# Information Retrieval

PRI 22/23 · Information Processing and Retrieval
M.EIC · Master in Informatics Engineering and Computation

Sérgio Nunes
Dept. Informatics Engineering
FEUP · U.Porto

Based on Chapter 1 from Modern Information Retrieval, Baeza-Yates, R. et al. (2011)
Based on Chapters 1 and 2 from Search Engines in Practice, Croft, B. et al. (2008)

# Project Milestone 1 — Data Preparation

# Project M1: Data Preparation

- M1 presentations are this week.

- Deadline for submitting your materials is the day before the lab class (until 18h).
- Presentation schedules are tight.
  - Be there on time.
  - 5 min presentations + 5 min discussion.
- Don’t forget the individual participation component (10%) — ask questions!

# Project Overview

- M1:
  - **from…** selected data sources
  - **to…** an organized (and studied) collection of documents
  - **plus…** and a set of prospective search tasks

- M2:
  - **from…** a collection of documents
  - **to…** the first version of a search system

# Today’s Lecture Outline

- Search systems
- Information retrieval concepts
  - Collections, documents, queries, results
  - Tasks, test collections, measures
  - Users, information needs, evaluation
- Architecture of information retrieval systems
  - Components of an information retrieval system
- History of information retrieval
  - Relation to text and data mining, machine learning, natural language processing

# Search systems

# Search and Information Retrieval

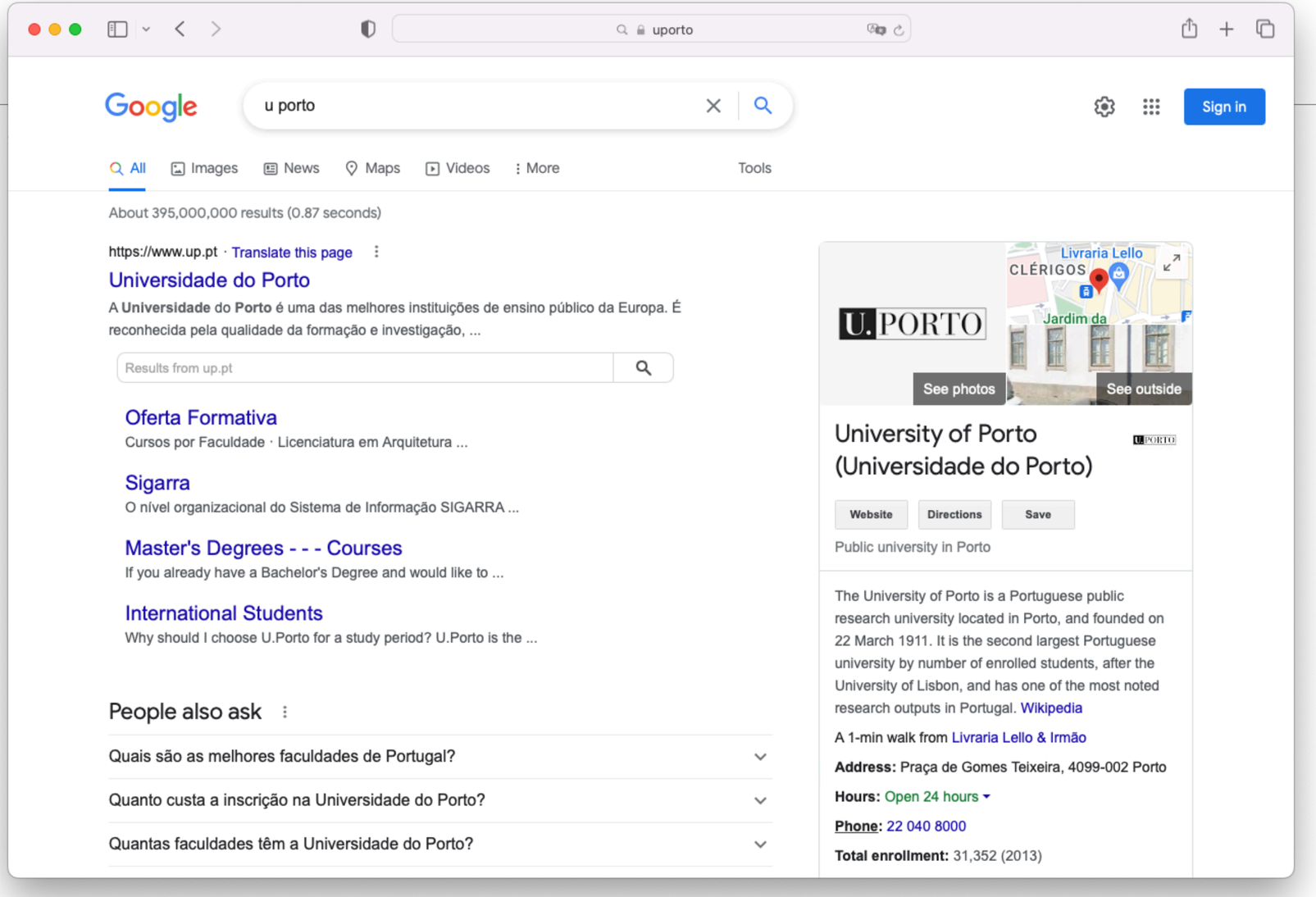
➔ Search is a daily activity for every computer, web, smart phone, … user.

➔ Search exists, *and is expected*, in every application.

➔ The web has brought the concept of keyword-based search to the center stage.

➔ Search contexts: web, site-specific, drive, computer, folders, email, messaging system.

➔ Many different types: web search, maps search, image similarity search, social search, etc.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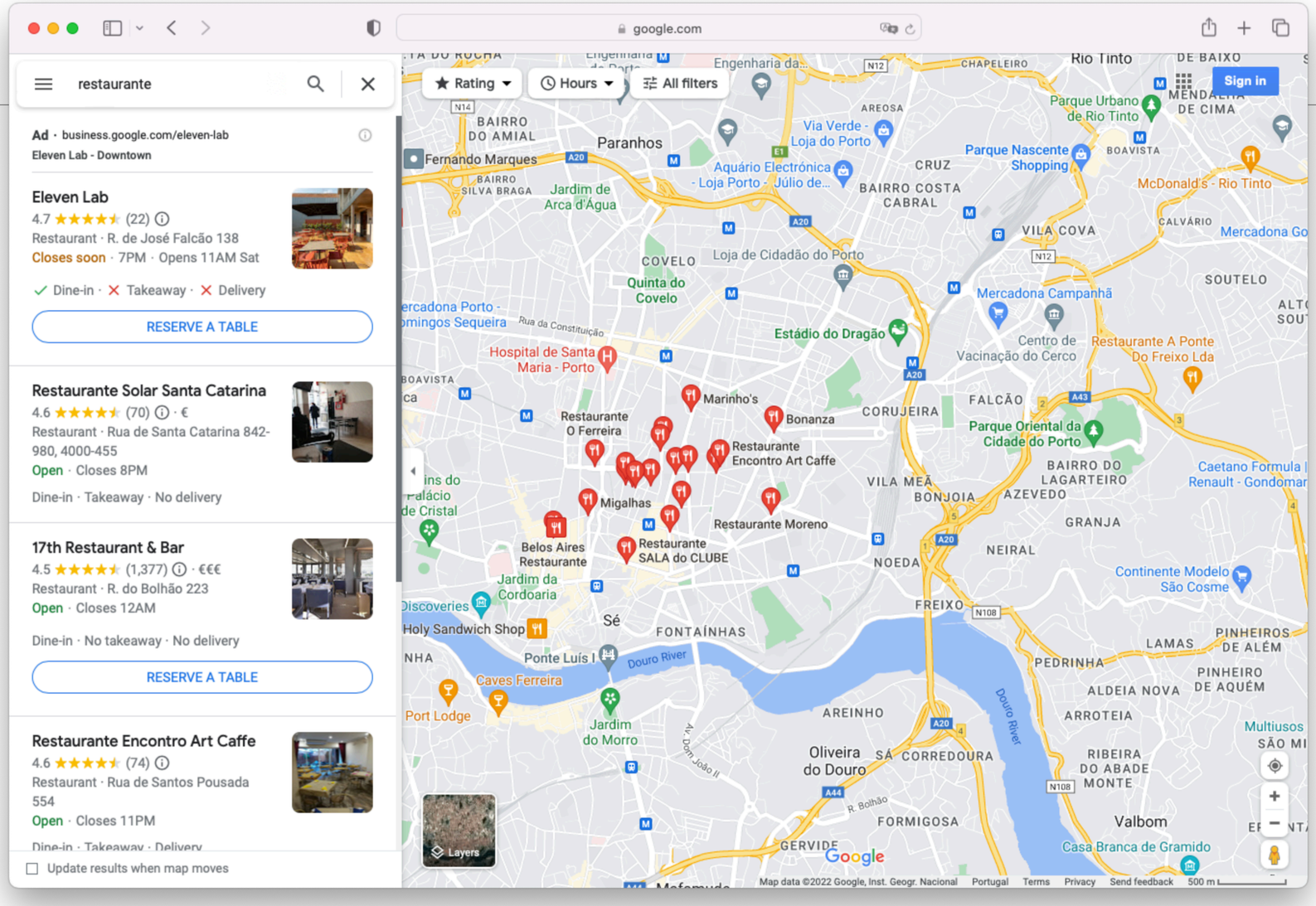
Public university in Porto
The University of Porto is a Portuguese public research university located in Porto, and founded on 22 March 1911. It is the second largest Portuguese university by number of enrolled students, after the University of Lisbon, and has one of the most noted research outputs in Portugal. Wikipedia
A 1-min walk from Livraria Lello & Irmão
Address: Praça de Gomes Teixeira, 4099-002 Porto
Hours: Open 24 hours
Phone: 22 040 8000
Total enrollment: 31,352 (2013)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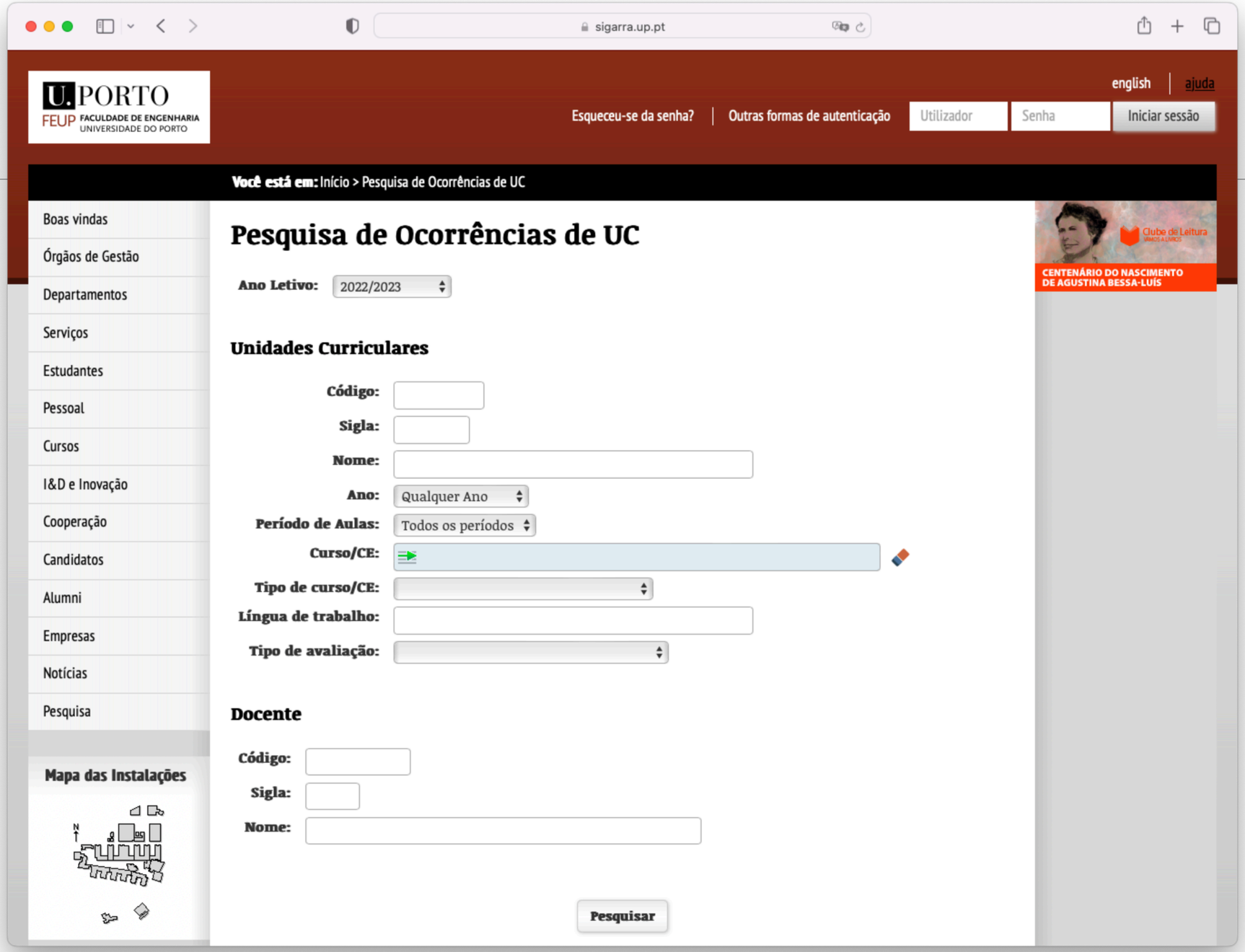
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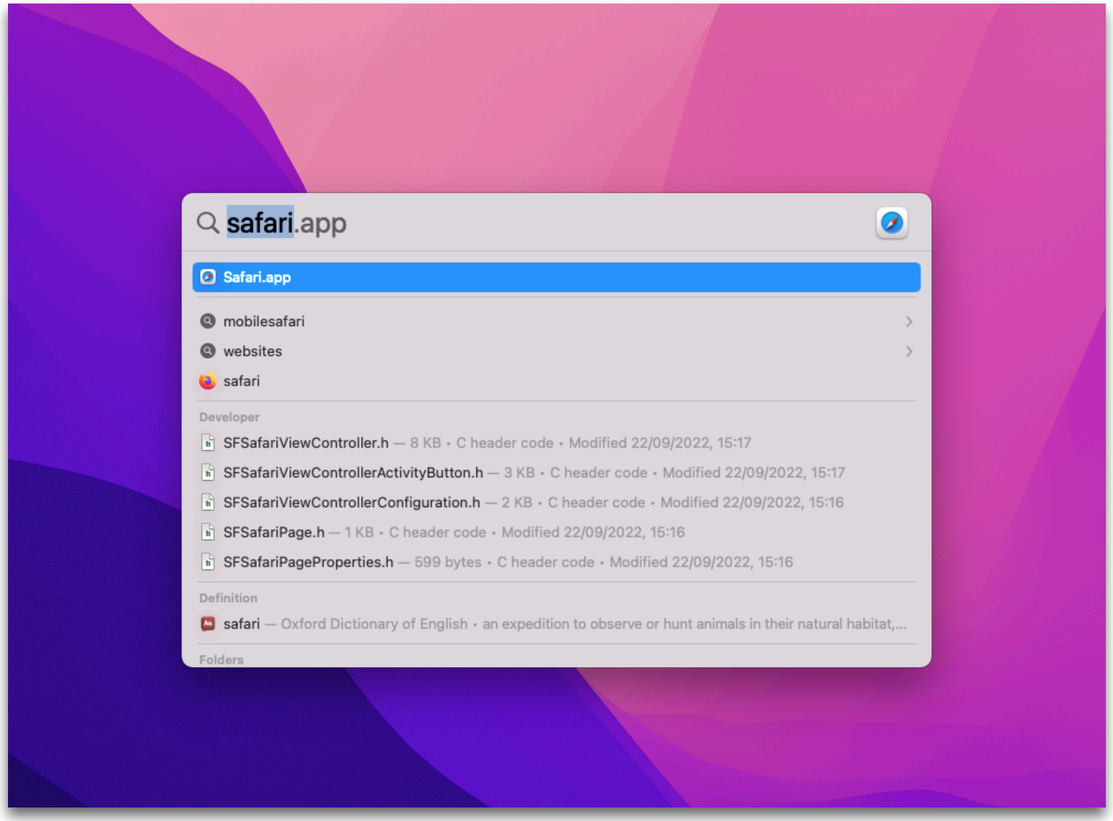
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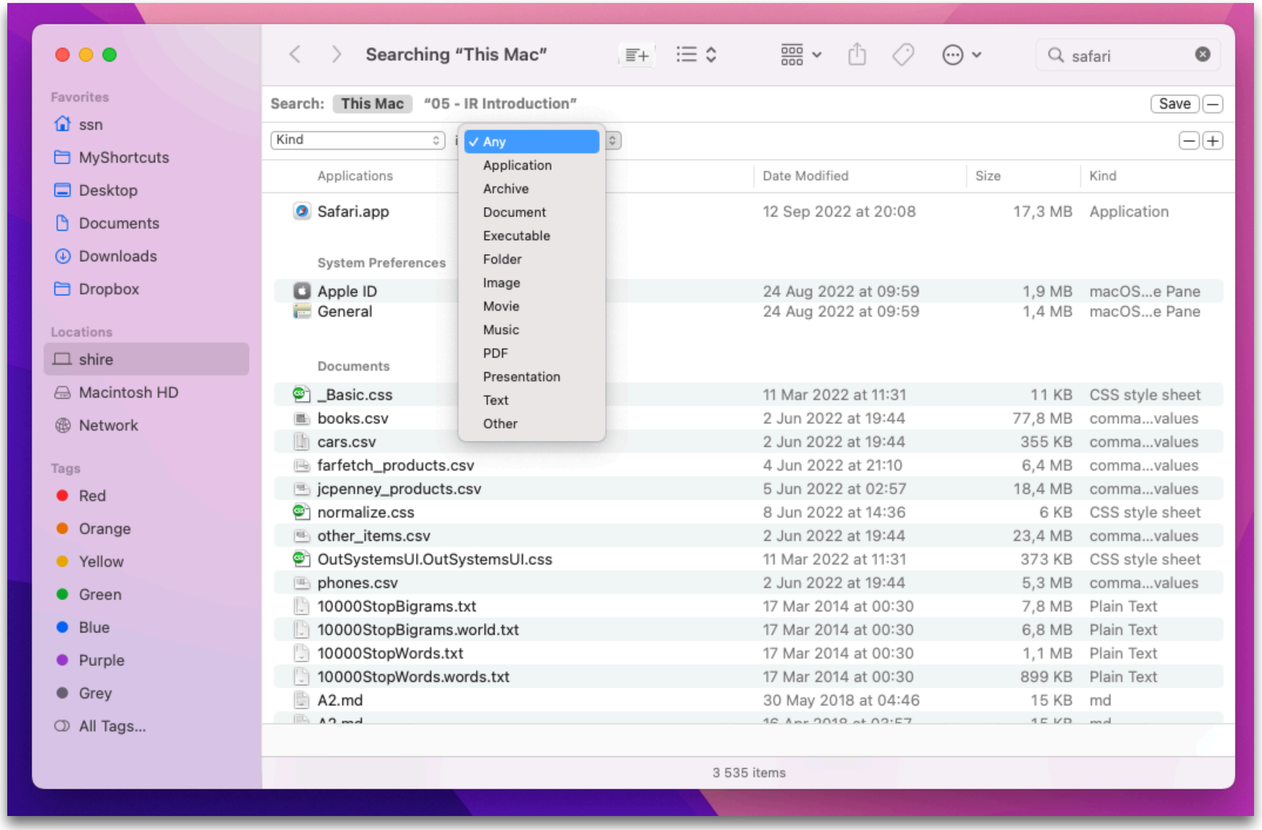
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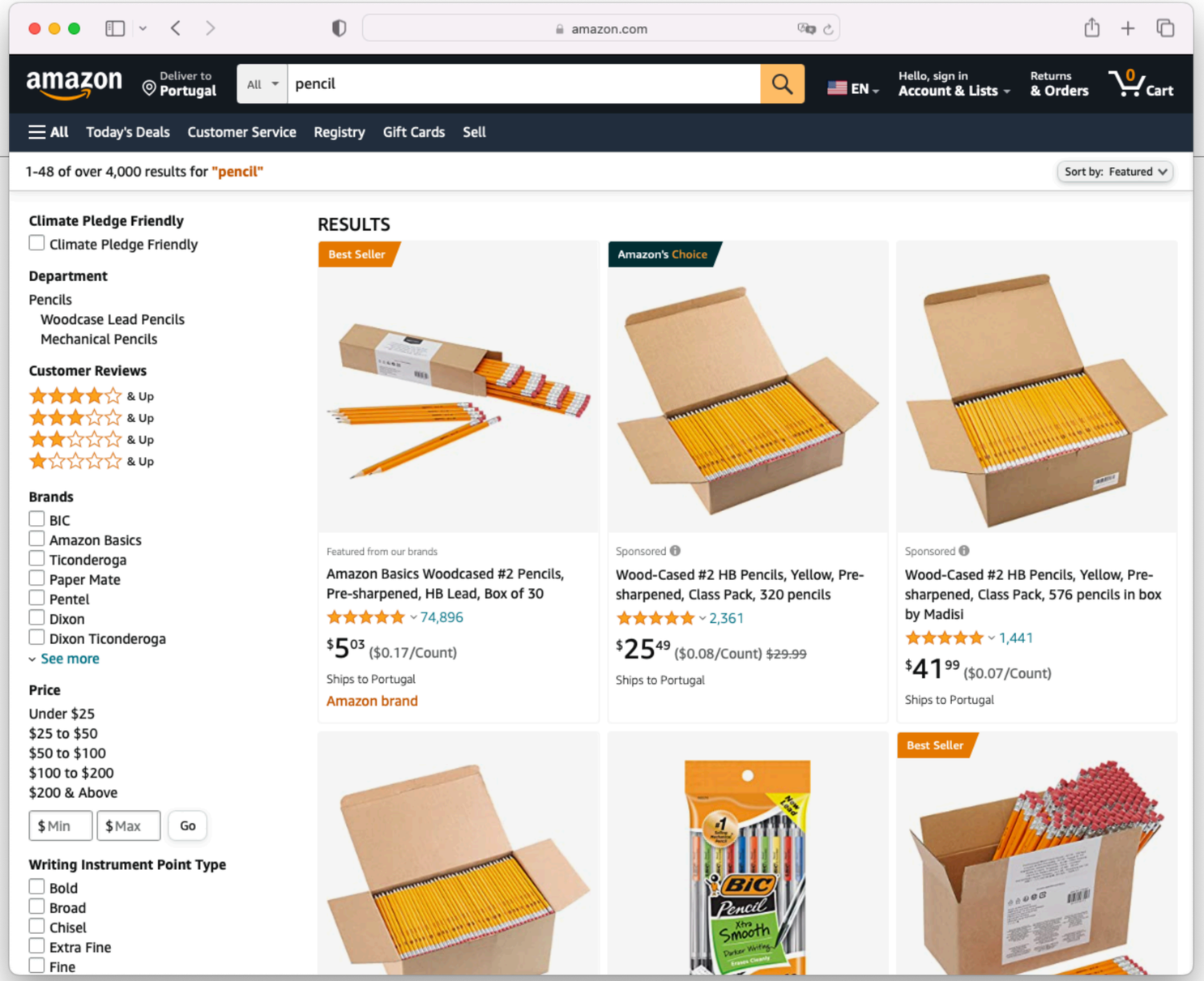
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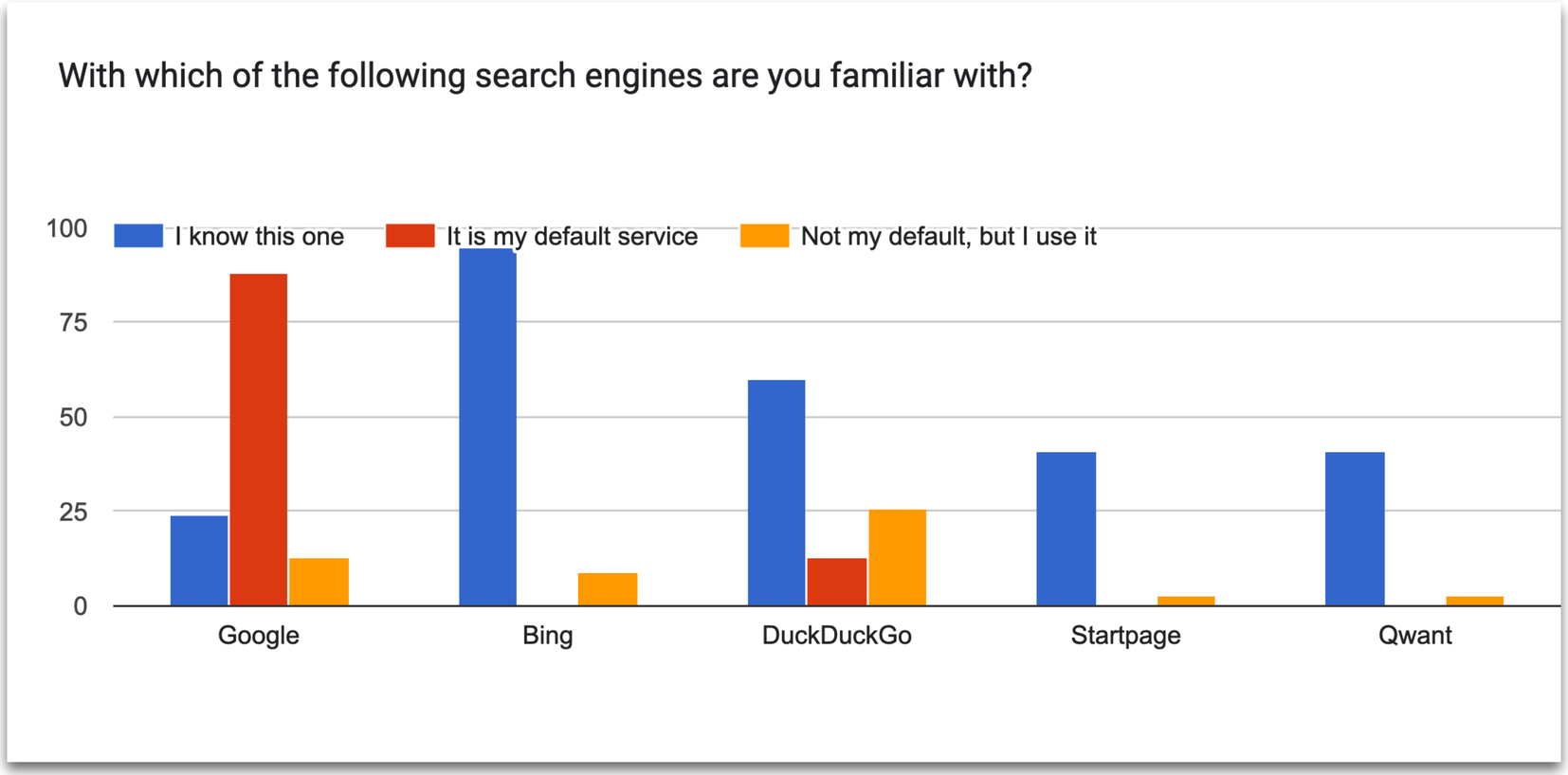
# Student Survey

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# Information retrieval concepts

# Information Retrieval

- In computer science, the field that is most involved in search problems and developments is
  - Information Systems > **Information Retrieval**, and includes sub-areas such as:
    - Document representation
    - Information retrieval query processing
    - Users and interactive retrieval
    - Retrieval models and ranking
    - Retrieval tasks and goals
    - Evaluation of retrieval results
    - Search engines architectures and scalability

# Defining Information Retrieval

- “Information retrieval is a field concerned with the structure, analysis, organization, storage, searching, and retrieval of information”, Salton (1968)
  - General definition that can be applied to many types of search applications.
  - Primary focus since the 50s has been on text and documents.

- “Information retrieval (IR) is finding material (usually documents) of an unstructured nature (usually text) that satisfies an information need from within large collections (usually stored on computers)”, Manning et al. (2008)

# Documents

- Documents can be web pages, email messages, books, news articles, research papers, computer files (PDF, Word, text), text messages, etc.
- Common properties:
  - Significant text content.
  - Some structure, e.g. title, body, date, tags, author.
- From PRI projects:
  - linux packages, songs lyrics, cooking recipes, MSc dissertations, game plays, etc.

# Different from Databases

- “A database management system is a software system that enables the creation, maintenance, and use of large amounts of data” (Abiteboul et al., 1995)
- Information retrieval and database systems have a lot in common.
- But emphasize different aspects of information management.
  - Databases contains highly structured data, queried using formal query languages, and the results are set-based — results are true or false for a given condition.
  - Information retrieval systems support interactive processes, support natural language queries, and results are rank-based — results are more or less relevant for a given information need. Not just text matching!

# Information Retrieval and Databases

**Table 1.1** Comparison of database systems and information retrieval, based on [40]

| | Database systems | Information retrieval |
|---|---|---|
| Data type | Numbers, short strings | Text |
| Foundation | Algebraic/logic based | Probabilistic/statistics based |
| Search paradigm | Boolean retrieval | Ranked retrieval |
| Queries | Structured query languages | Free text queries |
| Evaluation criteria | Efficiency | Effectiveness (user satisfaction) |
| User | Programmer | Nontechnical person |

Table from Entity-Oriented Search, Balog (2018).

# Documents vs. Records (tuples) Queries

- Example **database queries**
  - All students enrolled in course “ABC” in year 22/23.
  - All bank account transferences between account A and account B, within a given date interval, ordered by transferred amount.

- Example **search engine queries**
  - [ feup enrolled students ABC 22/23 ]
  - [ weather porto site:pt ]

# Information Retrieval Tasks

- Information retrieval applications and research are typically structured around tasks.
- Tasks address specific contexts, and specific information access problems.
- Examples of classical information retrieval tasks:
  - Ad-hoc search, find relevant documents for an arbitrary text query.
  - Filtering, identify relevant user profiles for a new document.
  - Classification, identify relevant labels for documents.
  - Question answering, give specific answer to a question.
- Yearly evaluation initiatives with classical and novel tasks at TREC
  - https://trec.nist.gov/pubs/call2022.html

# Dimensions of Information Retrieval

| Content | Applications | Tasks |
|---|---|---|
| Text | Web search | Ad hoc search |
| Images | Vertical search | Filtering |
| Video | Enterprise search | Classification |
| Scanned docs | Desktop search | Question answering |
| Audio | Forum search | |
| Music | P2P search | |
| | Literature search | |

Image from Search Engines: Information Retrieval in Practice, Croft et al. (2009)

# Central issues in information retrieval

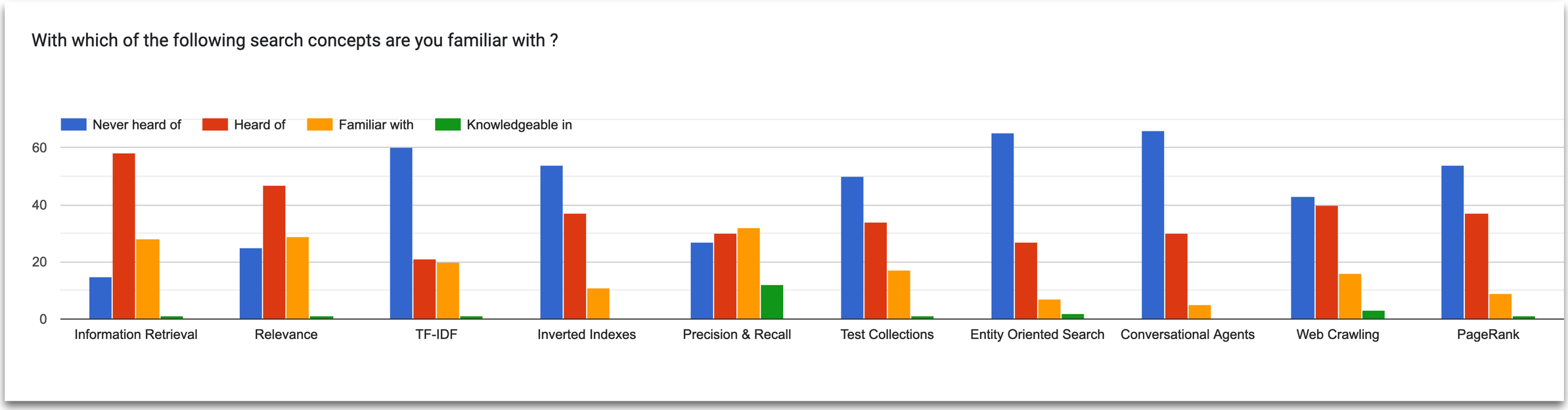
# Relevance

- ➔ The concept of relevance is a key issue in information retrieval.
- ➔ Many factors impact a person's decision of what is relevant,
  e.g. task, context, previous knowledge, etc.
- ➔ Simple definition of relevance,
  - ➔ a relevant document contains the information that a person was looking for when submitting a query to a search engine.

# Evaluation

- ➔ Evaluation setups are based on the use of annotated test collections of documents, queries, and relevance judgements.
- ➔ Evaluation in information retrieval dates back to the 1960s (Cranfield paradigm).
- ➔ IR evaluation methodologies have been adopted by many fields.
  - ➔ Recall and precision are two examples of widely used measures.
- ➔ Information needs drive the search process and result from the underlying task users' have.

# Student Survey - IR Concepts



# Information Retrieval and Search Engines

- ➔ Search engines are practical applications of information retrieval techniques.
- ➔ Existing open-source and commercial solutions that support development and research:
  - ➔ Apache Solr, Elasticsearch, Open Search, Terrier.

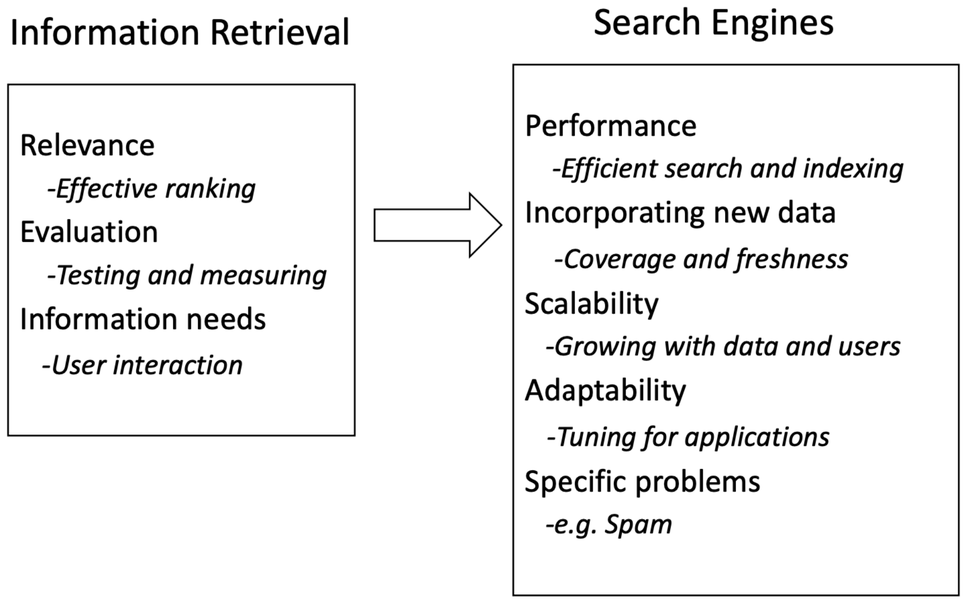
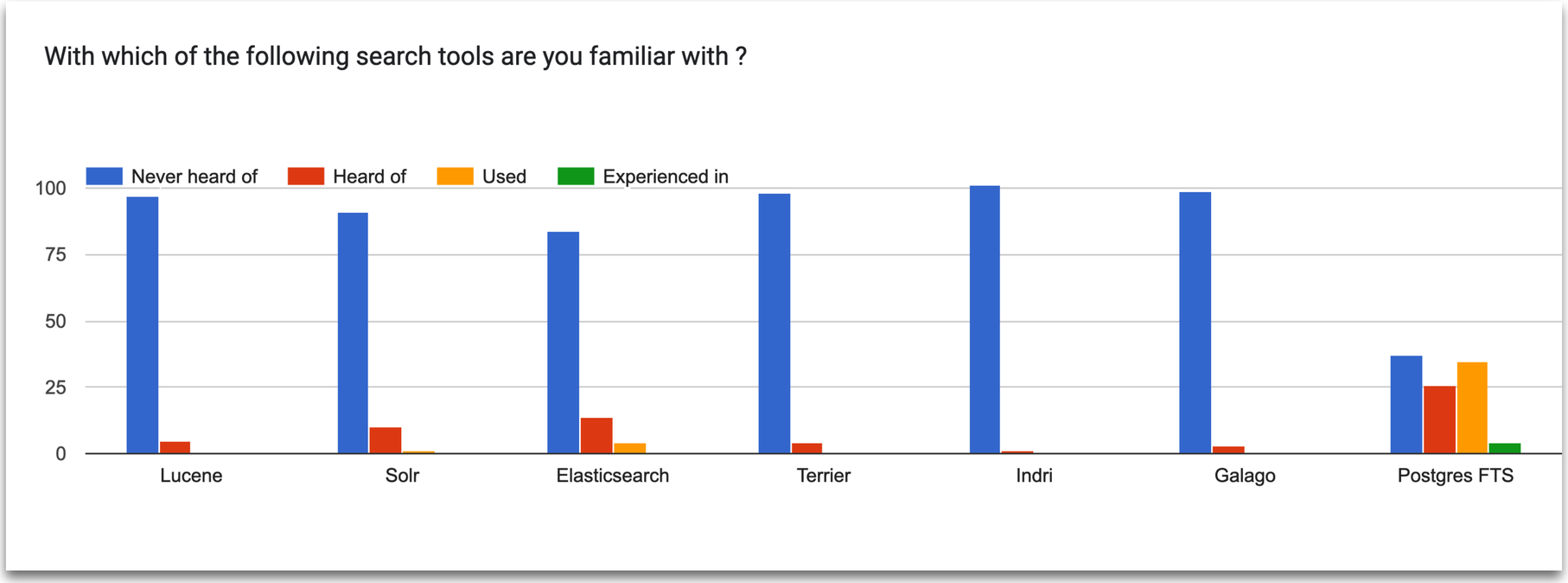


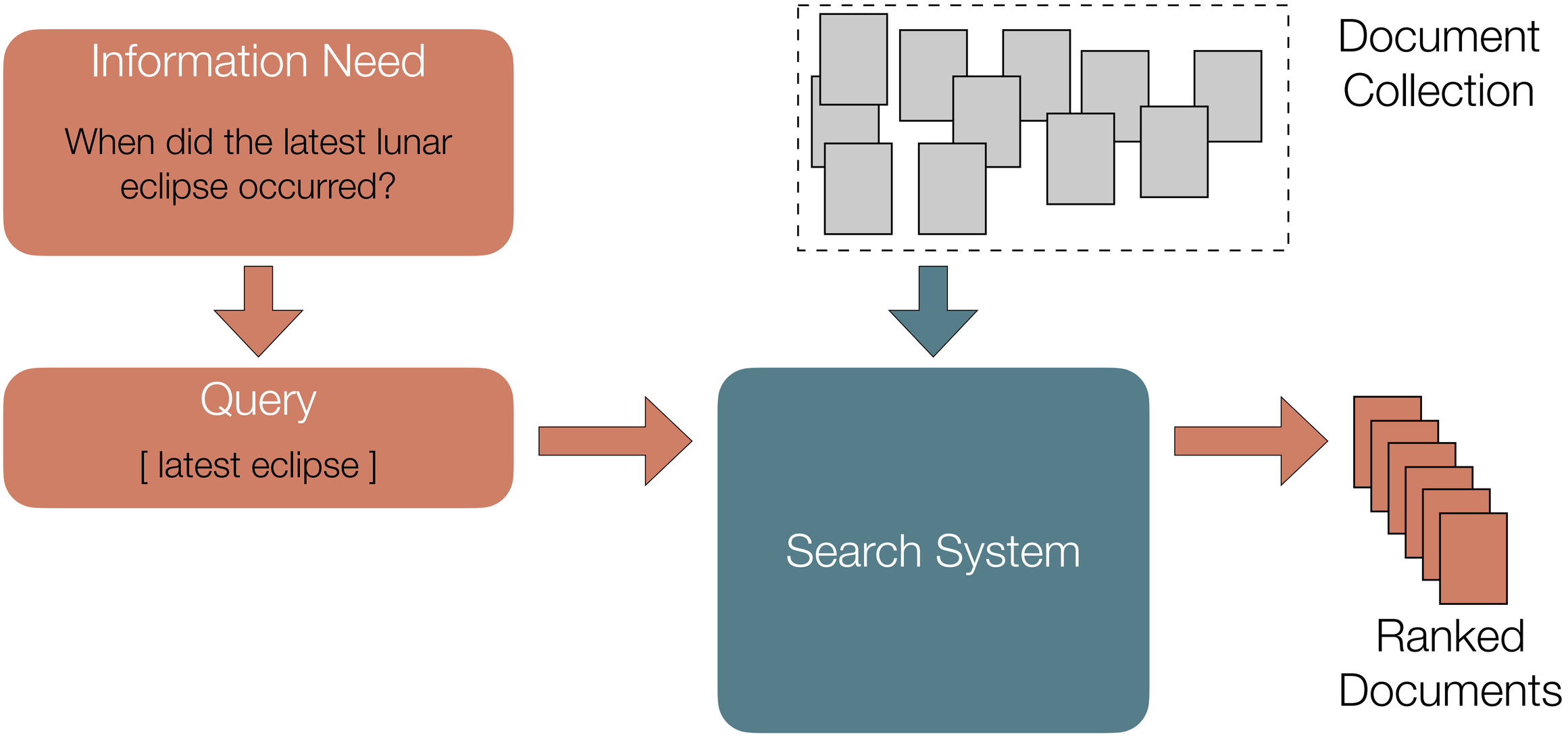

Image from Search Engines: Information Retrieval in Practice, Croft et al. (2009)

# Student Survey - IR Technologies



# Architecture of information retrieval systems

# Classic Information Retrieval



# Architecture of an Information Retrieval System

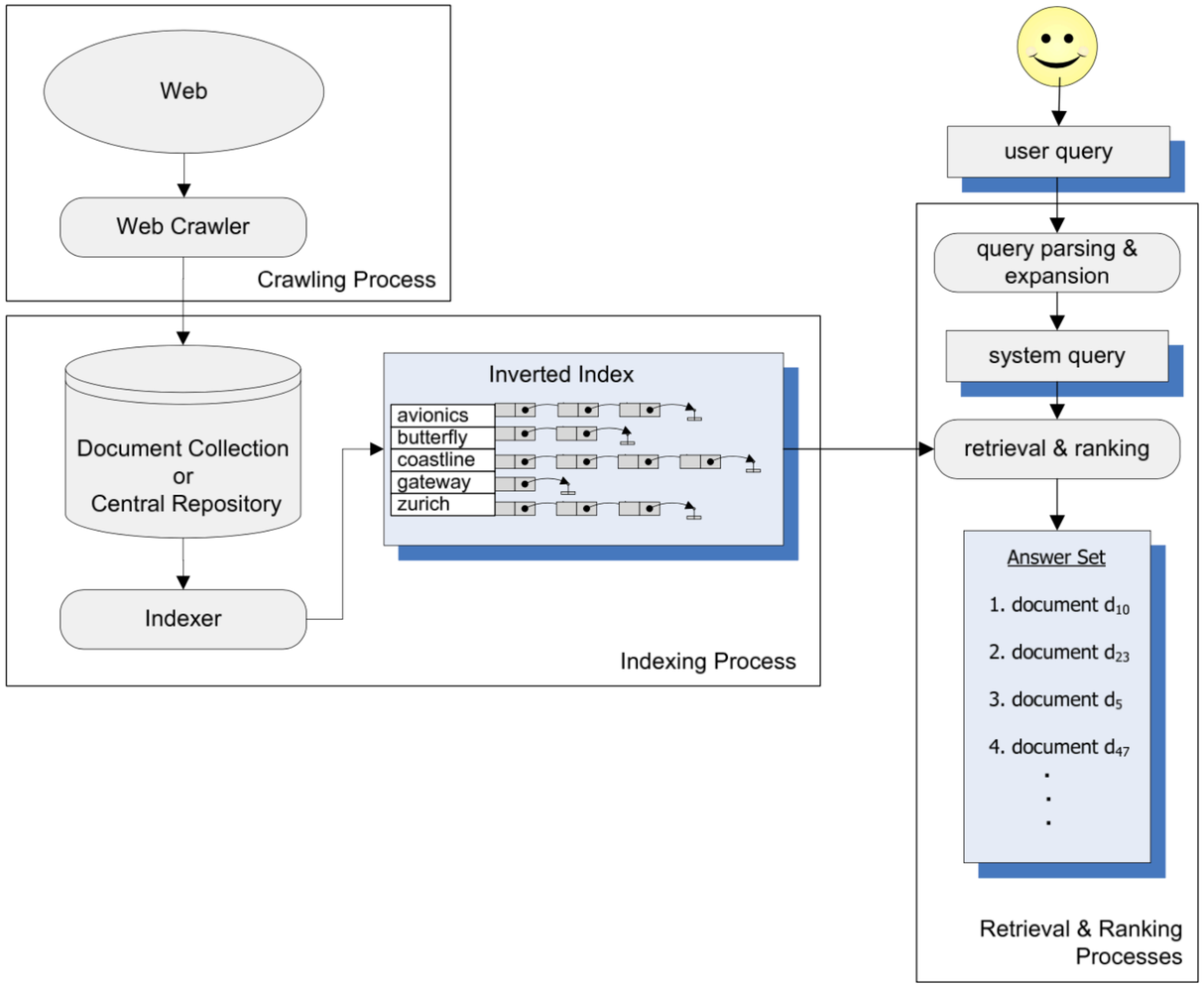



Image from Modern Information Retrieval, Baeza-Yates et al. (2011)

# Indexing Process

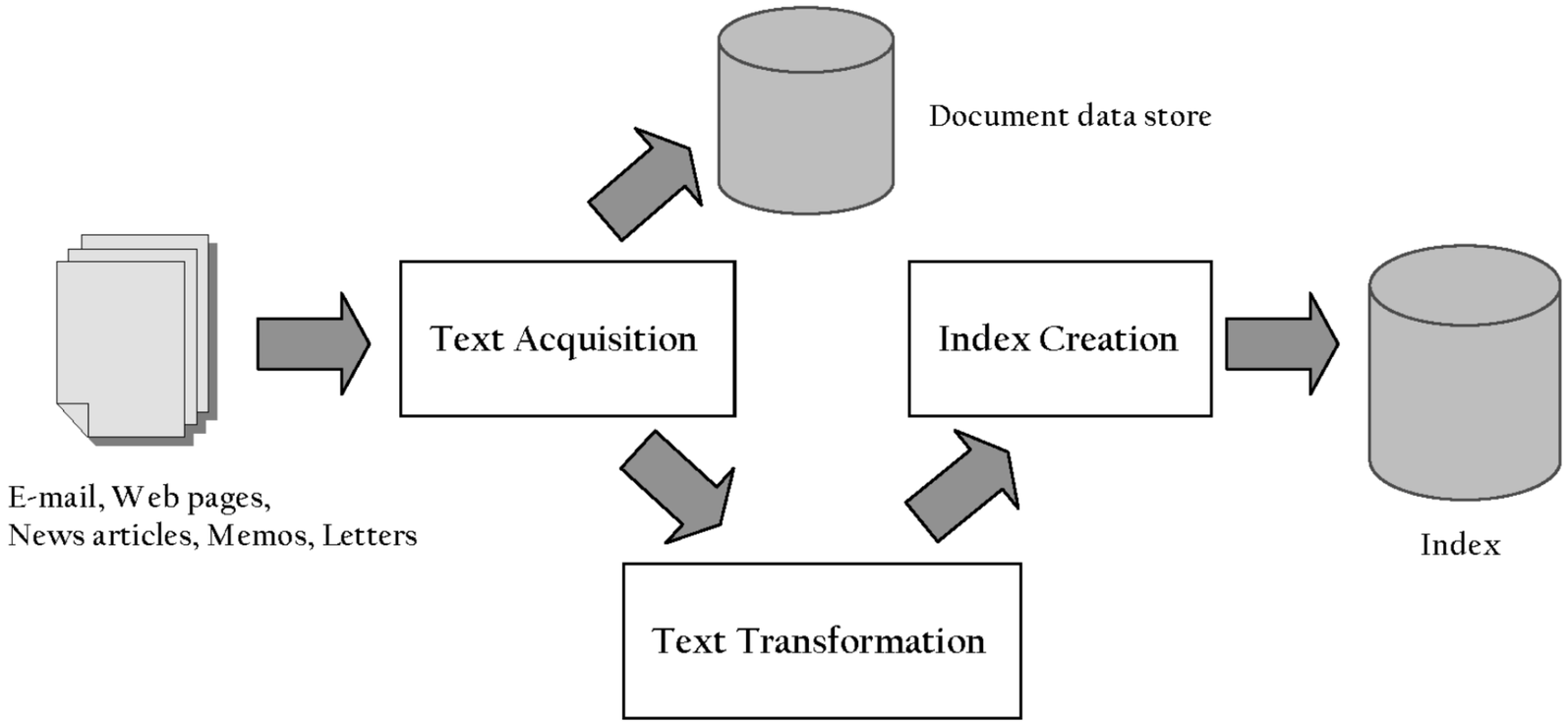



Image from Search Engines: Information Retrieval in Practice, Croft et al. (2009)

# Query Process

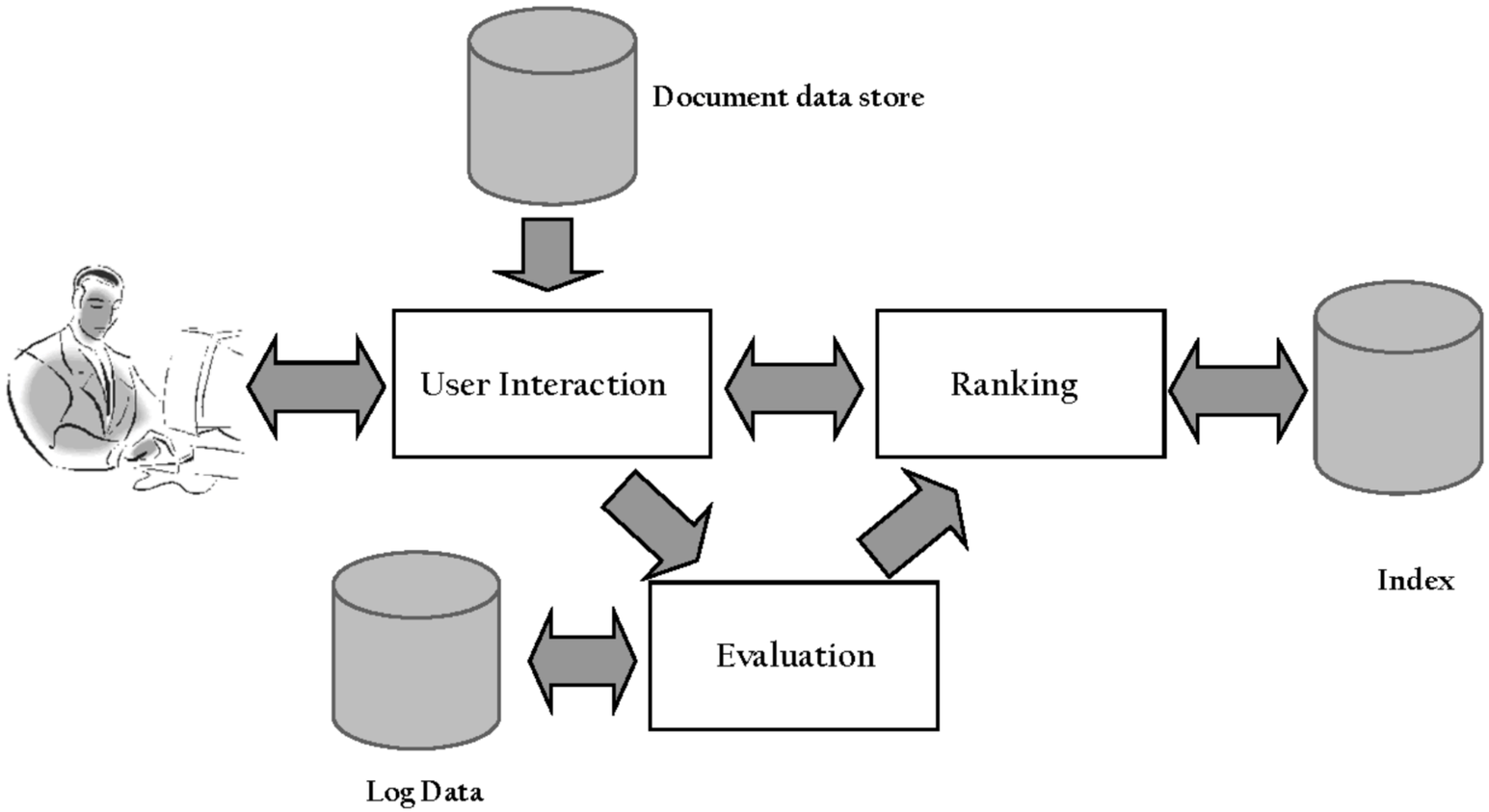



Image from Search Engines: Information Retrieval in Practice, Croft et al. (2009)

# History of information retrieval

# Historic Context

- At the end of World War II, Vannebar Bush, who headed the R&D office during the war, reflected on applications of new technologies in peace times.
- He wrote a landmark essay entitled As We May Think in 1945, where a new device, the Memex, capable of managing and interlinking knowledge is described.
  - https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/
- This essay greatly influenced the next generation of innovators.
  - Douglas Engelbart and the development of the computer mouse ("the mother of demos"), 1968.
  - Ted Nelson and the development of the concept of hypertext (Project Xanadu), 1960s.
  - Tim Berners-Lee and the World Wide Web, in 1989.
  - Web search engines, such as Lycos (94), Altavista (95), and Google (98).

# Searching the Web

- ➔ The web represented a unique search challenge.
- ➔ A unique document collection, millions of documents, connected through hyperlinks, and distributed through multiple repositories (required crawling).
- ➔ The size of the collection and the user base, millions of documents and users. Performance and scalability became a key issue.
- ➔ Predicting relevance in such a large and heterogeneous collection is complex. New sources of evidence appeared (e.g. hyperlinks).
- ➔ The web is also a business platform, thus users needs are not limited to text search.
- ➔ Web spam is a real problem on the web, sometimes referred to as “adversarial information retrieval”.

# Information Retrieval Summary

➔ Information Retrieval dates back to 1940s.

➔ Well established field in Computer Science.

➔ Deals with a wide range of information access problems.

➔ Organized in tasks: web search, filtering, question answering, podcast search, conversational, enterprise / intranet search, entity-oriented search

➔ Strong links with information science, NLP, machine learning, databases, etc.

➔ Core concepts: information need, index, query, relevance.

# Course Plan

# Course Plan

- ➔ Information Retrieval Overview (**today**)
- ➔ Evaluation
- ➔ Models and Indexing
- ➔ Retrieval and Web Retrieval
- ➔ Query Processing
- ➔ Entity-Oriented Search
- ➔ Neural IR

# Lab Classes

- Tutorials on Solr and IR Evaluation

- Develop M2: Information Retrieval
  - Index
  - Retrieve
  - Evaluate

# References and Further Reading


- Modern Information Retrieval (2nd Edition) (2011)
  Ricardo Baeza-Yates, Berthier Ribeiro-Neto. Addison-Wesley Professional.
  http://www.mir2ed.org

- Introduction to Information Retrieval (2008)
  Christopher Manning, Prabhakar Raghavan, Hinrich Schütze. Cambridge University Press.
  http://nlp.stanford.edu/IR-book

- Search Engines: Information Retrieval in Practice (2009)
  W. Bruce Croft, Donald Metzler, Trevor Strohman. Pearson.
  http://ciir.cs.umass.edu/downloads/SEIRiP.pdf

- Entity-Oriented Search (2018)
  Krisztian Balog. Springer One.
  https://link.springer.com/book/10.1007/978-3-319-93935-3