries, ...*)**
- **Solution 2:** **Hashing**

Discussion 3:

What are the pros and cons of using hashing, comparing to using search trees?

While not having enough memory ……

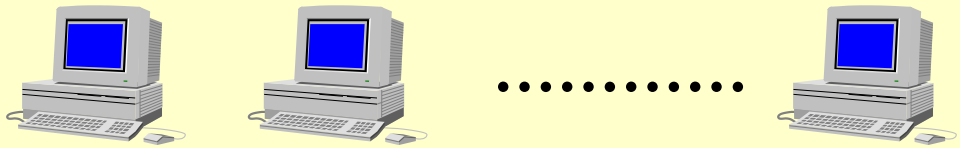
```
while ( read a document D ) {
  while ( read a term T in D ) {

    if ( Find( Dictionary, T ) == false )
      Insert( Dictionary, T );
    Get T's posting list;
    Insert a node to T's posting list;
  }
}
```

Sorted

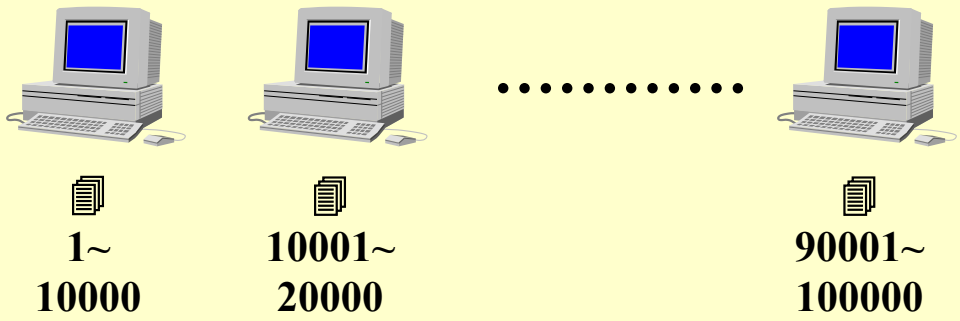
Distributed indexing (for web-scale indexing — don't try this at home!)

—— Each node contains index of a subset of collection

☞ **Solution 1:** Term-partitioned index

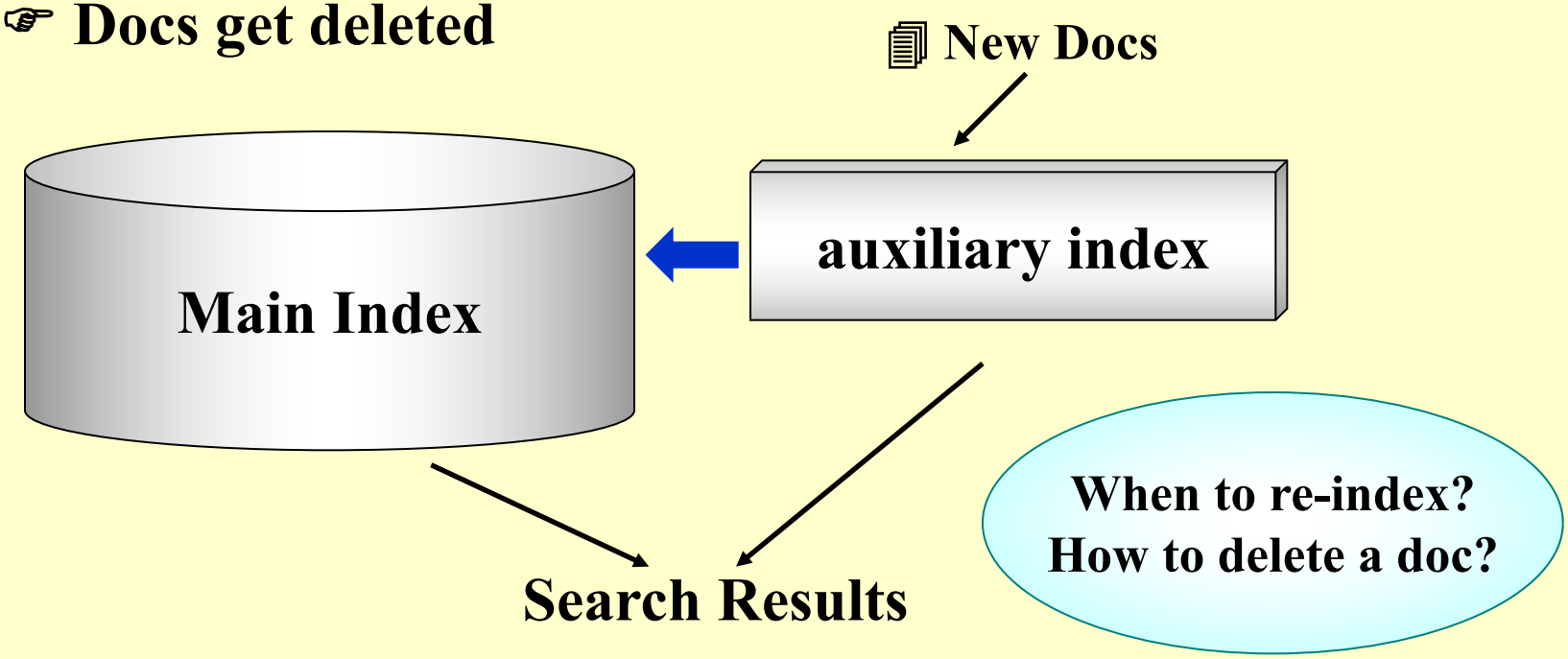


☞ **Solution 2:** Document-partitioned index

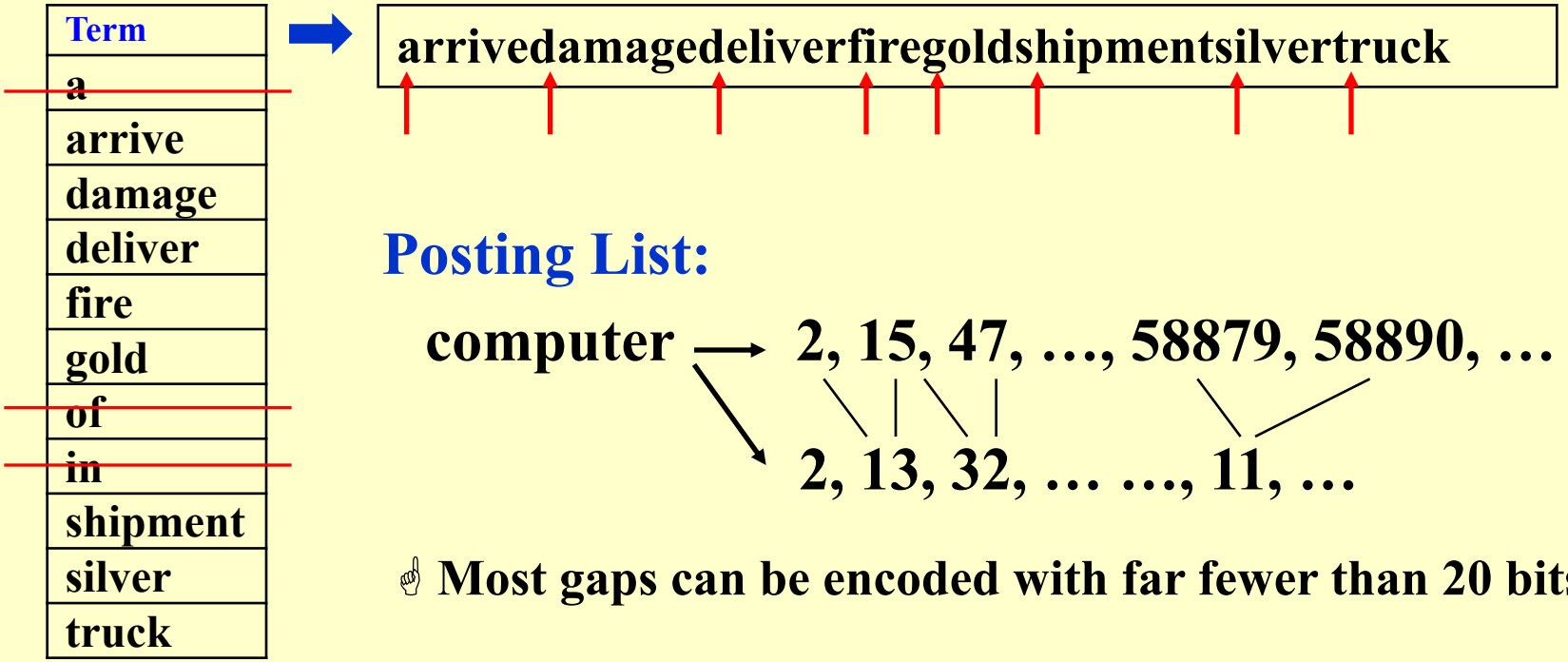


Dynamic indexing

- Docs come in over time
  - postings updates for terms already in dictionary
  - new terms added to dictionary
- Docs get deleted



Compression



Posting List:

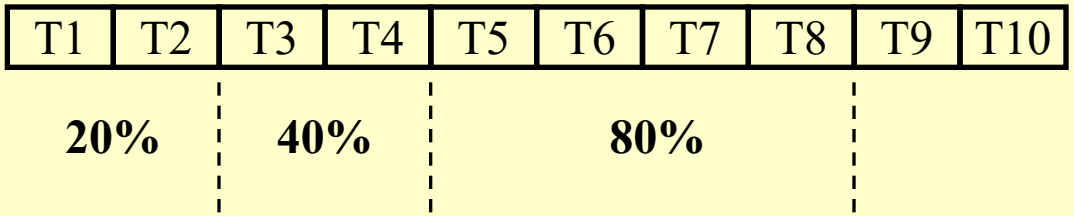
computer → 2, 15, 47, …, 58879, 58890, …

2, 13, 32, … …, 11, …

☝ Most gaps can be encoded with far fewer than 20 bits

Thresholding

- **Document:** only retrieve the top *x* documents where the documents are ranked by weight
  - Not feasible for Boolean queries
  - Can miss some relevant documents due to truncation
- **Query:** Sort the query terms by their frequency in ascending order; search according to only some percentage of the original query terms



Measures for a search engine

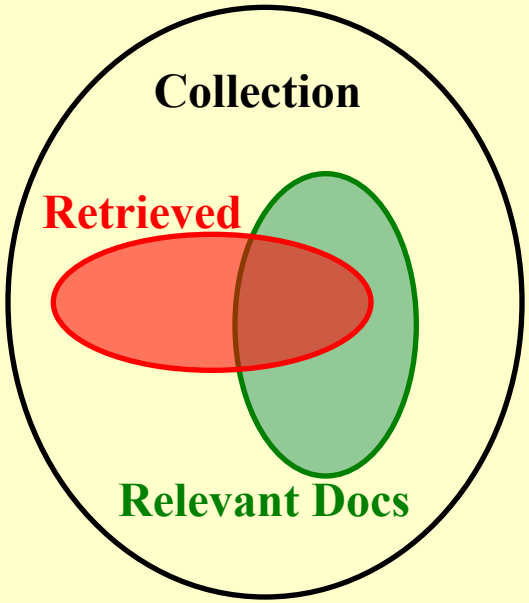
- How fast does it index
  - Number of documents/hour
- How fast does it search
  - Latency as a function of index size
- Expressiveness of query language
  - Ability to express complex information needs
  - Speed on complex queries

- User happiness ?
  - Data Retrieval Performance Evaluation (after establishing correctness)
    - > Response time
    - > Index space
  - Information Retrieval Performance Evaluation
    - > + How *relevant* is the answer set?

Relevance **measurement requires 3 elements:**

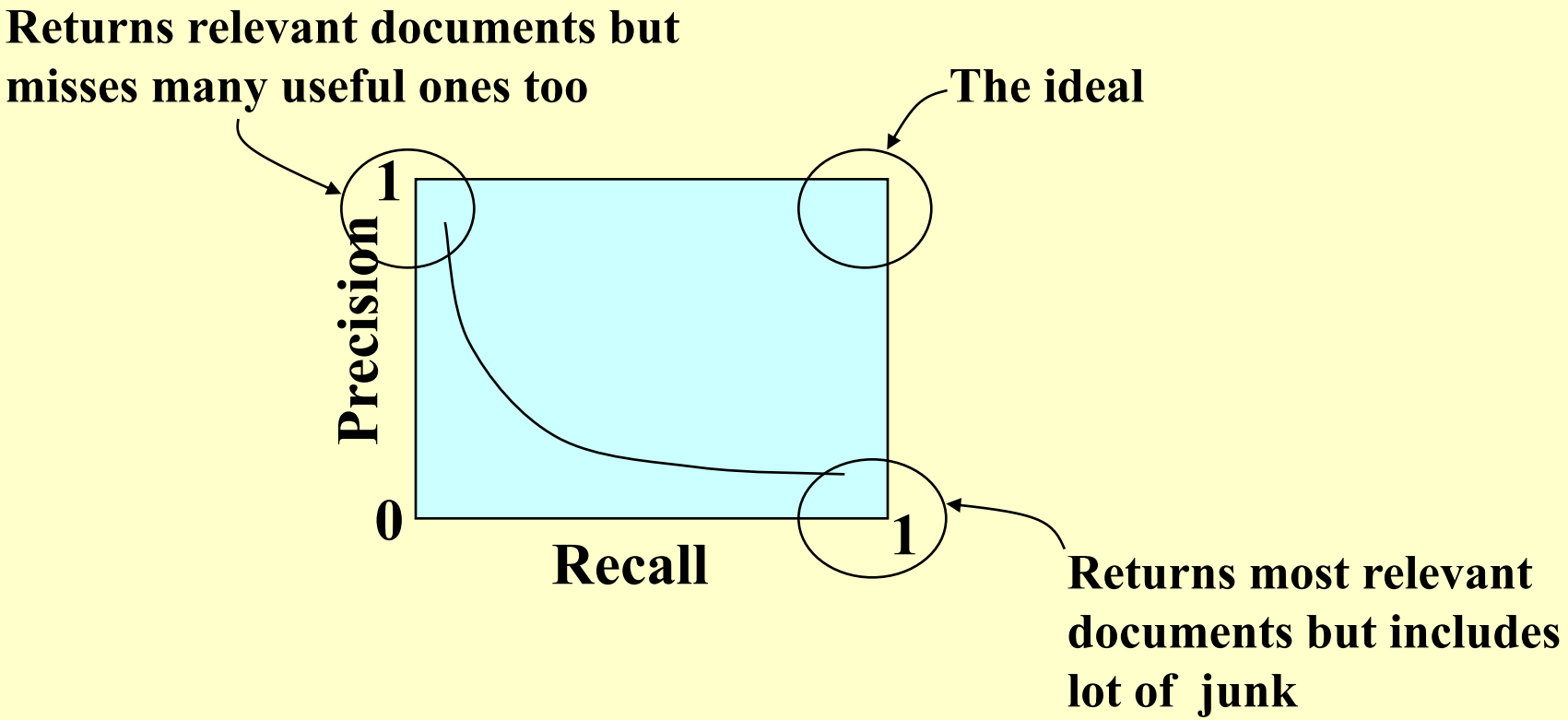
1. **A benchmark document collection**
2. **A benchmark suite of queries**
3. **A binary assessment of either Relevant or Irrelevant for each query-doc pair**

	Relevant	Irrelevant
Retrieved	R_R	I_R
Not Retrieved	R_N	I_N



Precision $P = R_R / (R_R + I_R)$

Recall $R = R_R / (R_R + R_N)$


Returns relevant documents but misses many useful ones too
The ideal
1
Precision
0
1
Recall
Returns most relevant documents but includes lot of junk

Discussion 4:

How to improve the *relevancy* of search results?

Reference:

Download "InvertedFileIndex.zip".

- **The Google File System.pdf**
- **Building an Inverted Index.pdf**
- **Inverted Index Construction(ppt).pdf**
- **Compression.pdf**