UFMG UNIVERSIDADE FEDERAL DE MINAS GERAIS

Information Retrieval

Search Architecture

Rodrygo L. T. Santos
rodrygo@dcc.ufmg.br

Search infrastructure

Search engines run on resource-intensive regimes

- ***Bandwidth*** for handling crawling and search traffic
- ***Storage*** for persisting documents, indexes, metadata
- ***Processing*** for crawling, indexing and retrieval

Must scale from a single computer in one datacenter…

- … to huge clusters spread across availability zones

Financial costs

Depreciation

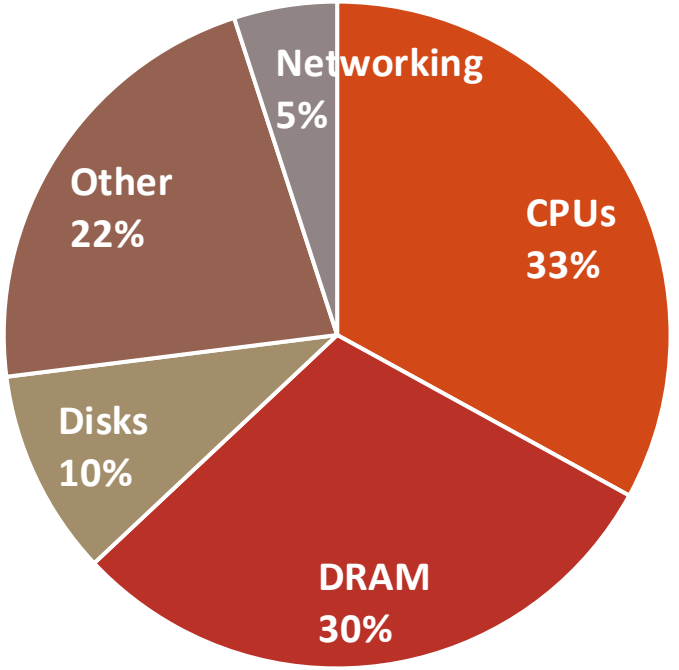
- Old hardware needs to be replaced

Maintenance

- Failures need to be handled

Operational

- Energy spending needs to be reduced



Credit: Jorge Jorquera

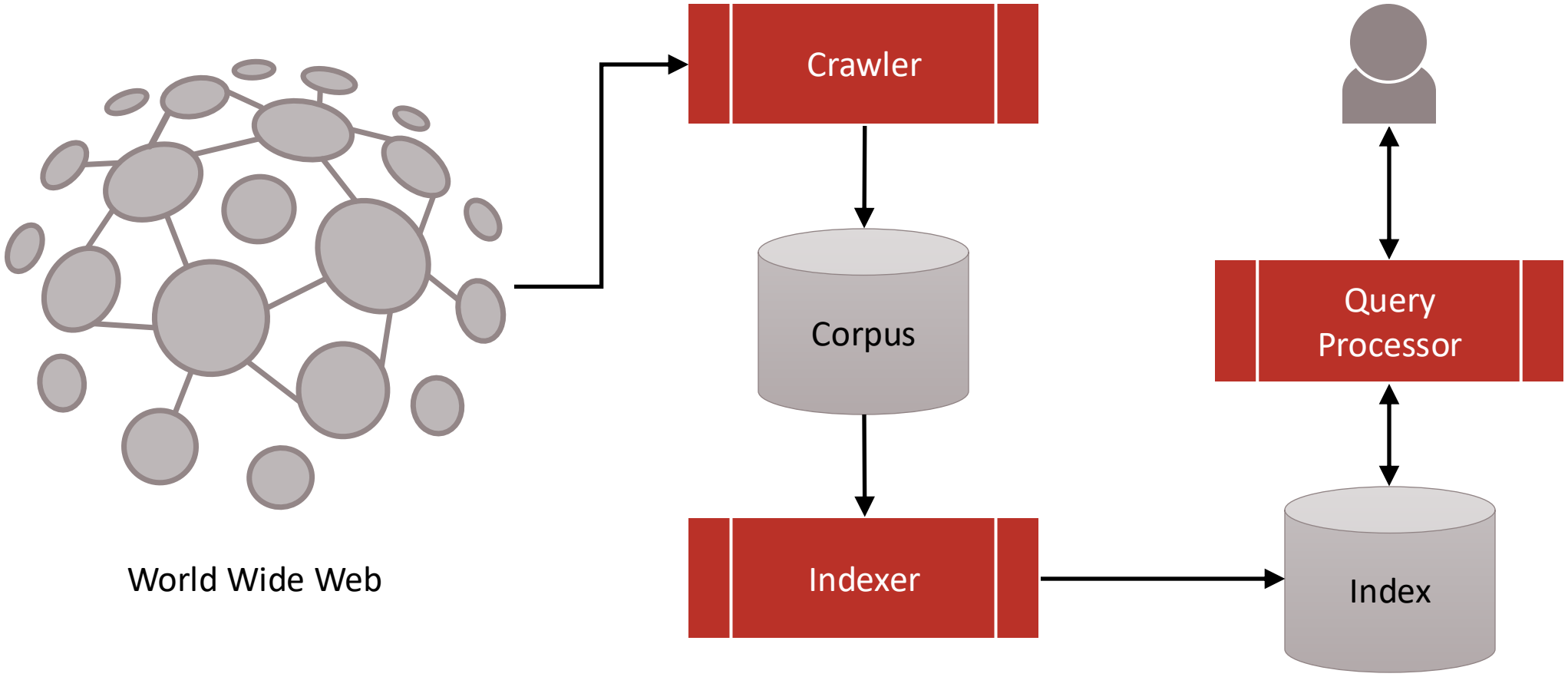
Search architecture

A software architecture consists of software components, the interfaces provided by those components, and the relationships between them

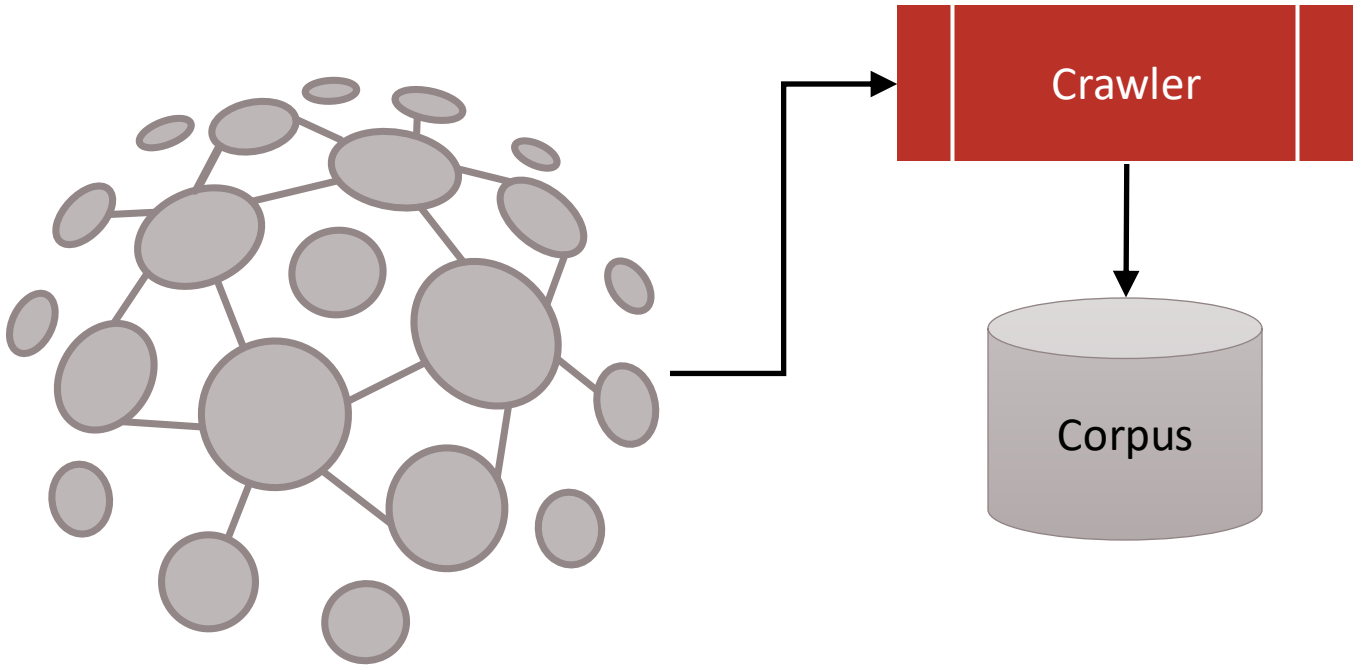
For search, we are concerned about

- Effectiveness (quality of results)
- Efficiency (response time and throughput)

Search components



Search components



World Wide Web

Crawling overview

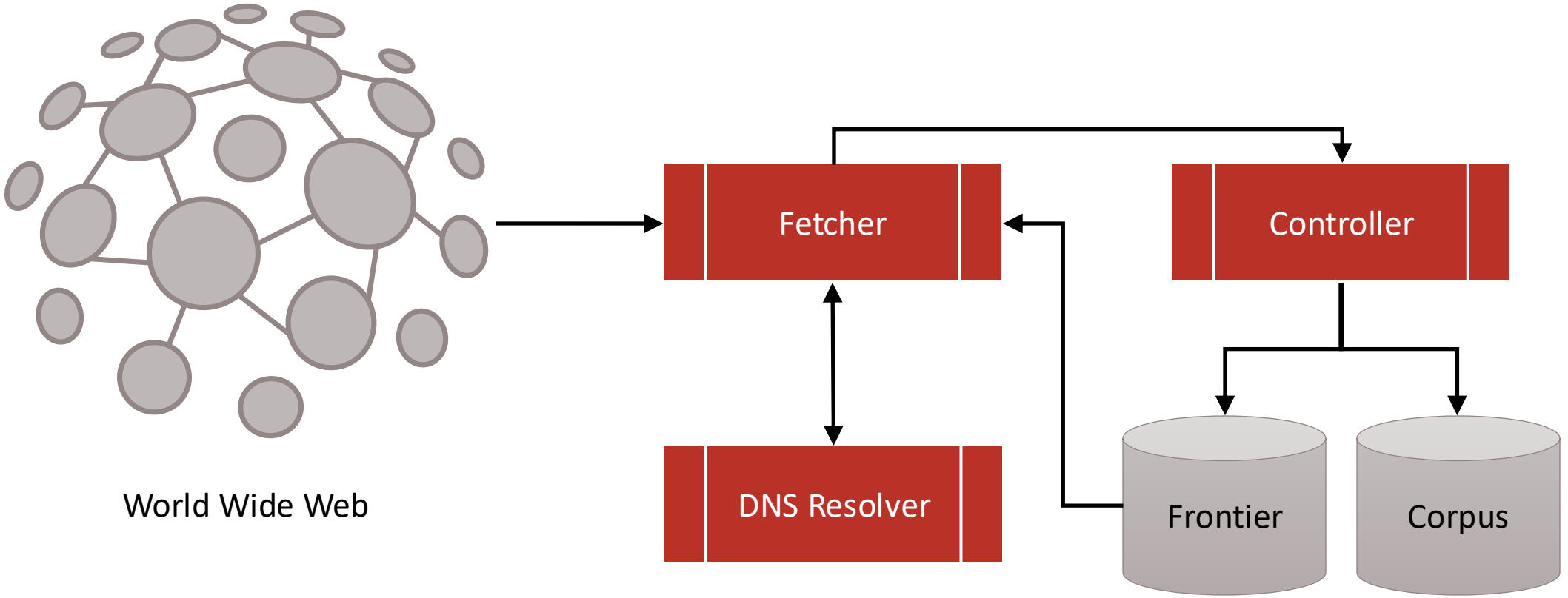
Document acquisition

- Builds a local corpus for searching
- Many types – Web, enterprise, desktop

Web crawlers follow links to find documents

- Must efficiently find huge numbers of web pages (coverage) and keep them up-to-date (freshness)

Crawling overview



Key challenges

Web is huge and constantly changing

- Not under the control of search providers

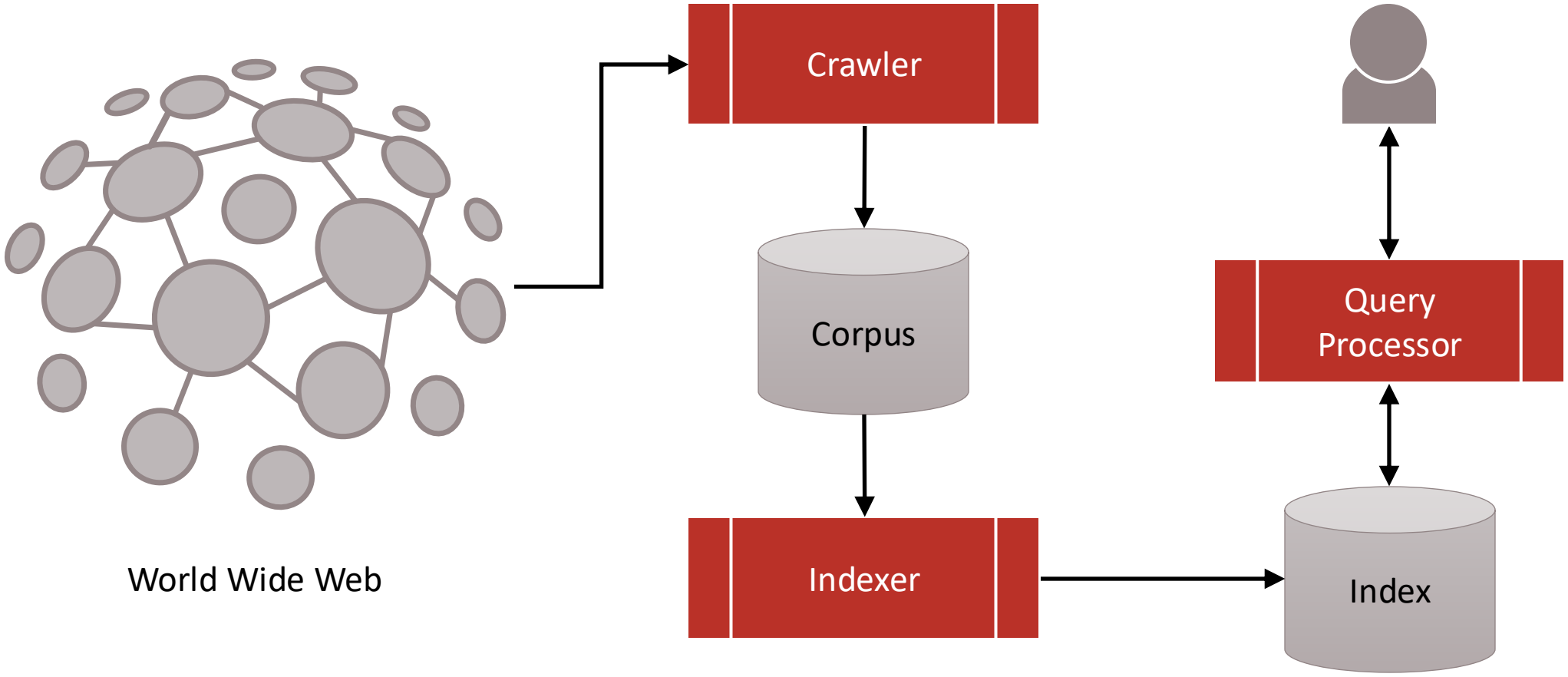
A lot of time is spent waiting for responses

- Parallel crawling is essential

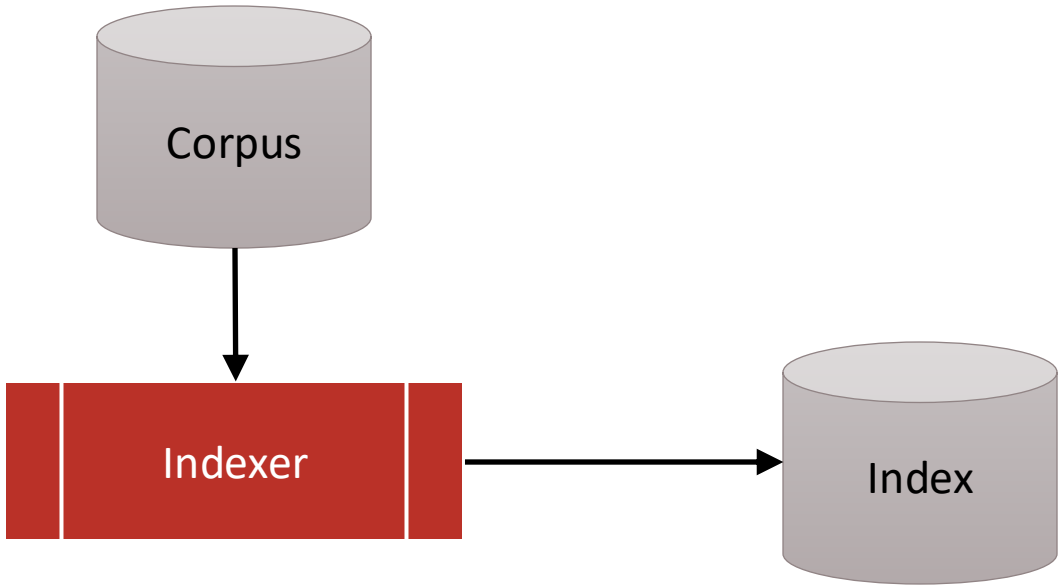
Could potentially flood sites with requests

- To avoid this problem, use politeness policies

Search components



Search components



Indexing overview

Document representation

- From raw text to index terms
- +annotations (e.g., entities, categories, embeddings)

Off-document evidence

- Anchor text, link analysis
- Social network signals

Document representation

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).

Document representation

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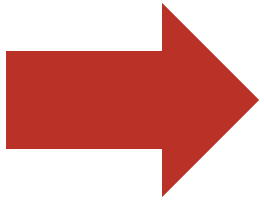


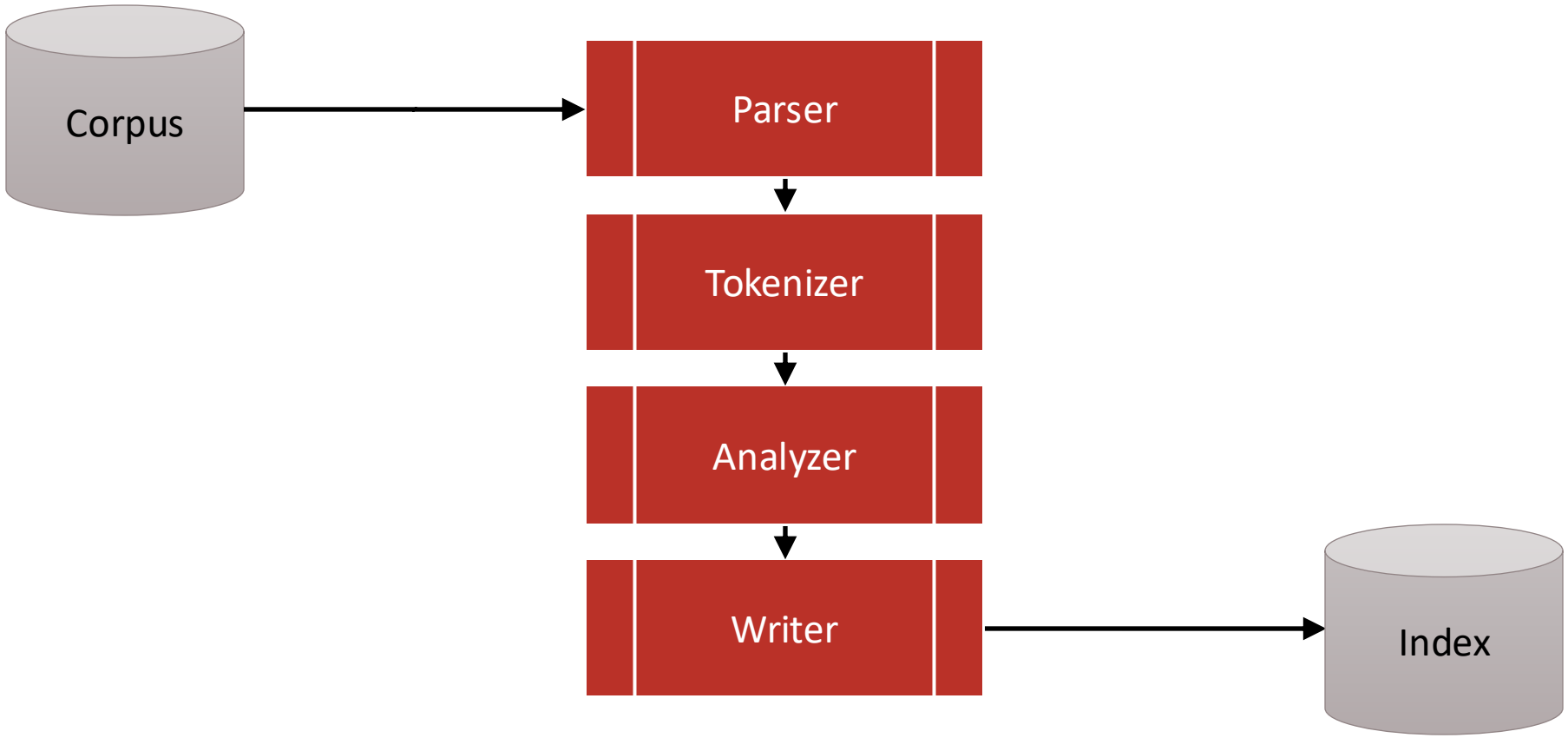
Topical features

9.7	fish
4.2	tropical
22.1	tropical fish
8.2	seaweed
4.2	surfboards

Quality features

14	incoming links
3	days since last update

Indexing overview



Key challenges

Support effective retrieval

- Extract meaningful document features
- Both topical and quality features

Support efficient retrieval

- Quick scoring of matched documents

Index structures

Indexes are designed to make search faster

- Unique requirements, unique data structures

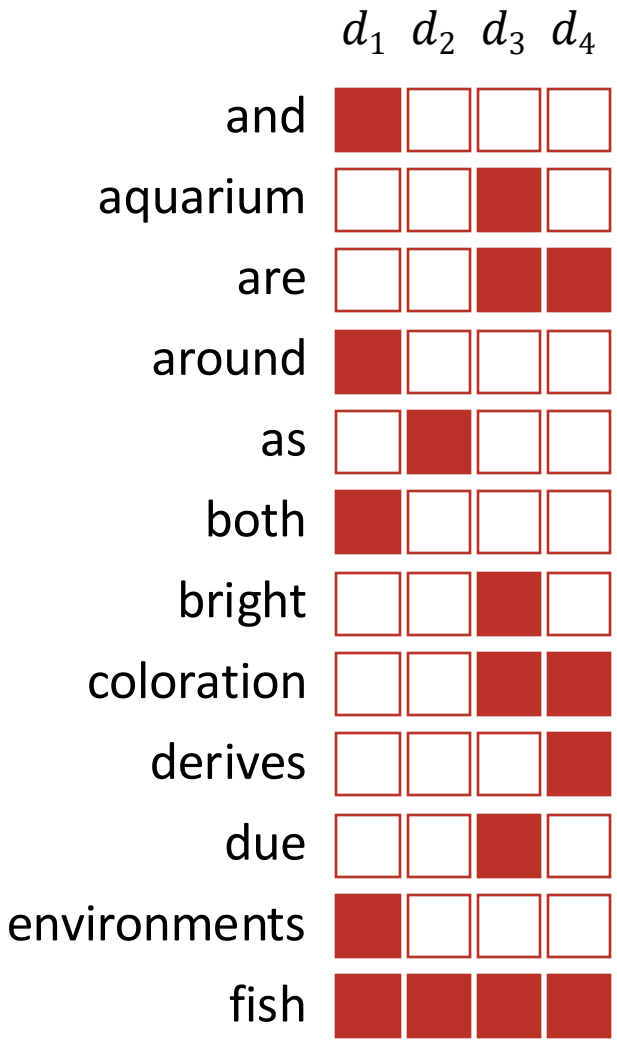
Most common structure is the inverted index

- General name for a class of structures
- “Inverted” because documents are associated with words, rather than words with documents

Example “corpus”

d_1	Tropical fish include fish found in tropical environments around the world, including both freshwater and salt water species.
d_2	Fish keepers often use the term tropical fish to refer only those requiring fresh water, with saltwater tropical fish referred to as marine fish.
d_3	Tropical fish are popular aquarium fish, due to their often bright coloration.
d_4	In freshwater fish, this coloration typically derives from iridescence, while salt water fish are generally pigmented.

Incidence matrix



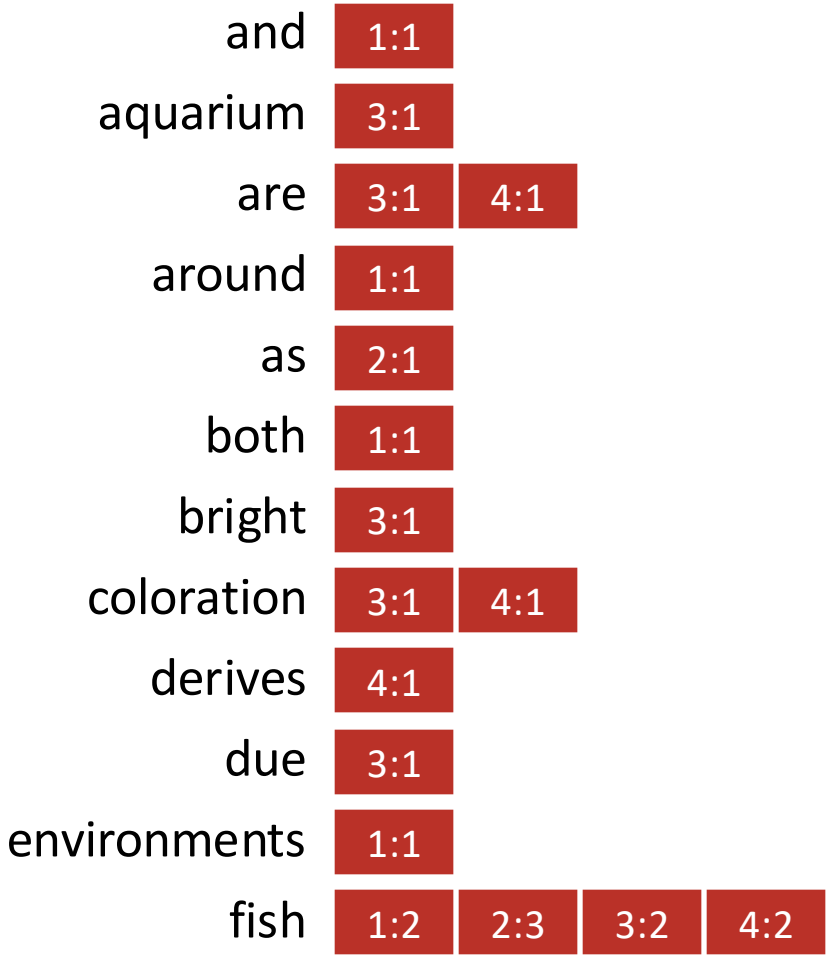
Straigthforward but…

… is it efficient?

Inverted index

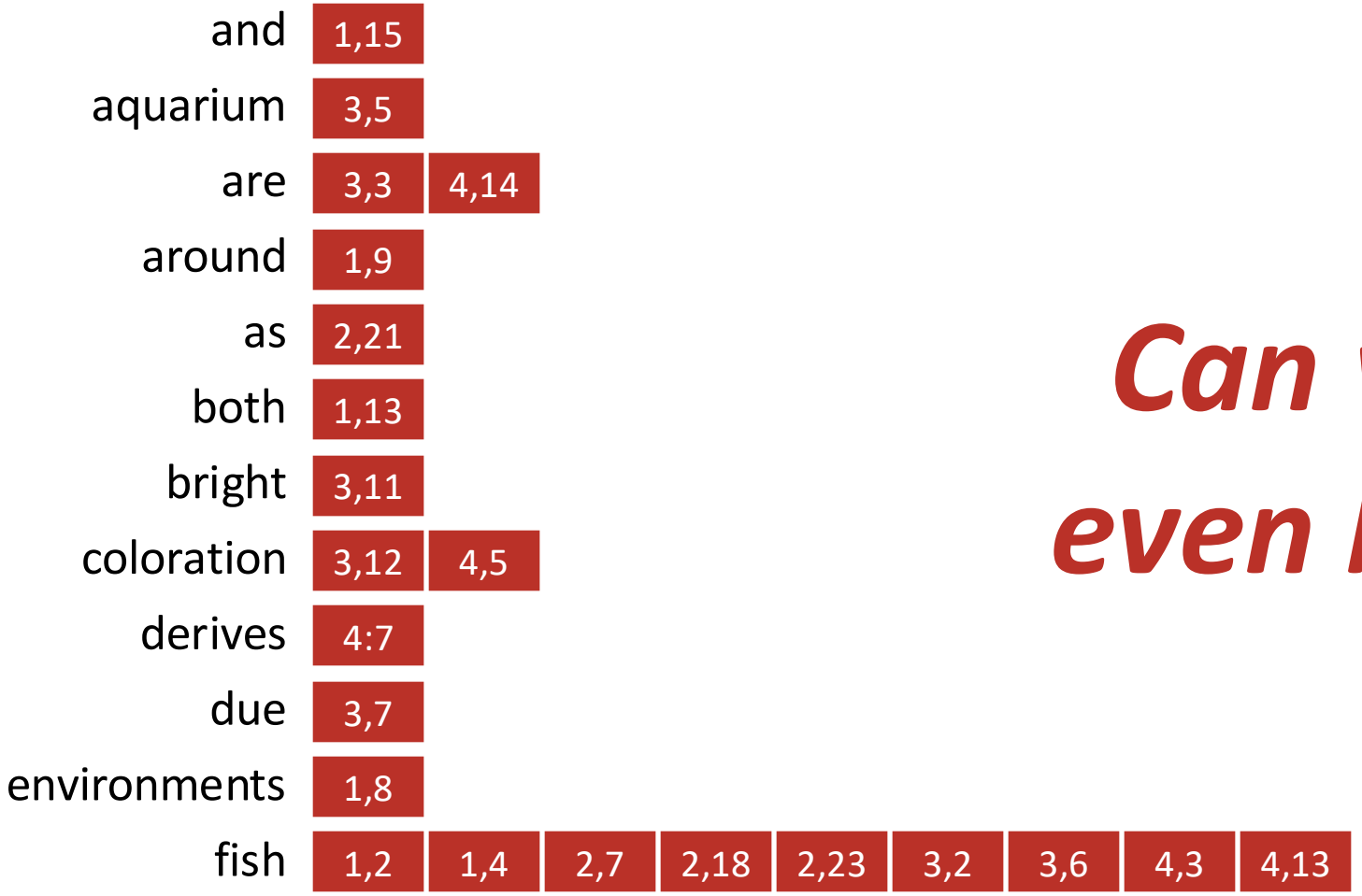
Aren't we missing anything?

Inverted index: counts



Can we do better?

Inverted index: positions



Can we do even better?

Inverted index: fields

Document structure is useful in search

- Field restrictions (e.g., date:, from:)
- Some fields more important (e.g., title, h1)

A couple of options

- Separate inverted lists for each field type
- Add information about fields to postings

Auxiliary structures

Vocabulary, dictionary, or lexicon

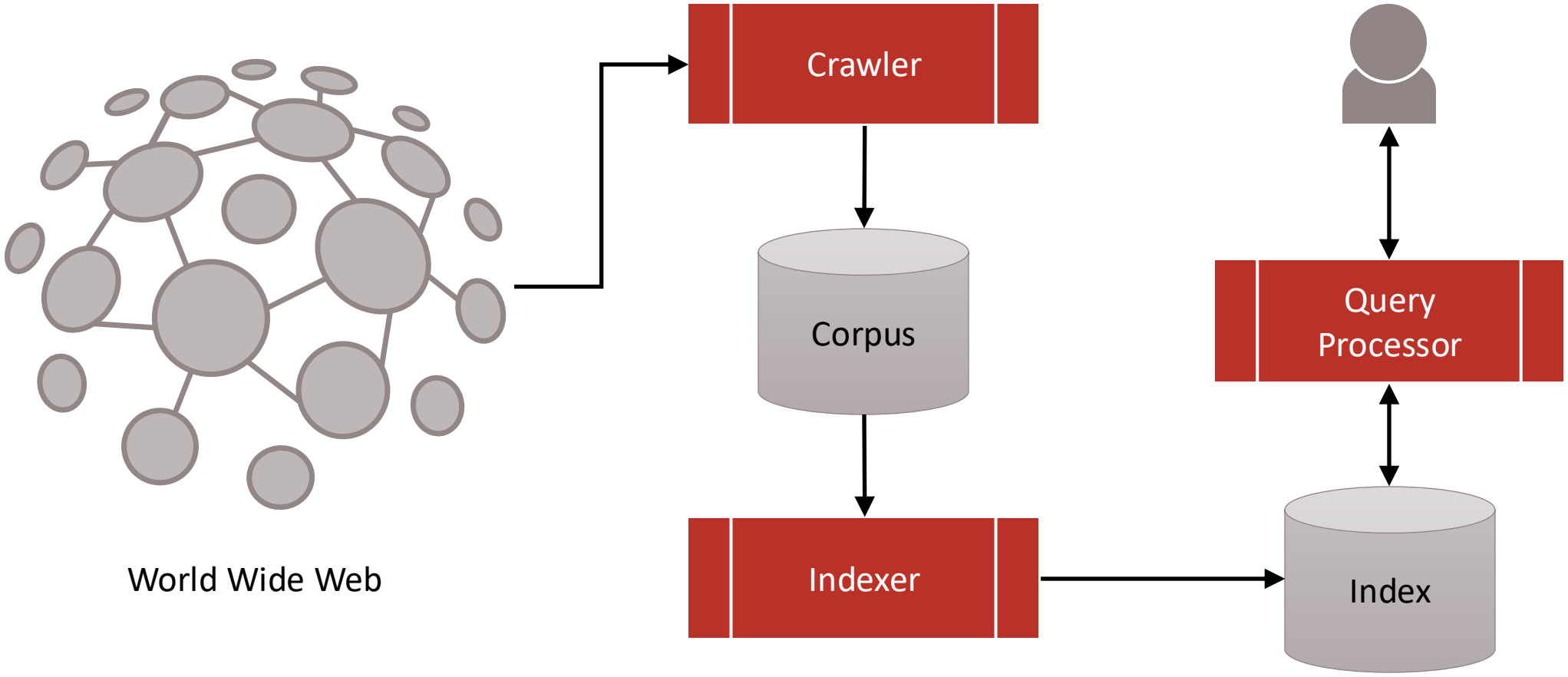
- Lookup table from term to inverted list
- Either hash table in memory or B-tree for disk

Additional structures for document data

- Basic statistics, static features, metadata

Additional structure for corpus statistics

Search components



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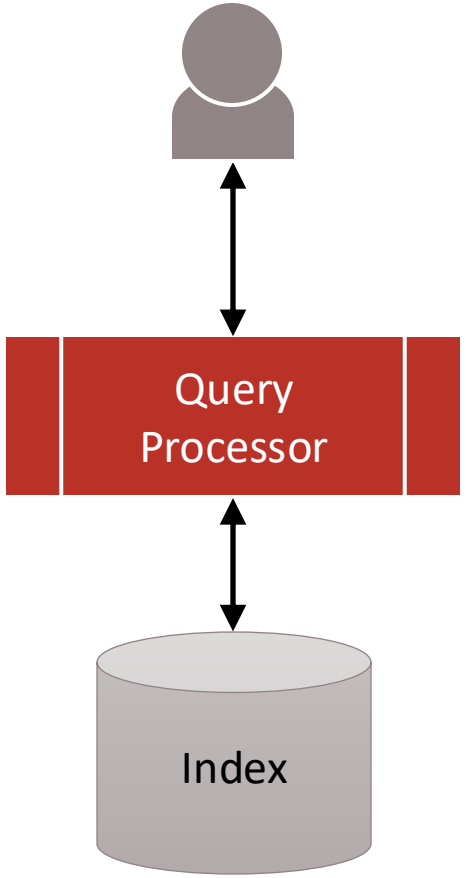


Query processing overview

Query representation

- Infers user's need from a keyword query

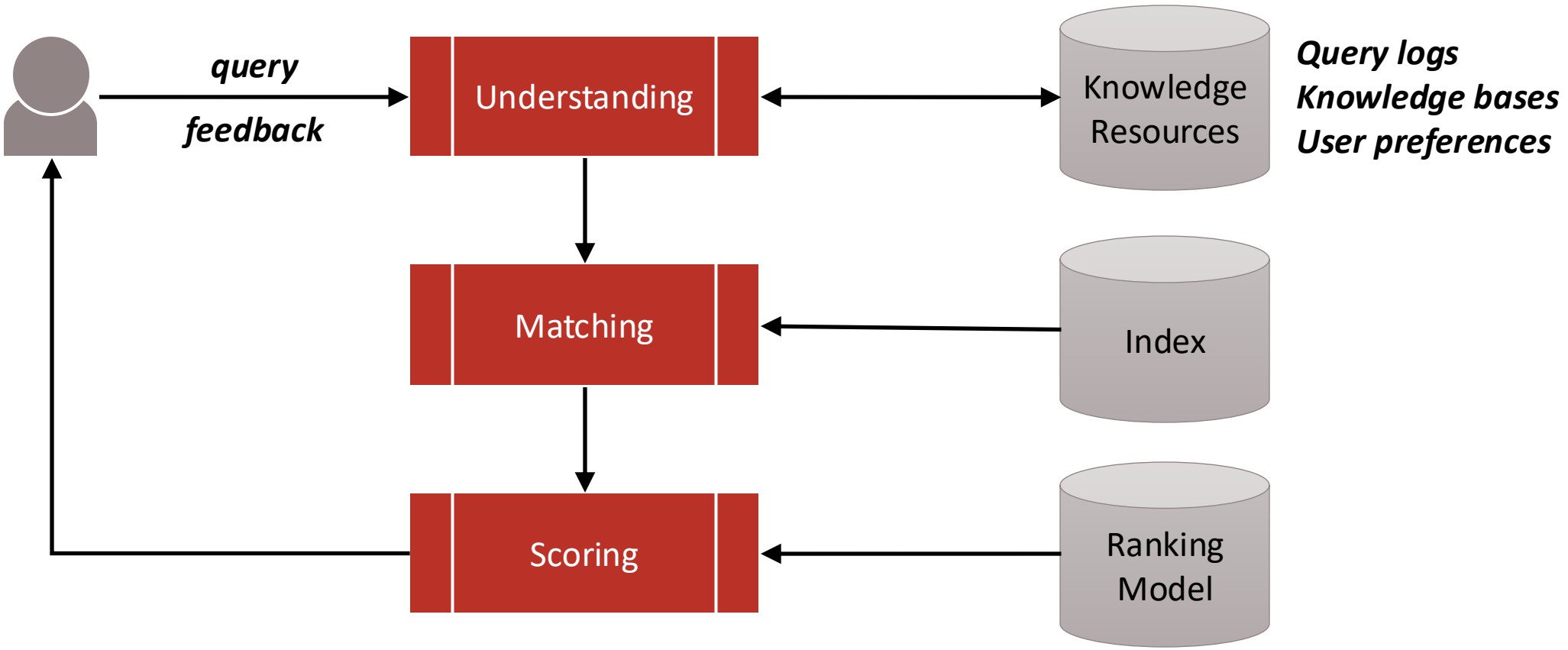
Document ranking

- Matches and scores indexed documents

Feedback handling

- Both explicit and implicit signals

Query processing overview



Key challenges

Queries are typically short, ill-specified

- Long queries tend to be difficult

Finding matching documents can be expensive

- Particularly for common terms or long queries

Ranking is a tough business

- Different queries, different requirements

Query understanding: expand matches

Query relaxation

- [information about tropical fish]

  ↳ [tropical fish]

Query expansion

- [tropical fish]

  ↳ [tropical fish aquarium]

Query understanding: narrow results

Query segmentation

- [tropical fish captive breeding]

  ↳ [”tropical fish” AND ”captive breeding”]

Query scoping

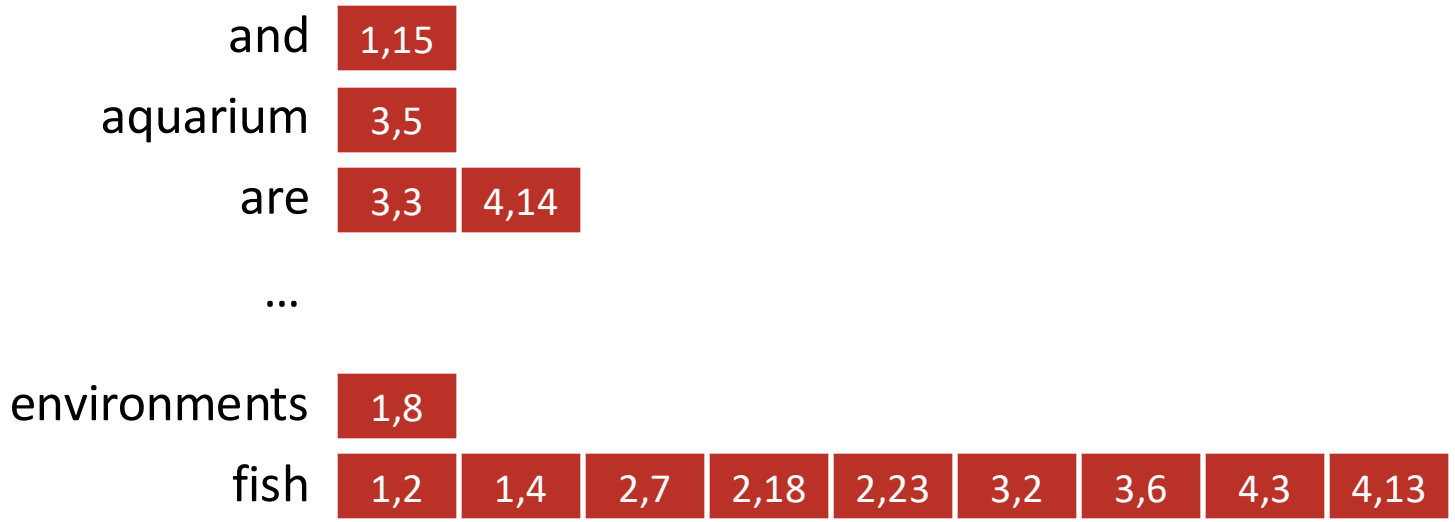
- [tropical fish hawaii]

  ↳ [category:”tropical fish” place:hawaii]

Document matching

Scan postings lists for all query terms

- [aquarium fish]



Document matching

Scan postings lists for all query terms

- [aquarium fish]

Score matching documents

- $f(q,d) = \sum_{t \in q} f(t,d)$

Document ranking

Many alternatives

- Lexical models (bag-of-words)
- Structural models (query + document structure)
- Semantic models (implicit + explicit semantics)
- Interactive models (user feedback)
- Feature-based models (aka learning to rank)

Summary

Search is a tough business

- Big data, big usage

An architecture tailored for efficiency is crucial

- Crawling, indexing, query processing

Must also cater for effectiveness

- Rule of thumb: don’t throw anything away

References

Search Engines: Information Retrieval in Practice, Ch. 2

Croft et al., 2009

Scalability Challenges in Web Search Engines

Cambazoglu and Baeza-Yates, 2015

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Coming next…

Web Crawling

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