Information Retrieval and Web Search

Introduction

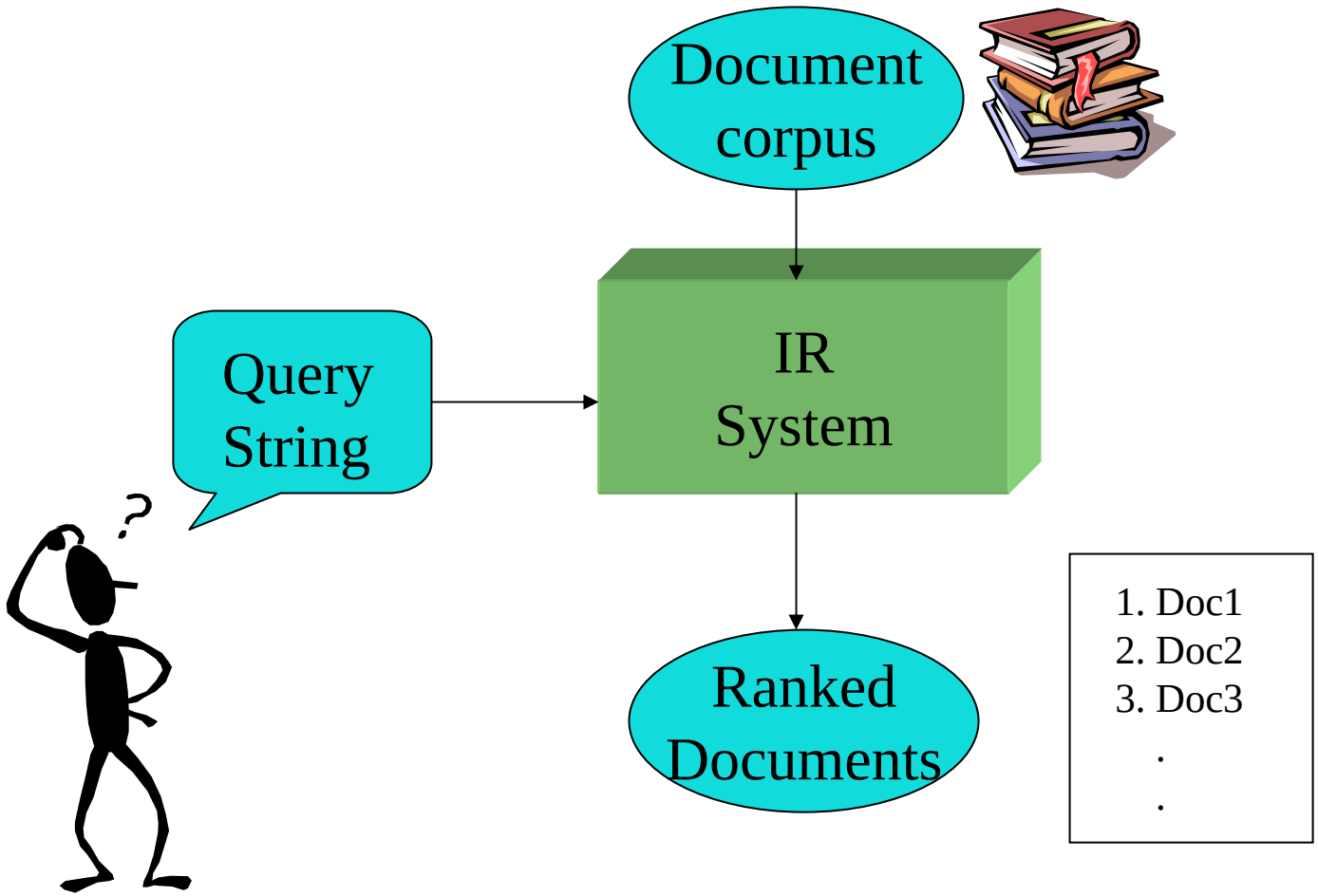
Information Retrieval (IR)

- The indexing and retrieval of textual documents.
- Searching for pages on the World Wide Web is the most recent “killer app.”
- Concerned firstly with retrieving *relevant* documents to a query.
- Concerned secondly with retrieving from *large* sets of documents *efficiently*.
- Try to search *colt* at google.com and yahoo.com

Typical IR Task

- Given:
  - A corpus of textual natural-language documents.
  - A user query in the form of a textual string.
- Find:
  - A ranked set of documents that are relevant to the query.

IR System


Document corpus
Query String
IR System
Ranked Documents
1. Doc1
2. Doc2
3. Doc3
.
.

Relevance

- Relevance is a subjective judgment and may include:
  - Being on the proper subject.
  - Being timely (recent information).
  - Being authoritative (from a trusted source).
  - Satisfying the goals of the user and his/her intended use of the information (*information need*).

Keyword Search

- Simplest notion of relevance is that the query string appears verbatim in the document.
- Slightly less strict notion is that the words in the query appear frequently in the document, in any order (*bag of words*).

Problems with Keywords

- May not retrieve relevant documents that include synonymous terms.
  - “restaurant” vs. “café”
  - “PRC” vs. “China”
- May retrieve irrelevant documents that include ambiguous terms.
  - “bat” (baseball vs. mammal)
  - “Apple” (company vs. fruit)
  - “bit” (unit of data vs. act of eating)
  - “colt” ?
  - (horse, gun, COmputational Learning Theory)

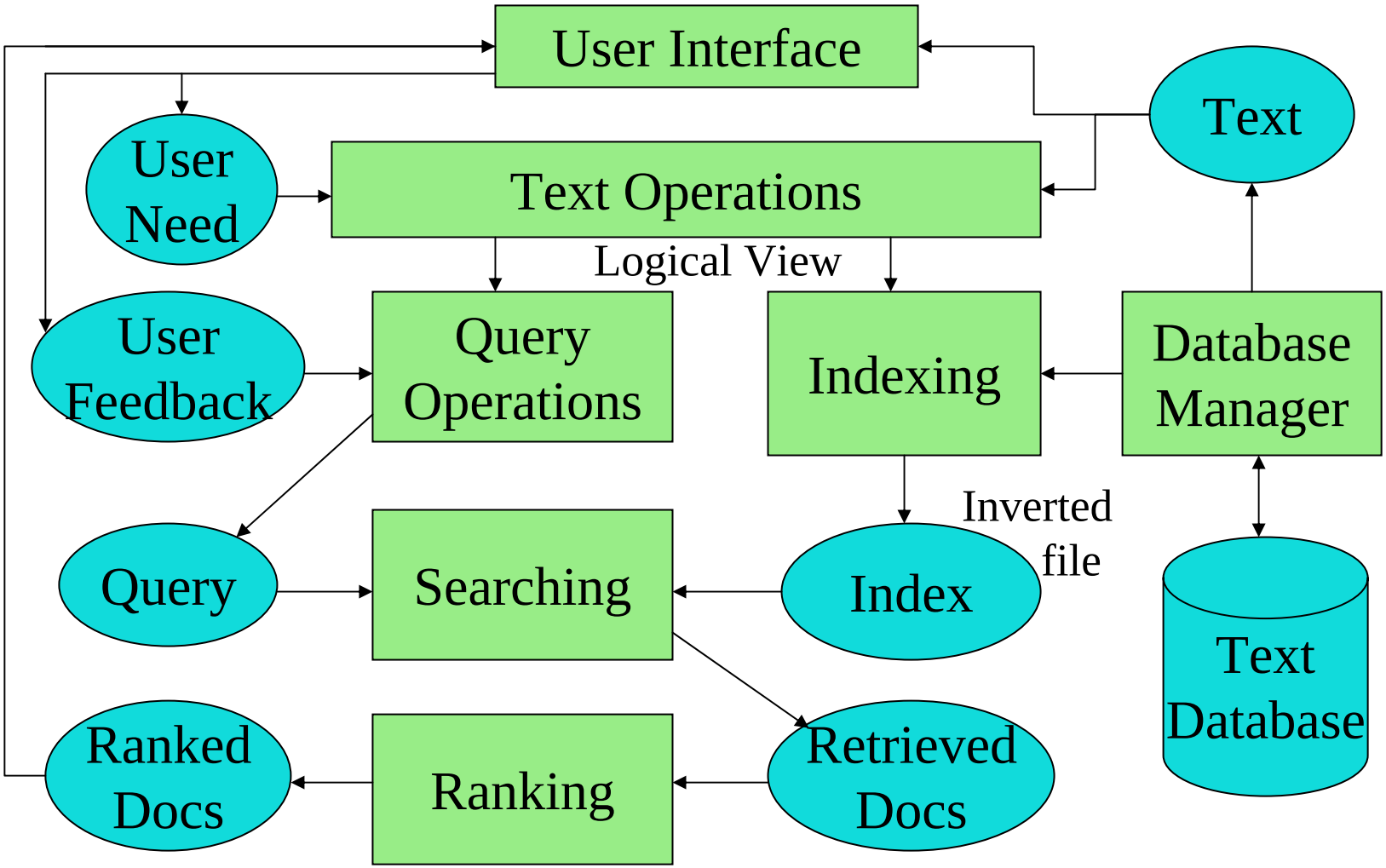
Beyond Keywords

- We will cover the basics of keyword-based IR, but…
- We will focus on extensions and recent developments that go beyond keywords.
- We will cover the basics of building an *efficient* IR system, but…
- We will focus on basic capabilities and algorithms rather than system's issues that allow scaling to industrial size databases.

Intelligent IR

- Taking into account the *meaning* of the words used.
- Taking into account the *order* of words in the query.
- Adapting to the user based on direct or indirect feedback.
- Taking into account the *authority* of the source.

IR System Architecture



IR System Components

- Text Operations forms index words (tokens).
  - Stopword removal
  - Stemming
- Indexing constructs an *inverted index* of word to document pointers.
- Searching retrieves documents that contain a given query token from the inverted index.
- Ranking scores all retrieved documents according to a relevance metric.

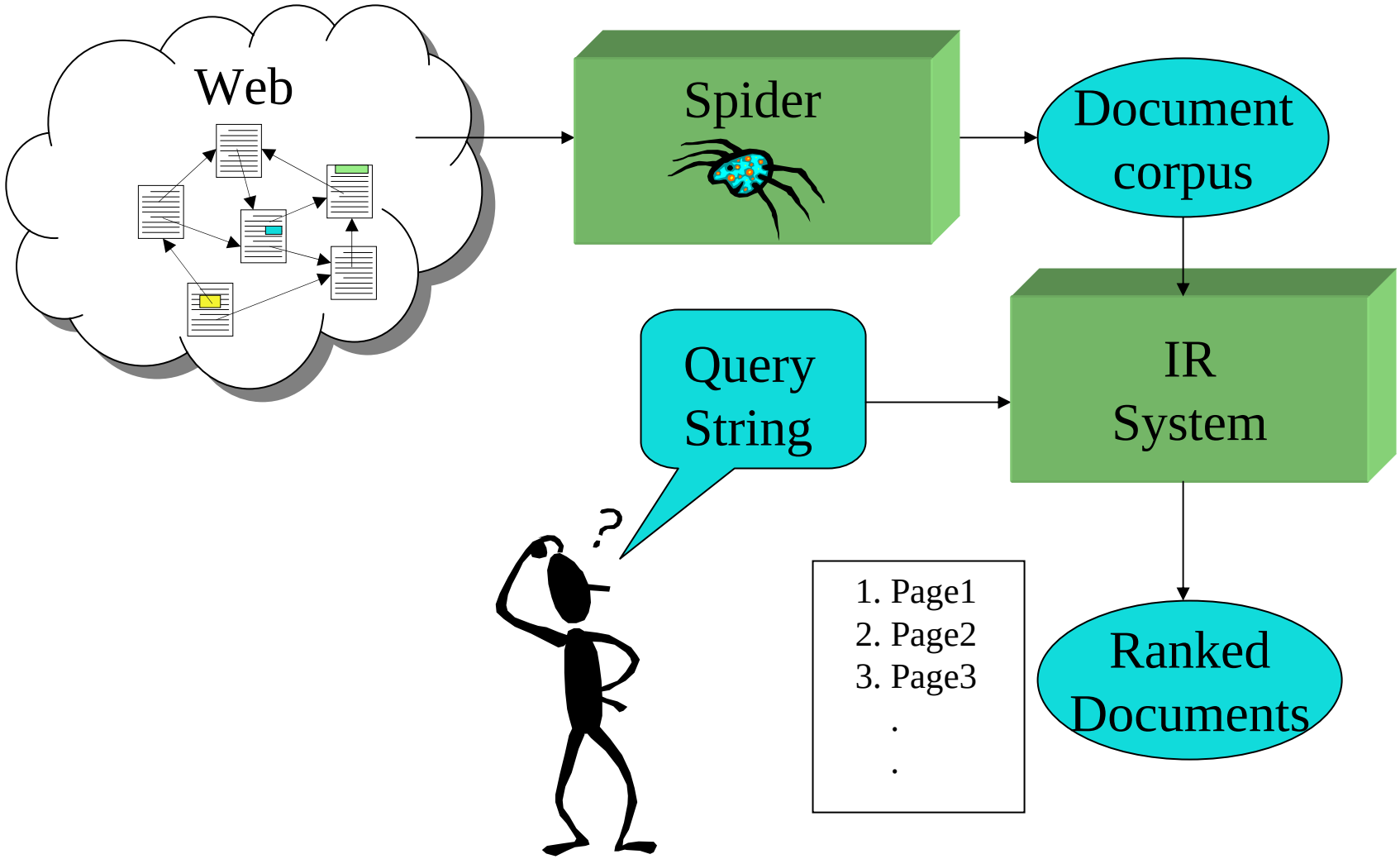
IR System Components (continued)

- User Interface manages interaction with the user:
  - Query input and document output.
  - Relevance feedback.
  - Visualization of results.
- Query Operations transform the query to improve retrieval:
  - Query expansion using a thesaurus.
  - Query transformation using relevance feedback.

Web Search

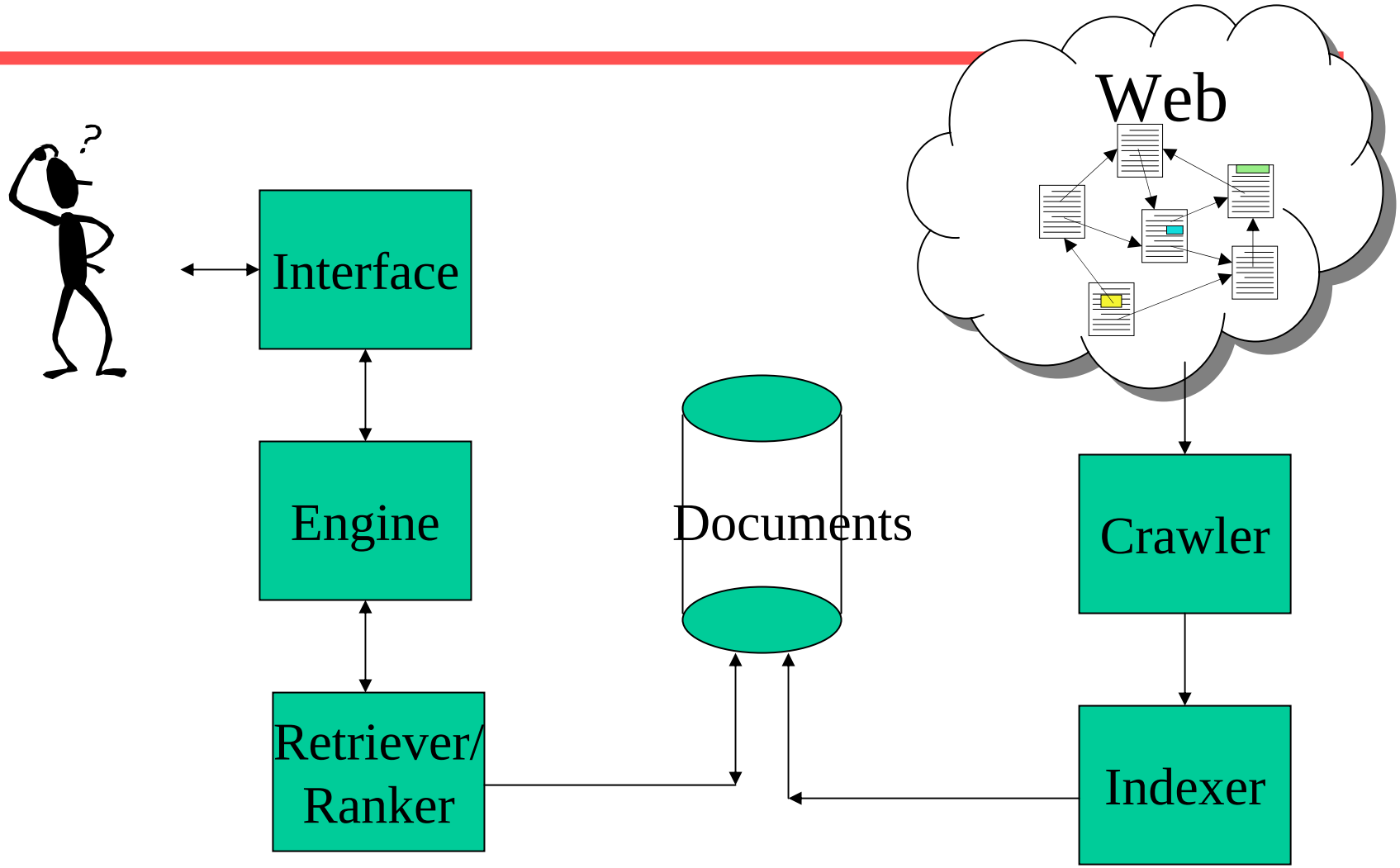
- Application of IR to HTML documents on the World Wide Web.
- Differences:
  - Must assemble document corpus by spidering the web.
  - Can exploit the structural layout information in HTML (XML).
  - Documents change uncontrollably.
  - Can exploit the link structure of the web.

Web Search System



Our Project

- User interface
- Search engine
- Retriever
- Document sets
- Crawler
- Indexer


Web
Interface
Engine
Documents
Crawler
Retriever/
Ranker
Indexer

Other IR-Related Tasks

- Automated document categorization
- Information filtering (spam filtering)
- Information routing
- Automated document clustering
- Recommending information or products
- Information extraction
- Information integration
- Question answering

History of IR

- 1960-70's:
  - Initial exploration of text retrieval systems for "small" corpora of scientific abstracts, and law and business documents.
  - Development of the basic Boolean and vector-space models of retrieval.
  - Prof. Salton and his students at Cornell University are the leading researchers in the area.

IR History Continued

- 1980's:
  - Large document database systems, many run by companies:
    - Lexis-Nexis – *authoritative legal, news, public record, business information*
    - Dialog – *publishers' information*
    - MEDLINE – *health supply catalogue*

IR History Continued

- 1990's:
  - Searching FTPable documents on the Internet
    - Archie
    - WAIS
  - Searching the World Wide Web
    - Lycos
    - Yahoo
    - Altavista

IR History Continued

- 1990's continued:
  - Organized Competitions
    - NIST TREC (*National Inst. of Standards & Technology, Text Retrieval Conferences*)
  - Recommender Systems
    - Ringo
    - Amazon
    - NetPerceptions
  - Automated Text Categorization & Clustering

Recent IR History

- 2000's
  - Link analysis for Web Search
    - Google
  - Automated Information Extraction
    - Whizbang
    - Fetch
    - Burning Glass
  - Question Answering
    - TREC Q/A track

Recent IR History

- 2000's continued:
  - Multimedia IR
    - Image
    - Video
    - Audio and music
  - Cross-Language IR
    - DARPA Tides
  - Document Summarization

Related Areas

- Database Management
- Library and Information Science
- Artificial Intelligence
- Natural Language Processing
- Machine Learning

Database Management

- Focused on *structured* data stored in relational tables rather than free-form text.
- Focused on efficient processing of well-defined queries in a formal language (SQL).
- Clearer semantics for both data and queries.
- Recent move towards *semi-structured* data (XML) brings it closer to IR.

Library and Information Science

- Focused on the human user aspects of information retrieval (human-computer interaction, user interface, visualization).
- Concerned with effective categorization of human knowledge.
- Concerned with citation analysis and *bibliometrics* (structure of information).
- Recent work on *digital libraries* brings it closer to CS & IR.

Artificial Intelligence

- Focused on the representation of knowledge, reasoning, and intelligent action.
- Formalisms for representing knowledge and queries:
  - First-order Predicate Logic
  - Bayesian Networks
- Recent work on web ontologies and intelligent information agents brings it closer to IR.

Natural Language Processing

- Focused on the syntactic, semantic, and pragmatic analysis of natural language text and discourse.
- Ability to analyze syntax (phrase structure) and semantics could allow retrieval based on *meaning* rather than keywords.

Natural Language Processing: IR Directions

- Methods for determining the sense of an ambiguous word based on context (*word sense disambiguation*).
- Methods for identifying specific pieces of information in a document (*information extraction*).
- Methods for answering specific NL questions from document corpora.

Machine Learning

- Focused on the development of computational systems that improve their performance with experience.
- Automated classification of examples based on learning concepts from labeled training examples (*supervised learning*).
- Automated methods for clustering unlabeled examples into meaningful groups (*unsupervised learning*).

Machine Learning: IR Directions

- Text Categorization
  - Automatic hierarchical classification (Yahoo).
  - Adaptive filtering/routing/recommending.
  - Automated spam filtering.
- Text Clustering
  - Clustering of IR query results.
  - Automatic formation of hierarchies (Yahoo).
- Learning for Information Extraction
- Text Mining