IS4200/CS6200
Information Retrieval

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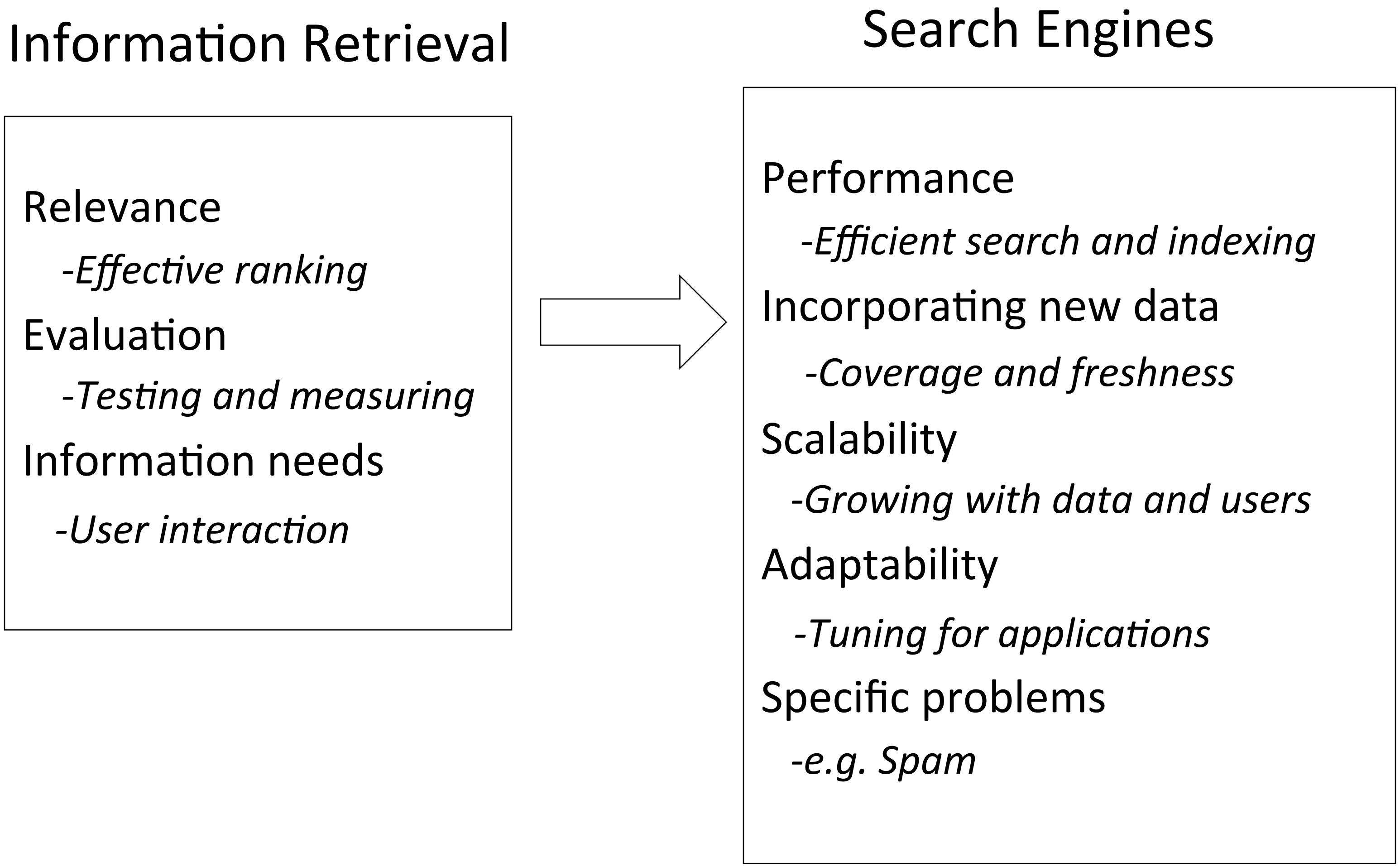
IR and Search Engines



Information Retrieval

Relevance

-Effective ranking

Evaluation

-Testing and measuring

Information needs

-User interaction

Search Engines

Performance

-Efficient search and indexing

Incorporating new data

-Coverage and freshness

Scalability

-Growing with data and users

Adaptability

-Tuning for applications

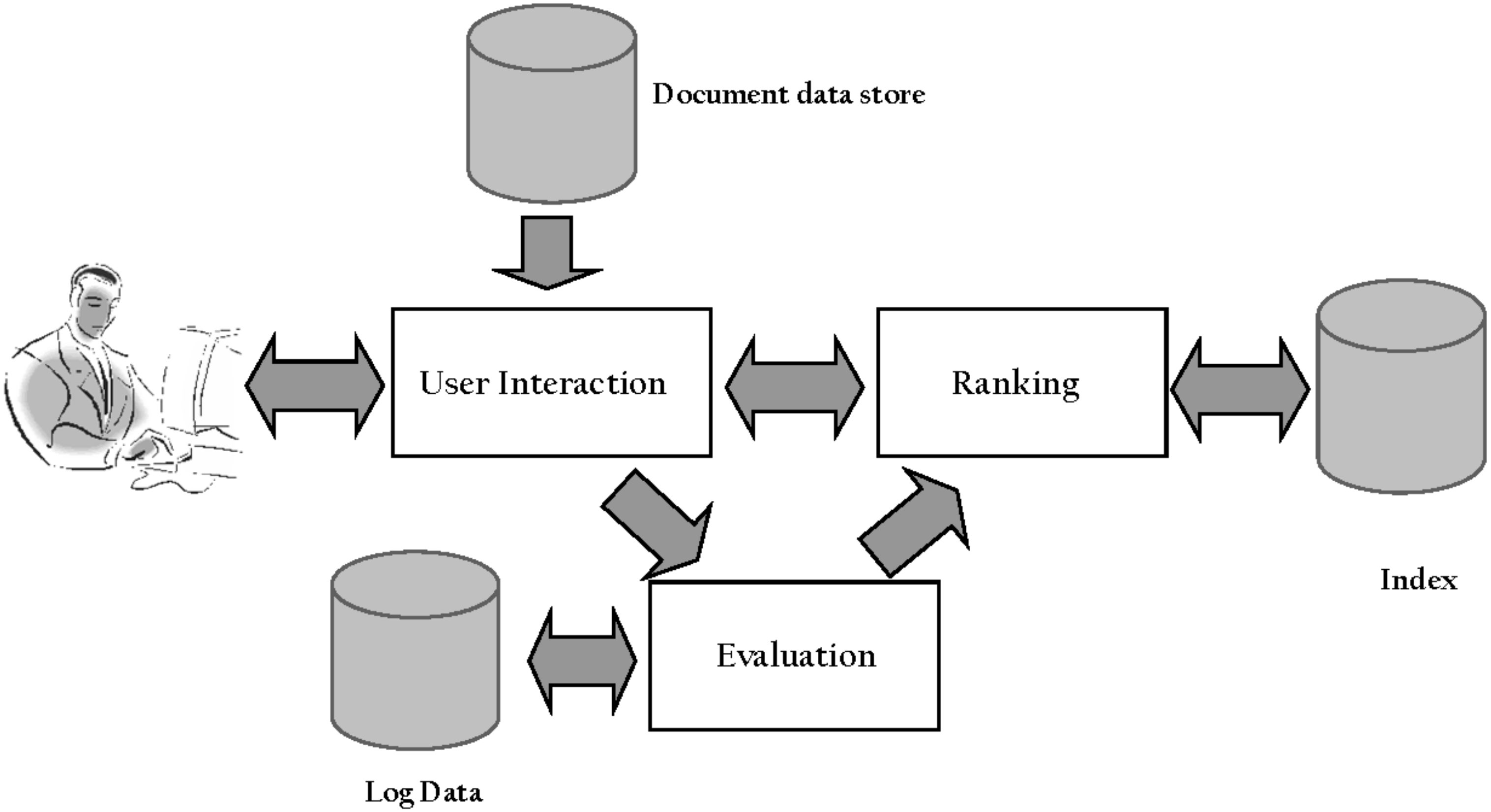
Specific problems

-e.g. Spam

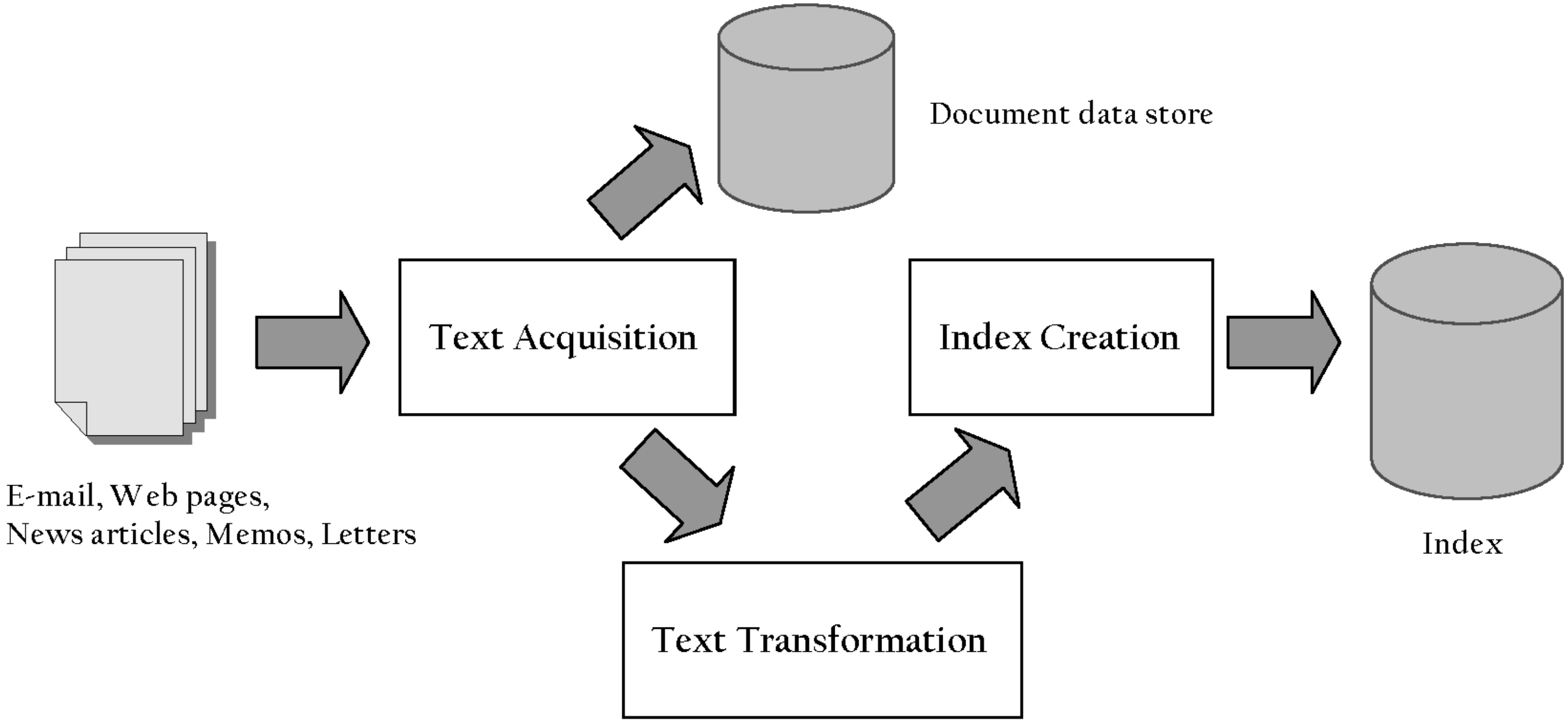
Search Engine Architecture

- A software architecture consists of software components, the interfaces provided by those components, and the relationships between them
  - describes a system at a particular level of abstraction
- Architecture of a search engine determined by 2 requirements
  - effectiveness (quality of results) and efficiency (response time and throughput)

Query Process



Indexing Process



Details: Text Acquisition

- Crawler
  - Identifies and acquires documents for search engine
  - 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*)
    - Single site crawlers for *site search*
    - *Topical* or *focused* crawlers for vertical search
  - *Document* crawlers for enterprise and desktop search
    - Follow links and scan directories

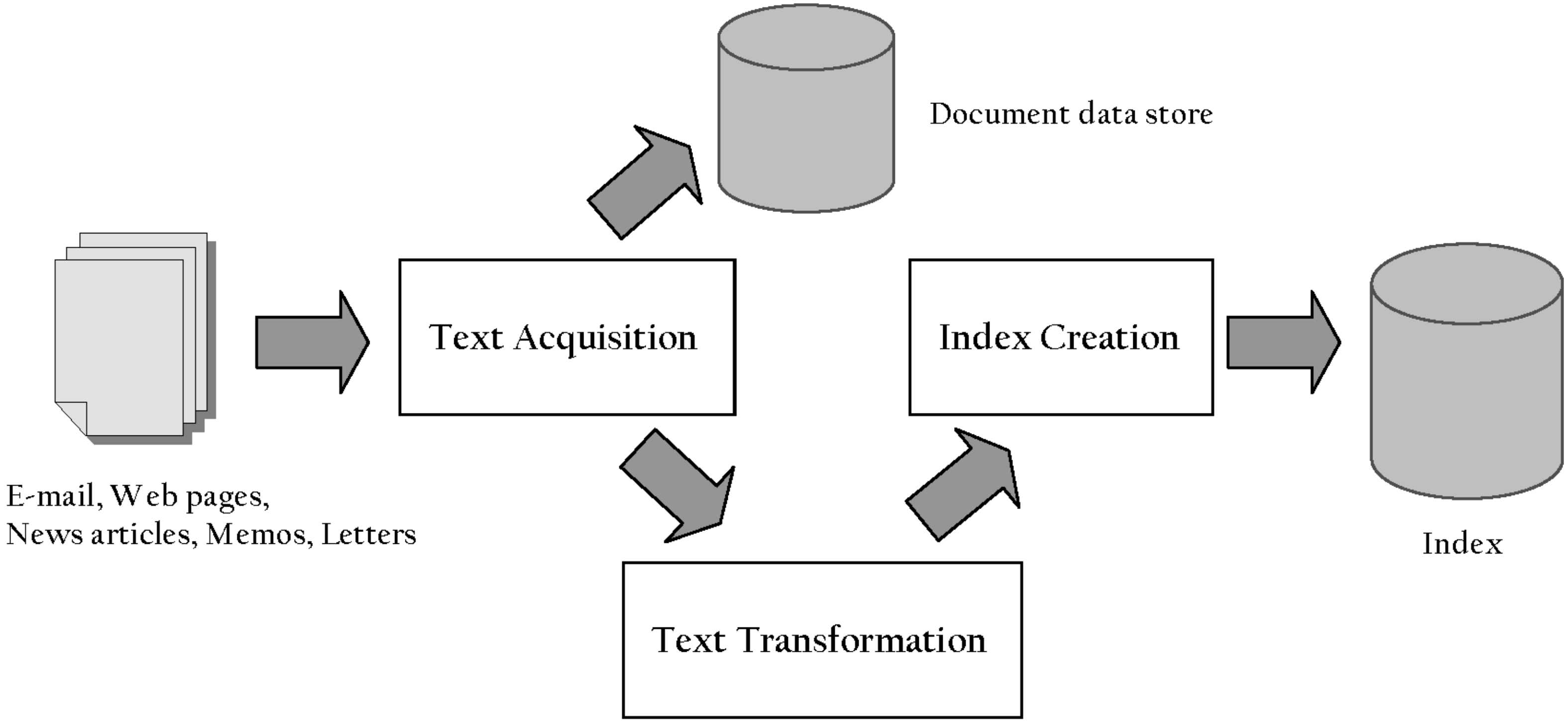
Text Acquisition

- Feeds
  - Real-time streams of documents
    - e.g., web feeds for news, blogs, video, radio, TV
  - RSS is common standard
    - RSS “reader” can provide new XML documents to search engine
- Conversion
  - Convert variety of documents into a consistent text plus metadata format
    - e.g. HTML, XML, Word, PDF, etc. → XML
  - Convert text encoding for different languages
    - Using a Unicode standard like UTF-8

Text Acquisition

- Document data store
  - Stores text, metadata, and other related content for documents
    - Metadata is information about document such as type and creation date
    - Other content includes links, anchor text
  - Provides fast access to document contents for search engine components
    - e.g. result list generation
  - Could use relational database system
    - More typically, a simpler, more efficient storage system is used due to huge numbers of documents

Indexing Process



Text Transformation

- Parser
  - Processing the sequence of text *tokens* in the document to recognize structural elements
    - e.g., titles, links, headings, etc.
  - *Tokenizer* recognizes “words” in the text
    - must consider issues like capitalization, hyphens, apostrophes, non-alpha characters, separators
  - *Markup languages* such as HTML, XML often used to specify structure
    - *Tags* used to specify document *elements*
      - E.g., <h2> Overview </h2>
    - Document parser uses *syntax* of markup language (or other formatting) to identify structure

Text Transformation

- Stopping
  – Remove common words
    - e.g., “and”, “or”, “the”, “in”
  – Some impact on efficiency and effectiveness
  – Can be a problem for some queries
- Stemming
  – Group words derived from a common *stem*
    - e.g., “computer”, “computers”, “computing”, “compute”
  – Usually effective, but not for all queries
  – Benefits vary for different languages

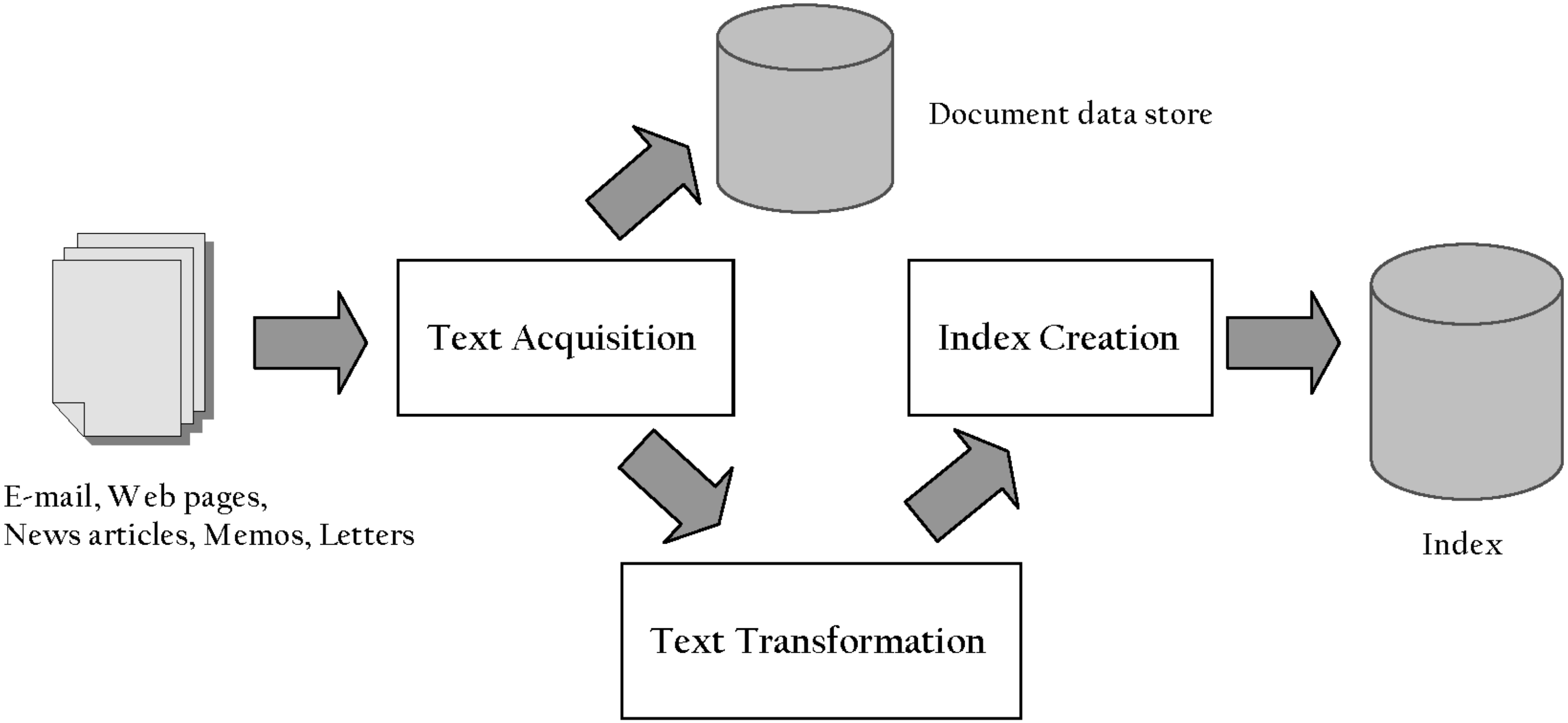
Text Transformation

- Link Analysis
  - Makes use of *links* and *anchor text* in web pages
  - Link analysis identifies *popularity* and *community* information
    - e.g., PageRank
  - Anchor text can significantly enhance the representation of pages pointed to by links
  - Significant impact on web search
    - Less importance in other applications

Text Transformation

- Information Extraction
  - Identify classes of index terms that are important for some applications
  - e.g., *named entity recognizers* identify classes such as *people*, *locations*, *companies*, *dates,* etc.
- Classifier
  - Identifies class-related metadata for documents
    - i.e., assigns labels to documents
    - e.g., topics, reading levels, sentiment, genre
  - Use depends on application

Indexing Process



Index Creation

- Document Statistics
  - Gathers counts and positions of words and other features
  - Used in ranking algorithm
- Weighting
  - Computes weights for index terms
  - Used in ranking algorithm
  - e.g., *tf.idf* weight
    - Combination of *term frequency* in document and *inverse document frequency* in the collection

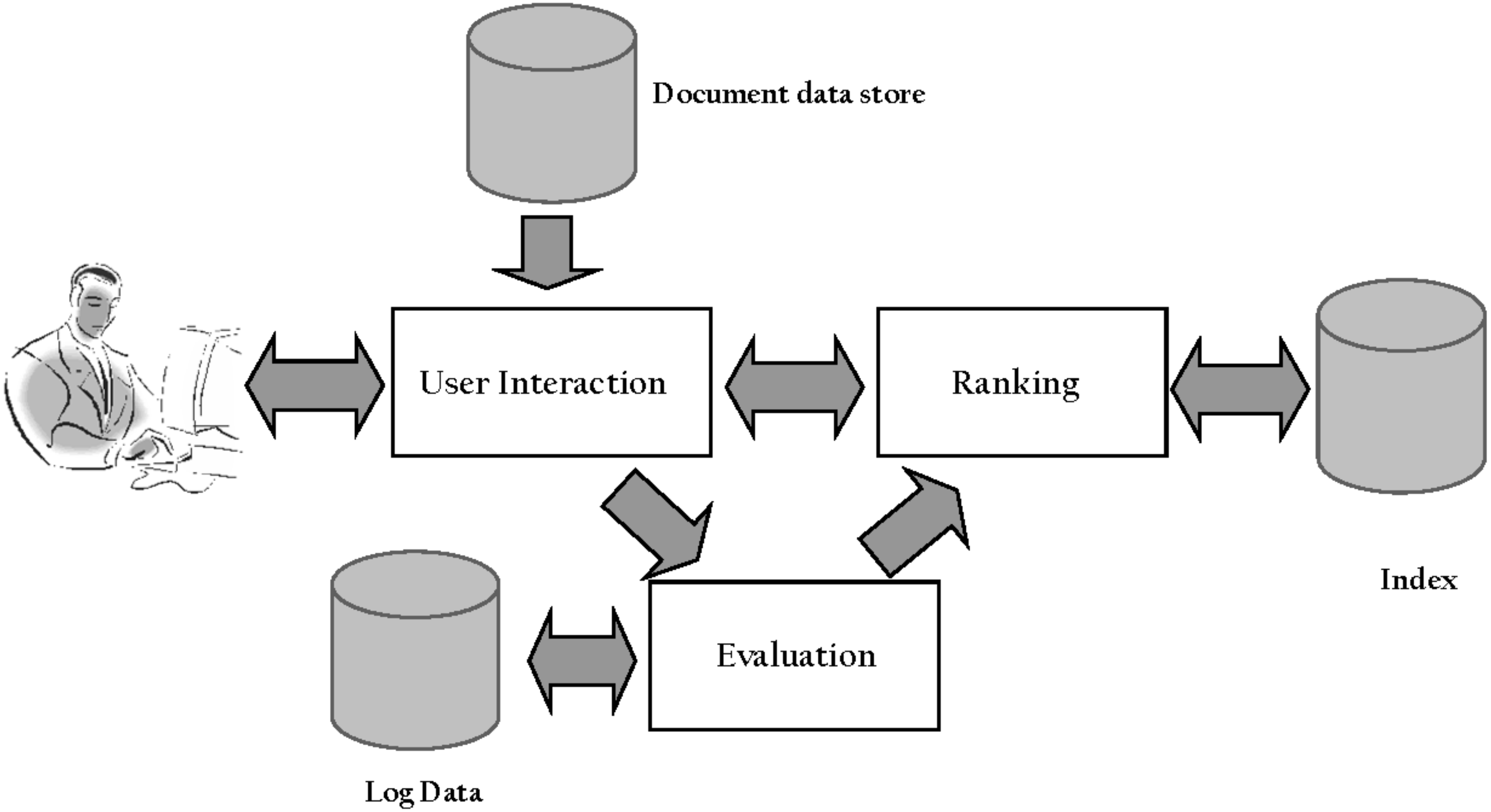
Index Creation

- Inversion
  - Core of indexing process
  - Converts document-term information to term-document for indexing
    - Difficult for very large numbers of documents
  - Format of inverted file is designed for fast query processing
    - Must also handle updates
    - Compression used for efficiency

Index Creation

- Index Distribution
  - Distributes indexes across multiple computers and/or multiple sites
  - Essential for fast query processing with large numbers of documents
  - Many variations
    - Document distribution, term distribution, replication
  - *P2P* and *distributed IR* involve search across multiple sites

Query Process



User Interaction

- Query input
  - Provides interface and parser for *query language*
  - Most web queries are very simple, other applications may use forms
  - Query language used to describe more complex queries and results of query transformation
    - e.g., Boolean queries, Indri and Galago query languages
    - similar to SQL language used in database applications
    - IR query languages also allow content and structure specifications, but focus on content

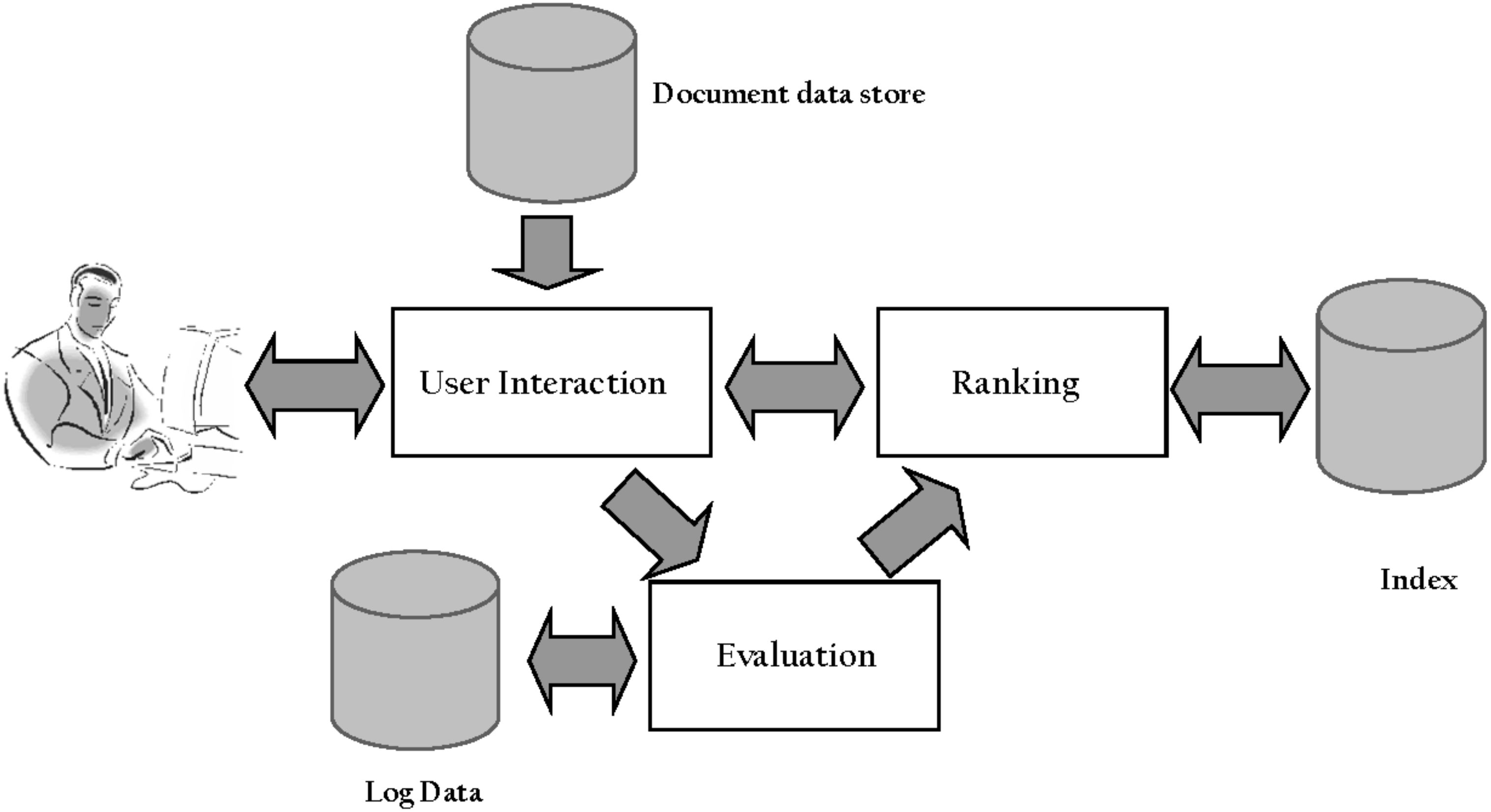
User Interaction

- Query transformation
  - Improves initial query, both before and after initial search
  - Includes text transformation techniques used for documents
  - *Spell checking* and *query suggestion* provide alternatives to original query
  - *Query expansion* and *relevance feedback* modify the original query with additional terms

User Interaction

- Results output
  - Constructs the display of ranked documents for a query
  - Generates *snippets* to show how queries match documents
  - *Highlights* important words and passages
  - Retrieves appropriate *advertising* in many applications
  - May provide *clustering* and other visualization tools

Query Process



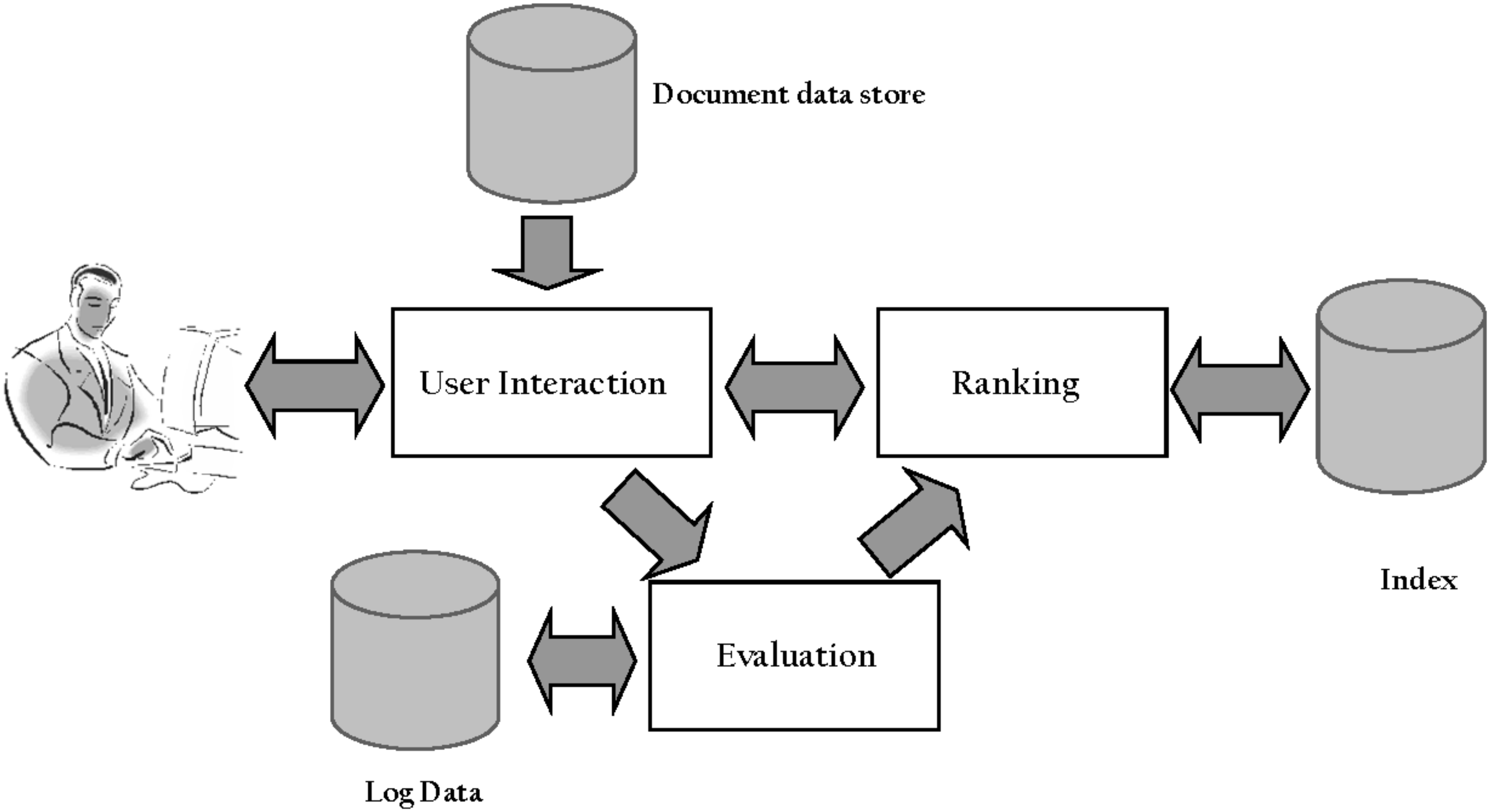
Ranking

- Scoring
  - Calculates scores for documents using a ranking algorithm
  - Core component of search engine
  - Basic form of score is $\sum q_i d_i$
    - q_i and d_i are query and document term weights for term i
  - Many variations of ranking algorithms and retrieval models

Ranking

- Performance optimization
  - Designing ranking algorithms for efficient processing
    - *Term-at-a time* vs. *document-at-a-time* processing
    - *Safe* vs. *unsafe* optimizations
- Distribution
  - Processing queries in a distributed environment
  - *Query broker* distributes queries and assembles results
  - *Caching* is a form of distributed searching

Query Process



Evaluation

- Logging
  - Logging user queries and interaction is crucial for improving search effectiveness and efficiency
  - *Query logs* and *clickthrough data* used for query suggestion, spell checking, query caching, ranking, advertising search, and other components
- Ranking analysis
  - Measuring and tuning ranking effectiveness
- Performance analysis
  - Measuring and tuning system efficiency

How Does It *Really* Work?

- This course explains these components of a search engine in more detail
- Often many possible approaches and techniques for a given component
  - Focus is on the most important alternatives
  - i.e., explain a small number of approaches in detail rather than many approaches
  - “Importance” based on research results and use in actual search engines
  - Alternatives described in references

Topics

- *Overview*
- Architecture of a search engine
- **Data acquisition**
- Text representation
- Information extraction
- Indexing
- Query processing
- Ranking
- Evaluation
- Classification and clustering
- Social search
- More…

Topics

- For background read:
  - *Search Engines* chapter 3, or
  - Intro to IR, chapters 19 and 20